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COMPETITIVE SUSTAINABILITY OF NATIONS – AN EMPIRICAL ANALYSIS

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This thesis is dedicated to my family.

Abstract English

This master thesis focuses on the underexplored relationship between sustainability and competitiveness at a national level. The literature shows that both topics are separately well explored, but the interconnection between them is under researched at a macro level. This thesis uses a higher-order latent-variable model (Multiple Indicator Multiple Cause model) and a sample of 138 countries. We further test the empirical representation of sustainable development with a three- or four-dimensional model. The primary results support that four dimensions instead of three pillars represent sustainability better. Furthermore, we find a positive relationship between sustainability and competitiveness. Thus, the research contains three major contributions: first, it provides further empirical support for the four-dimension approach; second, it proposes a new methodological model (MIMIC model) in the area of competitive sustainability; and, third, it recommends policies that can lead towards a more sustainable path of development.

Abstract Portuguese

Esta tese de mestrado centra-se na relação entre sustentabilidade e competitividade a nível nacional. A literatura demonstra que ambos os temas estão bem explorados per si, mas a relação entre eles a nível macro tem sido pouco estudada. Esta tese explora essa relação usando um modelo de variáveis latentes de ordem superior (Multiple Indicator Multiple Cause) e uma amostra de 138 países. Foi igualmente testada a representação empírica do desenvolvimento sustentável com um modelo de três ou quatro dimensões. Os resultados reforçam que quatro dimensões, em vez de três, representam melhor a sustentabilidade. Adicionalmente encontrámos uma relação positiva entre sustentabilidade e competitividade. Assim, o trabalho contribui em três direções: primeiro, fornece suporte empírico adicional para a abordagem à sustentabilidade a quatro dimensões; segundo, introduz um novo modelo metodológico (modelo MIMIC) na área da sustentabilidade competitiva; terceiro, recomenda políticas fundamentadas de orientação da nossa sociedade no sentido de um desenvolvimento mais sustentável.

Competitiveness, Sustainability, Latent Variable Model, Structural Equation Model

JEL: Q01, Y40

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List of Abbreviations

aBIC	Sample-size adjusted Bayesian Information Criterion
AIC	Akaike Information Criterion
BIC	Bayesian Information Criterion
CCA	Canonical Correlation Analysis
CDI	Commitment to Development Index
CFI	Comparative Fit Index
CIP	Competitive Industrial Performance Index
Cov	Covariance
Comp	Competitiveness
CSD	Commission on Sustainable Development
CSR	Corporate Social Responsibility
DoF	Degrees of Freedom
Eco	Economic
EF	Ecological Footprint
Env	Environment
EPI	Environmental Performance Index
ESI	Environmental Sustainability Index
EU	European Union
EVI	Environmental Vulnerability Index
GCI	Global Competitiveness Index
GDP	Gross Domestic Product
GNI	Gross National Income

GPI	Genuine Progress Indicator
HDI	Human Development Index
HIV	Human Immunodeficiency Virus
Inst	Insitutional
ISEW	Index of Sustainable Economic Welfare
IUCN	International Union for Conservation of Nature
JRC	Joint Research Centre
LVM	Latent Variable Model
MDG	Millennium Development Goal
MIMIC	Multiple Indicators Multiple Causes
OECD	Organisation for Economic Co-operation and Development
p.c.	Per capita
PCT	Patent Cooperation Treaty
PPP	Purchasing Power Parities
R&D	Research and Development
RMSEA	Root Mean Square Error Approximation
S.E.	Standard Error
SD	Sustainable Development
SDG	Sustainable Development Goal
SDI	Sustainable Development Indicator
SEM	Structural Equation Model
SGCI	Sustainability-adjusted Global Competitiveness Index
Soc	Social

Soc2	Social2
SRMR	Standardized Root Mean Square Residual
SSI	Sustainable Society Index
Sus	Sustainability
TLI	Tucker-Lewis Index
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNCHE	United Nations Conference on the Human Environment
UNCSD	United Nations Conference on Sustainable Development
UNEP	United Nations Environment Program
UNIDO	United Nations Industrial Development Organization
USA	United States of America
US	United States
WASH	Safe Water, Sanitation and Hygiene
WCI	World Competitiveness Index
WCS	World Conservation Strategy
WCY	World Competitiveness Yearbook
WEF	World Economic Forum
WGI	Worldwide Governance Indicators
WSSD	World Summit on Sustainable Development
WWF	World Wide Fund for Nature

Chapter 1

Introduction

Climate change has become one of the greatest challenges of humankind (United Nations Population Fund, 2016), resulting in higher sea levels and stronger storms. The magnitude of these impacts is expected to intensify if no countermeasures are taken. The 2015 United Nations Climate Change Conference in Paris was a milestone in this debate and defined the goal of a maximum increase of 1.5°C in global average temperature (United Nations, 2016). The increasing number of publications in the area of sustainability further represents this growing global awareness in recent decades. From 1973 to 2016 the number of publications on Web of Science had an average annual growth rate of 10.43%,[1] while encouraging changes in current lifestyle toward more sustainable standards and paths of development.

Today, the most widely used definition is the one established by the Brundtland report. It defines sustainable development[2] based on three equally important pillars (social, economic, and environmental). Various authors critically discuss this definition, however and argue in favor of a four-dimensional representation of sustainable development. This leads to our first research question: given empirical data, which measures sustainable development better - three pillars or four?

This discussion is not only limited to the sustainability of nations, and should also consider the competitiveness of these countries. This latter concept has evolved since the 18th century and tends to be equated with the productivity of nations. Today, three major indices attempt to measure the concept in one composite index: the Global Competitiveness Index (GCI), the Competitive Industrial Performance Index (CIP), and the IMD World Competitiveness Yearbook (WCY).

Politicians and researchers around the world acknowledge the importance of combing both topics (sustainable development and competitiveness) instead of analyzing it separately. A new area has emerged in this context, which can be termed *competitive sustainability*, exploring the

[1] Figure A.1 in the Appendix shows the number of publications for a search of the topic "sustainability" or "sustainable" on Web of Science by May 2nd, 2017.

[2] As Waas et al. (2011, p. 1639), we will not distinguish between the terms sustainability and sustainable development; they are interchangeable in this work.

relationship between sustainability and competitiveness.

Results from the World Economic Forum (2014) and dos Santos & Brandi (2014) indicate a possible relationship between competitiveness and (environmental) sustainability. This, leads to our second research question: is there an empirical relationship between competitiveness and sustainability?

The reasoning underpinning this master thesis is: to provide a long-lasting basis for the production of goods and services of a country, three important aspects need to be considered. That is, the nation should take care of its economic growth (first) while considering environmental (second) and social issues (third). For example, the pollution of fresh water sources with heavy metals by industrial activity may allow companies to increase their short-term profit since they are not investing in environmental protection. This may cause long-run ecological and social drawbacks. As the contamination of fresh water will cause serious problems such as health problems, lower productivity of water use, and potentially even the abandonment of low-quality living spaces, the pollution results in a decrease of economic growth. On the other hand, if the environment is preserved, production costs may be higher in the short run, but it may provide a long-lasting basis for the production of goods and services, in turn resulting in a stable level of income or even economic growth. This line of reasoning can also be applied to the social aspects.

This thesis focuses on the under-explored relationship between sustainability (four pillars: institutional, social, economic, and environmental) and competitiveness (World Economic Forum, 2014) at a macro level (138 countries) with higher order latent variable models.[3]

The literature review that leads to the conceptual model is presented in the next chapter. The hypotheses, data, indicator selection, and the operational model, are presented in the methodology chapter. After the primary results are presented, discussed, and policy recommendations derived, we conclude.

[3] This research uses cross-section data as basis and no long-run estimations are made.

Chapter 2

Sustainability and Competitiveness, precursors and latest developments

2.1 Sustainability

The history of sustainability reaches far into the past, offering insights and giving examples of civilizations that prospered or suffered due to their environmental behavior. For example, traditional wisdom, expressed in indigenous traditions and the beliefs of many religions, has much to offer regarding harmonious existence of human society and nature, one of the fundamental principles of sustainability (Mebratu, 1998). While some civilizations have managed to thrive sustainably over a long period (Cairns, 2001), others have suffered from a downfall caused by environmental problems (Diamond, 2003).

In the 19^{th} century Thomas Malthus (1826, 1836) and John Stuart Mill (1848) were among the first political economists to mention a notion of sustainability. For the preservation of welfare, the environment needs to be protected from unrestricted growth. Malthus famously argued that it is impossible to have exponential population growth in a world with finite resources.

More recently an increasing number of important events (e.g. see milestones below), publications (e.g. Böhringer & Jochem, 2007; Gallego-Alvaerez et al., 2015; Hosseini & Kaneko, 2011; Mog, 2004; Moldan & Dahl, 2007; Moldan et al., 2012; Moran et al., 2008; Pelenc & Ballet, 2015; Saisana & Philippas, 2012; Shearman, 1990; Singh et al., 2012; Waas et al., 2011), and reports (e.g. Commission on Sustainable Development, 2001; United Nations, 2007; United Nations, 2015; United Nations, 2016b) have molded the definition of sustainability in crucial ways.

In order to provide an overview of the evolving concept of sustainability, it is useful to recall key milestones that deserve special attention (e.g. European Commission, 2010; Kates et al., 2000; Waas et al., 2011; Zaccai, 2012) due to their impact and broad reach, namely:

- United Nations Conference on the Human Environment (UNCHE, 1972)

- World Conservation Strategy (WCS, 1980)
- Our Common Future (1987)
- United Nations Conference on Environment and Development (UNCED, 1992)
- Sustainability Science (2000)
- Millennium Development Goals (MDGs, 2000)
- United Nations World Summit on Sustainable Development (WSSD, 2002)
- Europe 2020 strategy (2010)
- Rio+20 United Nations Conference on Sustainable development (UNCSD, 2012)
- Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (2014)
- Sustainable Development Goals (SDGs, 2015)

United Nations Conference on the Human Environment

In 1972 the *United Nations Conference on the Human Environment* was held in Stockholm. It was the first conference with the environment on the international political agenda (Dresner, 2008, p. 31). This created a considerable increase in global environmental awareness (Quental et al., 2011; UNEP, 2002). The final declaration (also called "Stockholm Declaration") contained 26 principles on the enhancement and preservation of the human environment and an action plan with 109 recommendations. As a result of the conference, the UN body for environmental affairs (UNEP) was established (UNEP, 2002).

World Conservation Strategy

In 1980 the *"World Conservation Strategy - Living Resources Conservation for Sustainable Development"* was published (IUCN et al., 1980), enhancing the concept of sustainability. The primary concern was the environment, in particular, how sustainable development can be achieved "through the conservation of living resources" (Waas et al., 2011, p. 1641). However, while the document pointed out the challenges, it did not achieve a precise integration of the concepts of environment and development (Pearce et al., 1990).

Our Common Future

The Brundtland Report, officially entitled "Our Common Future", defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Devel-

opment, 1987). The report shifted the way the scientific community and politicians looked at economic growth. Before then only economic factors were taken into account, while the new concept embodied three equally important pillars: social, economic, and environmental.

United Nations Conference on Environment and Development (UNCED)
In Rio de Janeiro (1992) an unprecedented UN conference took place *The Earth Summit*. Its size and scope were the first of its kind (United Nations, 1997), with contributions from numerous researchers and authors (Goodland, 1995). The key message stressed the importance of transforming our current behavior and attitudes to achieve the necessary changes (to enhance or preserve the environment) (United Nations, 1997). The main issue is very complex, and both poverty and excessive consumption on the part of wealthier countries are included as drivers of environmental damages (United Nations, 1997). The conference produced the Rio declaration, also called Agenda 21, referring to the 21st century (Zaccai, 2012). This was a comprehensive action plan for different levels (local, national, and global) and areas where humans affect the environment (United Nations, 2017b). All ensuing conferences on "the relationship between human rights, population, social development, women and human settlements" have this conference (The Earth Summit) (United Nations, 1997) as a foundation.

Sustainability Science
In 2000 "Sustainability Science" was coined as a new field of research in a working paper by many international researchers from various areas, forcefully pointing out the need for further research (Kates et al., 2000). The final paper was published in Science in 2001, and it is "in the top 5% of all research outputs scored by Altmetric", highlighting its importance (Altmetric, 2017).

Millennium Development Goals (MDGs)
In 2000 the United Nations established the Millennium Development Goals (MDGs), with a temporal horizon of 15 years. The main objective was to advance toward sustainable development by reaching eight goals, among which there were 18 quantified targets, including reduction of extreme poverty by 50% and ensuring primary education for all (United Nations, 2015). The final results, assessed in 2015, revealed a broad spectrum of achievements: a few targets were attained or showed fair progress, such as "[r]educe extreme poverty by half", while other targets saw a highly uneven progress, ranging from excellent to poor or even deterioration, depending on the region, such as "[h]alve proportion of population without improved drinking water" (United Nations, 2015a). A search for "Millennium Development Goals" in Web of

Science results in over 3,600 papers (May 2nd, 2017). This vast research ranges from ways to help reach the MDGs to estimations of the progress on single goals (e.g. Lozano et al., 2011; Travis et al., 2004).

United Nations World Summit on Sustainable Development

In 2002 the first UNCED follow-up conference took place. The primary goal was to put in place a mechanism to implement Agenda 21, given that progress had been relatively weak until then (Rees, 2010). The Johannesburg Declaration was adopted by the World Summit on Sustainable Development to reconfirm the political and international engagement on sustainable development (Hens & Nath, 2003). Another important aspect was the creation of Type II partnerships. These partnerships include civil society projects "to contribute to the implementation of sustainable development" (Hens & Nath, 2003, p. 7). These partnerships are democratic instruments and can be powerful tools for the implementation of Agenda 21 (Hens & Nath, 2003).

Europe 2020 strategy

In March 2010 the European Commission presented the *Europe 2020 strategy*, defining the agenda for the European Union (EU) for 2010-2020 in terms of jobs and growth. The primary focus is on overcoming "the crisis and prepare EU economy for the next decade" with smart, sustainable and inclusive growth (European Commission, 2010). Target areas include Employment (with a goal of 75% employment rate, age 20-64), Research and Development (3% of EU GDP invested in R&D), Climate Change and Energy (decrease of 20% in greenhouse gas emissions compared to base year 1990; 20% energy consumption supplied by renewables; increase of 20% in energy efficiency), Education (Early school leavers rate < 10%; "at least 40% of people aged 30-34 having completed higher education") and Poverty & Social Exclusion ("at least 20 million fewer people on - or at risk of - poverty/social exclusion") (European Commission, 2010; European Commission, 2017).

Rio+20 United Nations Conference on Sustainable development (UNCSD)

In 2012 at Rio+20 nations confirmed a new agenda. Its primary purpose was the promotion of a viable future (social, economic, and environmental) for our planet while being inter- and intragenerational fair. "They called for the development of 'Sustainable Development Goals"' (United Nations Environment Program, 2015).

Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (2014)

The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 by the United

Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) to provide (in this field) objective and reliable technical and scientific assessment to policymakers (IPCC, 2014). The Climate Change 2014 report of the IPCC is the final product of the Fifth Assessment Report (AR5). This Synthesis Report contains the main results of the three working groups - "The Physical Science Basis, Impacts, Adaptation, and Vulnerability and Mitigation of Climate Change" (IPCC, 2014, p. viii). It is an exhaustive assessment of the latest socio-economic, technical, and scientific developments that address climate change (IPCC, 2014).

Sustainable Development Goals (SDGs)
In 2015 the MDGs were followed by the Sustainable Development Goals (SDGs). Although these build on the MDGs, proposing to achieve all the targets in progress, the SDGs go further. In terms of policy strategies and indicators, the SDGs define the latest status of sustainable development in practice and therefore provide the foundation for current research in this area. The objective is to establish a path of living that is sustainable by achieving 17 goals (including 169 targets), which range from “[e]nd poverty in all its forms everywhere” to “[s]trengthen the means of implementation and revitalize the global partnership for sustainable development”, and “[t]ake urgent action to combat climate change and its impacts” (United Nations, 2017). Action in crucial areas such as people, planet, prosperity, peace, and partnership are encouraged by the SDGs, while they “are integrated and indivisible and balance the three dimensions of sustainable development: the economic, social and environmental” (United Nations, 2017).[4]

The numbers of milestones, over the last decades, illustrate the diversity and various facets of sustainable development. As a consequence a complex framework emerges, which makes it challenging to develop adequate measures and combine them into one comprehensive framework. Nevertheless, numerous authors and researchers have sought to incorporate sustainable development or particular aspects of it, into one composite index. Table D.1 in the Appendix presents the most popular indices (Böhringer & Jochem, 2007; Gallego-Alvaerez et al., 2015; Moldan et al., 2012; Moran et al., 2008; Saisana & Philippas, 2012; Singh et al., 2012).

While these indices vary widely in terms of chosen aspects and theoretical foundations, we would like to highlight the Human Development Index, Sustainable Society Index, and Environmental Performance Index due to their importance, country coverage, and broad reach. Together they account for the three pillars of sustainability (Gallego-Álvarez et al., 2015; Moran et al., 2008; Saisana & Filippas, 2012). We would also emphasize the work of Hosseini &

[4] All 17 Sustainable Development Goals can be found in Appendix C.

Kaneko (2011) because they integrate four dimensions of sustainability in their analysis by adding the institutional one.

Human Development Index (HDI)
To measure the human development, the Human Development Index goes beyond the GDP (United Nations Development Programme, 2017). It contains three dimensions: "a long and healthy life, being knowledgeable and have a decent standard of living" (United Nations Development Programme, 2017). These dimensions are measured by life expectancy at birth, mean of years of schooling, expected years of schooling, and gross national income per capita. The final index is a geometric mean of the three dimensions (the two indicators of education are combined in the dimension being knowledgeable.). However, it must be noted that further important aspects, such as poverty, empowerment, inequalities, and human security, are not included in the standard HDI. Therefore, the United Nations Development Programme offers more composite indices that proxy additional fundamental issues.

Sustainable Society Index (SSI)
The foundation for the SSI is the Brundlandt definition with its three pillars. The SSI integrates environmental and human well-being, recognizing that economic well-being is an essential condition for human and environmental well-being to be achieved. The SSI "considered [it] as a safeguard to well-being" (Sustainable Society Foundation, 2016). Three dimensions (human, economic, and environmental well-being) establish the SSI with 21 indicators within the dimensions. The Joint Research Centre (JRC) of the European Commission audited the SSI in 2012 (Saisana & Filippas, 2012). They confirmed that it is conceptually coherent, the requirements of the JRC are met and "suited to assess nations' development towards sustainability in its broad sense: Human, Environmental and Economic Wellbeing" (Saisana & Filippas, 2012, p. 6).

Environmental Performance Index (EPI)
The EPI ranks the high-priority issues in the environmental performance of countries with two distinct objectives: protection of ecosystems and human health (Hsu et al., 2016). It provides an overview of the environmental performance of each nation and consequent support for decision makers. In its 15^{th} year, the EPI was launched by the World Economic Forum and provides further support for the achievement of the Sustainable Development Goals (20 indicators included in 9 areas). The indicators of the EPI measure the proximity of countries actual status to internationally agreed objectives. If there are no international targets that are agreed upon,

the indicators compare the nations in relation to each other (Hsu et al., 2016). All variables are normalized and range from zero to 100, while zero represents the greatest discrepancy to the objectives "100 [is] the closest" (Hsu et al., 2016, p. 28).

Hosseini and Kaneko (2011)
In their paper, Hosseini and Kaneko seek to access the dynamics of sustainability with selected macro sustainability indicators of a selected group of countries. They analyze sustainability with different indicators for the four dimensions (institutional, social, economic, and environmental). Their results show that there was progress in the economic, social, and institutional dimensions, while the environmental conditions worsened in the period under examination. Furthermore, they argue that when environmental, economic, and institutional dimensions are highly correlated, economic development alone is not sufficient to explain the worsening environmental dimension.

The Brundtland definition, with its three pillars, usually establishes the foundation for research in sustainable development (Böhringer & Jochem, 2007; Gallego-Álvarez et al. 2015; United Nations, 2017). Nonetheless, several authors have argued that having a single definition of sustainability is not desirable or even possible (Moldan & Dahl, 2007). Increasing understanding and experience must lead to a refinement of this dynamic concept (Mog, 2004; Moldan & Dahl, 2007; Shearman, 1990).

Recently there has been an increased emphasis on the fourth pillar - institutional - to be added to the other three (social, economic, and environmental). This fourth dimension is also referred to as "governance" or "democracy" (Meadowcroft, 2000). Such a view was embodied in the UN Commission on Sustainable Development's (CSD)'s proposals for Sustainable Development indicators (SDIs) to be divided into four pillars (Commission on Sustainable Development, 2001). The role of institutions is critical to implement other targets (social, economic, and environmental) and they are, therefore, recognized as a necessary part of sustainable development (Spangenberg, 2007; Waas et al., 2011). Already in "Our Common Future" there was a chapter containing proposals for institutional and legal change, along with the environmental and socio-economic chapters (World Commission on Environment and Development, 1987).

Some authors consider that the institutional dimension is already included in the social pillar. Other researchers believe in the advantage of defining it separately as a fourth pillar, as it reduces complexity and it can help identify and analyze possible trade-offs or complemen-

tarities among dimensions (Spangenberg, 2007, Hosseini & Kaneko, 2011, Waas et al. 2011). While discussing the goals of the Europe 2020 strategy, Pasimeni & Pasimeni (2016, p. 1036) suggest that "policy making should adopt a broader focus including the role of institutions".

As Waas et al. (2011) mention, whether there are three or four dimensions, it is necessary for every approach that the essential aspects of sustainable development are depicted. To account for intergenerational equity and dynamics, some scholars even add time variables to the model (Lozano, 2008). In the current work we define the four dimensions of sustainability following Waas et al. (2011, p. 1651 ff), who adopted it from Spangenberg (2004), "as a process of change":

- Institutional: change in the institution to combine the decisions in economics and environment, while ensuring the common interest via stronger public participation, at local and international level;
- Social: includes the concept of social justice to attain equality (for example, social groups and gender) in access to resources, welfare distribution, and opportunities;
- Economic: for a long-term satisfaction of the basic needs (energy, food, water, security, sanitation, consumption opportunities, and jobs) economic growth (long-term) represents the basis for creating welfare;
- Environmental: protection of the environment means to stay within the limits of the Earth's environment, while conserving and enhancing of the resource base provides an environmental long-term perspective.

The discussion on the right choice of sustainable development indicators is not limited to the question whether to use three or four dimensions. Some believe that all indicators are interconnected, and it is difficult to define a single indicator due to the multidimensional nature of sustainable development (United Nations, 2007). The SDG specific goals and targets "are integrated and indivisible and balance the three dimensions of sustainable development: the economic, social and environmental" (United Nations, 2017).

However, SDIs are very important regardless of the way they are grouped into dimensions since they measure global sustainability and also provide an assessment for each country (Hosseini & Kaneko, 2011). In 2003 Parris & Kates (2003) illustrated that over 500 quantitative sustainable development indicators had already been developed. Such indicators help communicate SD goals and track progress toward them at different levels of society, ranging from the general

population to politicians (McGlade, 2007). Additional aspects can be considered when picking SDIs. Bauler et al. (2007) presented five criteria to assess the quality of indicators: representativeness, measurability, communicability, reliability & feasibility, and purposefulness (Bauler et al., 2007).

One further challenge with Sustainable Development is that the time, until the impact of a measure can be felt, depends on the particular dimension (Karlsson et al., 2007): environmental effects tend to be long-range (e.g. climate change); economic implications, on the other hand, are noticeably much quicker (e.g. change in GDP); social effects range between these two extremes with short to medium-term impacts (e.g. poverty and education).
Using indicators for cross-country comparison is especially challenging. In 2007 Karlsson and colleagues presented guidelines for developing cross-country comparison indicators, while keeping in mind that there are specific indicators at local, regional, and national levels (Karlsson et al., 2007, p. 39):

- To select indicators, use a method that is unified and straightforward;
- The indicators selected should mirror targets for actions and facets of sustainable development that are commonly agreed upon;
- Indicators that are substantially affected by disparity in socioeconomic, cultural, and natural conditions should be avoided;
- The complete process should be transparent, ranging from the development of the indicators over the method and data collection to the presentation;
- The results should be validated by everybody who contributed to the process, and the results should be publicly available.

A final point regarding the selection of sustainable development indicators is the difference between strong sustainability and weak sustainability.[5] Weak sustainability means that natural resources can be depleted and destroyed without impairing the future as long as substitutes are found (Keohane, & Olmstead, 2007, p. 228; OECD, 2005). This paradigm is common among neoclassical environmental economists, who argue that the aggregate value of all types of productive capital stock should not be decreased, but rather maintained or in the best case even increased for future generations (Neumayer, 2012; Solow, 1991). This would mean, for instance, that "it does not matter whether the current generation uses up nonrenewable resources

[5] Appendix B includes the OECD definition.

or pollutes the environment as long as enough machinery, roads and ports, as well as schools and universities, are built in compensation" (Neumayer, 2013, p. 1). In other words degradation of natural capital could be offset by an equal amount of financial or manufactured capital (Pelenc & Ballet, 2015). It is assumed that technical progress provides solutions for the environmental problems associated with increasing production of services and goods (Ekins et al., 2003).

Other authors define an alternative concept known as strong sustainability (see among others Chiesura & de Groot, 2003; De Groot et al., 2003; Ekins et al., 2003; Neumayer, 2013). It is defended by ecological economists and generally implies that natural resource depletion should be avoided because no one knows whether they will be needed in the future or not (Keohane, & Olmstead, 2007, p. 228; OECD, 2005), and it may be impossible to provide adequate compensation for their depletion through investment in other forms of capital (Neumayer, 2012). The assumption of strong sustainability is that there are "critical" resources to human well-being that have an exclusive contribution to it (Chiesura & de Groot, 2003; Ekins et al., 2003). An example of critical resources can be seen in the supporting services provided by the ecosystem, based on natural capital, on which human survival depends (Brand, 2009).

However, a fair share of economists of all hues do not interpret this definition strictly, arguing that when a sustainable level of depletion is achieved (e.g., a limit to the level of tree felling) this also belongs to strong sustainability (Perman et al., 2003, p. 91ff). Not everything is substitutable but neither can all natural capital stocks remain untouchable. Furthermore, considering the above criteria of Karlsson et al. (2007) leads us to prefer a definition of weak sustainability for the choice of indicators for cross-country comparisons.

2.2 Competitiveness of nations and its precursors

The concept of the wealth of nations has undergone a steady evolution since classical political economist Adam Smith first mentioned it in 1776, relating it to available inputs. Over time the discussion has shifted toward the concept of competitiveness of nations (Garelli, 2006). In the 1990s Laura D'Andrea Tyson gave the most famous definition of competitiveness at that time: "competitiveness is our ability to produce goods and services that meet the best of international competition while our citizens enjoy a standard of living that is both rising and sustainable" (Krugman, 1994, p. 31). More recently, Rivkin (2015) notes that the competitiveness of the

United States of America (USA) can be seen as having two main goals: to "win global marketplace" (in terms of real GDP and company profits) and to "lift the living standards of the average American".

Different authors have discussed the reasons why some countries prosper while others fall behind (Browdin, 2016; Drucker, 1969; Krugman, 1991; Marx, 1909; Negroponte, 1995; Porter, 1990; Schumpeter, 1942; Sloan, 1963; Solow, 1957; Weber, 1905). The most important ideas on the competitiveness of nations are summarized in Table 2.1.

Table 2.1: Overview of the most influentials ideas on competitiveness

Name (year)	**Contribution**
Adam Smith (1776)	Four inputs: natural resources, land, labor, and capital
David Ricardo (1817)	Law of comparative advantage
Alfred Marshall (1890)	"[T]he concentration of specialized industries in particular localities"
Max Weber (1905)	Relationship between religion, values, economic performance, and beliefs of nations
Karl Marx (Marx, 1909)	Discussed the influence of sociopolitical environment on economic development: The change in political context, namely toward a communist system, should precede economic performance
Joseph Schumpeter (1942)	Highlighted: a factor of competitiveness is the role of the entrepreneur, due to the underlying disequilibrium and who facilitates technological improvement and innovation
Robert Solow (1957)	Studied the underlying factors for economic growth (US); highlighted relevance of increased know-how, education, and technological innovation
Alfred P. Sloan (1963) and Peter Drucker (1969)	Further development of the framework that management is an input which is key to competitiveness
Michael Porter (1990)	Aggregation of ideas into one systematic framework: "The Diamond of National Advantage"
Paul Krugman (1991)	Increasing Returns and Economic Geography
Paul Krugman (1994)	Productivity should be used instead of competitiveness for countries.
Nicholas Negroponte (1995) and numerous modern economists	Refinement of knowledge as a concept that represents the most current factor of input for competitiveness

The seminal work by Michael Porter in developing "The Diamond of National Advantage" (Porter, 1990) introduces an analytical framework to analyze the competitive performance of nations. In his work, Porter took out indicators that had been previously accepted for competitiveness, such as exchange rate, labor costs, bountiful natural resources, and economies of scale (Thore & Tarverdyan, 2016). He identified productivity instead as the "the true source of competitive advantage on the national level" (Thore & Tarverdyan, 2016, p. 108). The vast reach of his work can be seen in the fact that his fundamental idea was quickly incorporated into the primary textbooks for undergraduates in international business (Daniels & Radebaugh, 1994, pp. 190-2; Griffin & Pustay, 1995, pp. 96-9; Hill, 1994, pp. 137-41). However, there

is a spirited discussion on the use of such indicators and underlying concepts. Porter's framework, as summarized by Davies & Ellis (2000), has been criticized on methodological grounds and for not providing a clear definition of competitiveness, since he defined competitiveness as productivity, but investigated competitiveness in the sense of market share.

2.3 Productivity vs. competitiveness and current competitiveness indices

The concept of the competitiveness of nations has been a controversial subject over recent decades (e.g. Despotovic et al., 2015; Fagerberg et al., 2007; Krugman, 1994; Lall, 2001). For example, the definition itself seems to be a core theme of discussion in economics (Lall, 2001). The term comes originally from business-school literature, where it forms the basis for strategic analysis within firms. Companies compete against each other over resources and markets, and therefore profitability and market shares are analyzed to check for the competitiveness of enterprises and adopt strategies to improve their performance. However, the use of this approach for countries is not ideal. Although it could make sense to measure the competitive performance in some specific areas, e.g. in making computers or textiles the United States is more competitive (or less) than other countries, to argue that a whole nation is more or less competitive does not seem meaningful (Lall, 2001).

In theory, there is no commonly agreed conceptual definition of competitiveness of nations (Despotovic et al., 2015). In 1994 Krugman forcefully argued against the use of the term "competitiveness of nations" (Krugman, 1994). In his perspective, productivity should be used instead of competitiveness. Countries cannot go out of business as companies do; thus, the term competitiveness seems misplaced. Nonetheless, Krugman noted that the common use of the word in the business context makes it easily recognizable, thus helping to explain its popularity within economics. However, Krugman points out to the danger in the obsession with "competitiveness" and recommends caution.

Hay (2011, p. 463) discusses why "Paul Krugman's now-famous warnings as to the 'dangerous obsession' of competitiveness have fallen on deaf ears". First, there is a difference between Paul Krugman's assumption, what policy makers understand by competitiveness and what they do. Second, Krugman's criticism was too focused on the link between protectionism and competitiveness, which led him to ignore other important factors. For instance, he overlooks the problem of cost competitiveness, while in fact "[i]t is cost competitiveness specifically, rather

than competitiveness more generally, that is the dangerous obsession today" (Hay, 2011, p. 464). Fagerberg et al. (2007) present evidence that price competitiveness seems to be less necessary for development and growth than capacity[6] , technology, and demand competitiveness.

This discussion on whether productivity or competitiveness is the most appropriate concept for nations is ongoing. Atkinson (2013) questions the equivalence between productivity and competitiveness. In his perspective, productivity growth can influence competitiveness if it takes place in tradable sectors rather than non-tradable sectors (e.g., electric utilities, nursing homes, and grocery stores).

In the discussion of competitiveness, it is also important to mention the different levels at which competitiveness can take place and the factors influencing it. Usually, the literature distinguishes between macro- and micro-economic competitiveness (Despotovic et al., 2015), which can be divided into even more levels. For example, Kitson, & Tyler (2006) stated, that the most important aspect of the competitive phenomenon is the level (company, sector, region, national, and international competitiveness) at which it is observed. Despite the fact that these two main levels are different, competitiveness at the macro and micro level have a direct and strong relationship (Schwab & Porter, 2007). Considering the factors that affect competitiveness: in the 21^{st} century, innovation and intellectual capital are seen in recent research as essential elements for natural and corporate competitiveness (Costantini & Mazzanti, 2012; Rastogi, 2000; Grossman & Krueger, 1991; Nonaka, 1991).

A recent contribution to the debate of competitiveness at a national level is the Global Competitiveness Index (GCI) published annually by the World Economic Forum (WEF) (World Economic Forum, 2016). Thore & Tarverdyan (2016) describe the approach of the World Economic Forum as breaking competitiveness down "into its smallest component causal factors, calculating an overall index as an arithmetic weighted average of the values of the factors". The GCI is among the most influential indices that are widely used in the literature (Despotovic et al., 2015; Fonseca & Lima, 2015; Lall, 2001).[7] A possible explanation can be seen in the fact that leading researchers have been improving the GCI since its introduction by integrating the latest research, such as conceptual definitions or data sources for indicators, into

[6] Capacity competitiveness was used by Fagerberg et al. (2007) as an addition to price and technology competitiveness to account for the remaining aspects except demand competitiveness.

[7] For instance, a search for "World Competitiveness Report", "Competitive Industrial Performance Index", and "World Competitiveness Yearbook" on the Web of Science on January 11^{th} 2017 resulted in respectively 270, 51, and 36 articles.

the index. The World Economic Forum "define[s] *competitiveness as the set of institutions, policies, and factors that determine the level of productivity of an economy*, which in turn sets the level of prosperity that the country can achieve" (World Economic Forum, 2016, p 4). The GCI has received some criticism, e.g. Lall (2001) identified two main problems. First, there is the implicit assumption of efficient markets with a bias toward "market-friendly" policy intervention, which might be questionable, especially in developing markets with many market failures. Second, the GCI uses a comprehensive definition of the concept of competitiveness, which "diverts it from its legitimate focus on direct competition between countries, taking into areas where competitiveness analysis is both unwarranted and has little analytical advantage", e.g. "the transposition of concepts from business strategy to the national level does not work well: the results, in the end, looks fuzzy and confused" Lall (2001, p. 1519 ff). Additionally, Lall (2001) questions why the WEF uses qualitative interviews for areas in which hard data are already available.

Other important indices are the Competitive Industrial Performance Index (CIP) of the United Nations Industrial Development Organization (2016), and the IMD World Competitiveness Yearbook (WCY) of the International Institute for Management Development (2016). Each index has a different emphasis. The GCI focuses more on the "institutions, policies, and factors that determine the level of productivity of an economy" (World Economic Forum, 2016, p. 54), whereas "[t]he WCY analyzes and ranks how nations and enterprises manage the totality of their competencies to achieve increased prosperity." (The International Institute for Management Development, 2016, p. 484), and industrial competitiveness is benchmarked and assessed by UNIDO with their CIP by "building on a concept of competitiveness that emphasizes countries' manufacturing development, implying that industrial competitiveness is multidimensional" (United Nations Industrial Development Organization, 2016, p. 16).

The different focuses of the three indices can also be seen in the dimensions that each considers. In the GCI, twelve pillars combine 114 indicators in three sub-indices ("basic requirements, efficiency enhancers, and innovation and sophistication factors") (World Economic Forum, 2016, p. 55). The WCY includes over 340 criteria in four factors (Economic performance; Government efficiency; Business efficiency; and Infrastructure) and 20 sub-factors (The International Institute for Management Development, 2016). The CIP has eight sub-indicators and three dimensions (Capacity to produce and export manufacturers; Technological deepening and upgrading; and World impact).

The continuing discussion on the competitiveness of nations has been focused not only on whether competitiveness represents productivity and which index to use, but also on the development of new indicators (e.g., in the R&D sector it led to the development of the high-technology indicator) to help quantify countries' relative position (Godin, 2004). To attain in the future international competitiveness in the area of manufactured products (focus high-technology), researchers from the Georgia Institute of Technology developed indicators that monitor the national capacity to achieve this goal (Rossner et al., 1996). These new indicators give a broader perspective on the progress of the competitiveness of nations. Since 1987, the traditional Georgia Tech High Tech Indicators are used to compare every three years, 33 nations by their technological competitiveness. The latest report was published in 2008 (Porter et al.). The development of new indicators also facilitated the use of competitiveness indices.

Considering the definitions of Krugman (1994), Porter (1990), and the World Economic Forum (2016), this paper uses the same definition for competitiveness as the World Economic Forum (2016) due to the importance of this index and their definition that competitiveness equals productivity.[8]

2.4 Link between sustainability and competitiveness

Ever since competitiveness of nations was introduced, it has been clear that although economic aspects are important for the competitiveness of nations, social considerations are also required. This idea is explicit in Laura D'Andrea Tyson's definition as well as on the two main goals described by Rivkin (2015). As stressed by Sonntag (2000), social well-being is not ensured by competitiveness. She points out concerns regarding the unsustainable application of "current practices in the strategic use of advanced manufacturing technologies", due to an increase in the consumption of resources when market demand increases (Sonntag, 2000, p. 101).

Common perception suggests that the relationship between the sustainability and competitiveness may be negative, e.g., introducing or toughening regulations to enhance sustainability will harm competitiveness. For the United States, Jaffe et al. (1995, p. 159) suggest that differences in global environmental regulation do not justify a significant reduction of US environmental regulation, since there are "insufficient threats to US industrial competitiveness". Nevertheless,

[8] Note: this study focuses on the competitiveness of nations. Hence, competitiveness of regions, cities, and companies are not considered.

environmental (and social) regulations do tend to produce indirect and direct costs, and there is no proof that stricter regulations improve economic competitiveness. According to Jaffe and his colleagues, the truth lies somewhere in between these two extremes.

In 1993, Weis (1993) introduced the term "sustainable competitiveness". She joined the concepts of international competitiveness and sustainable development by focusing on economic growth and environmental protection to foster intergenerational equality. The terminology changed slightly over time, with the term "competitive sustainability" also gaining ground (e.g. "Europe 2020" strategy; Fonseca & Lima, 2015; Despotovic et al., 2015).[9]

Nonetheless, the relationship between sustainability and competitiveness is still insufficiently addressed (World Economic Forum, 2014). To contribute to this discussion, the World Economic Forum adapted its Global Competitiveness Index to create the Sustainability-adjusted Global Competitiveness Index (SGCI). It was defined to describe "the set of institutions, policies, and factors that make a nation productive over the longer term while ensuring social and environmental sustainability" (World Economic Forum, 2014, p. 55). The SGCI was published in the Global Competitiveness Report until 2014-2015[10]. Two different aspects are expressed by the World Economic Forum (2014):

- Productivity and competitiveness are interchangeable concepts. However, the framework of sustainable competitiveness is much broader, including crucial elements that go beyond economic facets to ensure "high-quality growth" [11];
- Attaining medium- and long-term growth is important for all nations. Despite that, the concept of sustainability demands an unceasing inquiry on whether we are creating the society in which we want to live.

Although the SGCI takes social, economic, and environmental concerns into account, the methodology can be questioned since it contradicts the idea underlying the Brundtland report that all pillars are equally important. In the SGCI, environmental and social components can

[9] The concept of Corporate Social Responsibility (CSR) is not covered in this work due to the focus on the country level.

[10] Today the WEF produces a separate report, the objective of which is the measurement of inclusive growth. Regarding the environmental aspects, the WEF established partnerships with CIESIN and YALE that provide them with a ranking of the countries that are most environmentally sustainable. Therefore, they no longer include the SCGI in their report. (Personal communication, November 1st, 2016).

[11] The WEF mentions for example "[e]fficient use of natural resources", "[c]arbon reduction", and "[i]mproved health" (World Economic Forum, 2014).

influence the index by only $\pm 20\%$. Nevertheless, the data of this index have also been used by other researchers, such as Thore & Tarverdyan (2016).

Several authors have approached features of the link between sustainability and competitiveness. Porter & van der Linde (1995) noticed a possible interaction between the environmental and economic dimensions. Berg & Ostry (2011) discussed the positive influence of social dimensions on the stable long-term growth of an economy. Their main results show that stable economic growth can be achieved by an equal income distribution, in spite of the countervailing effects of a wide redistributive policy within a country.

Fonseca & Lima (2015) studied the relationship between innovation, sustainability, and competitiveness at the national level. They used a correlation analysis of international indices to conclude that there is a high correlation between innovation, sustainability, and competitiveness. Dos Santos & Brandi (2014) examined the relationship between environmental indicators and competitiveness with a Canonical Correlation Analysis (CCA). In their analysis the GCI and its twelve pillars represent competitiveness and seven indicators from the EPI were used for the environmental dimension. Their results indicate a positive relationship (correlation) between competitiveness and environmental indicators.

Essentially, the concepts of sustainability and competitiveness have been well explored, but the links between them have not been thoroughly examined. Therefore, this master thesis focuses on the relationship between these two concepts, aiming to shed some light on their links in order to establish a solid foundation that can be brought to bear in policy recommendations.

Chapter 3

Methodology

The literature review leads to the development of two hypotheses, which are presented below along with the conceptual model underlying this thesis. The rest of this chapter addresses the statistical model (which will be applied to operationalize the conceptual model) and the indicator selection.

3.1 Hypotheses

The discussion of whether to use three pillars of sustainability or four is a considerable part of recent literature. Given the importance of the institutional dimension to implement goals for the other pillars, we hypothesize that:

H1: *Models including four dimensions (institutional, social, economic, and environmental) explain sustainability better than those with three dimensions (social, economic and environmental).*

The results from the World Economic Forum (2014) as well as from dos Santos & Brandi (2014) indicate that there is a positive relationship between competitiveness and (environmental) sustainability. Thus, we hypothesize that:

H2: *There is a positive relationship between sustainability and competitiveness.*

Figure 3.1 depicts the conceptual model underpinning this thesis. Sustainability is captured by four pillars (institutional, social, economic, and environmental). The competitiveness dimension co-varies with the sustainability dimension. Control variables are added to remove other influences from the analysis.

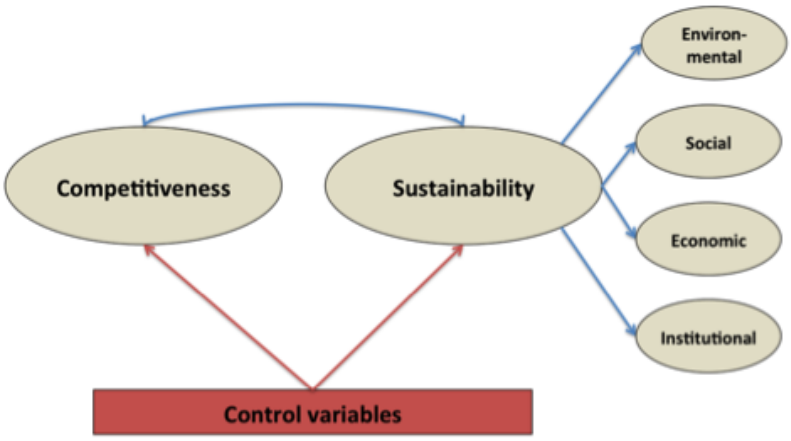

Figure 3.1: Conceptual model

3.2 Statistical model

A latent variable model (LVM) tests the conceptual model by measuring the distinct constructs using a set of indicators (observed indicators). These models, also known as structural equation models, covariance structure modeling, and causal modeling, are prevalent in different scientific fields because they join regression and factorial models into a single framework. The factorial component measures common latent variables from a set of indicators as neither sustainability nor competitiveness can be directly observed. Thus, the latent variable can be seen as a construct or true value without measurement error. The integration of factorial and regression models gives extreme flexibility to the LVM framework to conceptualize relationships between variables when the measurement is performed under error (Kline, 2011; Skrondal & Rabe-Hesketh, 2004).

A set of indicators is used to estimate each (first-order) latent variable. Let Y_{ij} represent the indicators of the five dimensions (Institutional, Social, Economic, and Environmental and Competitiveness). Now, assuming that a set of indicators measures a single dimension, they share a mutual latent factor (f_i). Thus, Institutional, Social, Economic, Environmental, and Competitiveness are first-order factors that are measured directly by indicators:

$$\boxed{Y_{ij} = \mu_j + \lambda_j f_i^{(h)} + \varepsilon_{ij}} \tag{3.1}$$

where Y_{ij} is vector for the indicators, μ_j is the mean of the indicator, λ_j is the factor loading of the latent ($f_i^{(h)}$), and ε_{ij} is the error term (with i = country and j = indicator). The variance of the error term ε_{ij} is σ_j^2. Apart from the first-order latent factors $f^{(h)}$ that represent Institutional, Social, Economic, Environmental, and Competitiveness, i.e., h=Inst, Soc, Eco, Env, and Comp, our conceptual model assumes a second-order factor called Sustainability that results from the four first-order dimensions - Institutional, Social, Economic, and Environmental - and is represented by $f^{(Sus)}$. The structural part of the model is given by

$$\boxed{\begin{bmatrix} f_i^{(Sus)} \\ f_i^{(Comp)} \end{bmatrix} \sim \mathrm{N}\left(\begin{bmatrix} E[f_i^{(Sus)}] \\ E[f_i^{(Comp)}] \end{bmatrix}, \begin{bmatrix} \sigma^2_{f^{(Sus)}} & \psi \\ \psi & \sigma^2_{f^{(Comp)}} \end{bmatrix} \right)} \tag{3.2}$$

where the joint factors follow a bivariate normal distribution with $E[f^{(Sus)}] = E[f^{(Comp)}] = 0$, and $f^{(Inst)} = \gamma_{Inst} f_i^{Sus} + \varepsilon_{Inst}$, $f^{(Soc)} = \gamma_{Soc} f_i^{Sus} + \varepsilon_{Soc}$, $f^{(Eco)} = \gamma_{Eco} f_i^{Sus} + \varepsilon_{Eco}$, $f^{(Env)} = \gamma_{Env} f_i^{Sus} + \varepsilon_{Env}$. Additionally, $\mathrm{Var}(\varepsilon_f) = \sigma_f^2$, and all factor are conditional independent, except $f_i^{(Sus)}$ and $f_i^{(Comp)}$ whose covariance is ψ. Thus, the expected value of a high order factor to the indicators through the first-order factor (Koufteros et al. 2009).[12] Sustainability covers therefore the four pillars defined by first-order factors.

In the conceptual model (represented in Figure 1) we have also added control variables (W_k). Thus, the Multiple Indicators Multiple Causes (MIMIC) structure of the model is given by:

$$\boxed{E[f^{(Sus)}] = \sum_k \beta_k^{Sus} W_{ik}} \tag{3.3}$$

$$\boxed{E[f^{(Comp)}] = \sum_k \beta_k^{Comp} W_{ik}} \tag{3.4}$$

Missing variables were omitted to estimate the model. The fit of the SEM is tested with the chi-square test. Given its sensitivity to sample size, further indices were applied: the Standardized Root Mean Square Residual (SRMR), the Tucker-Lewis Index (TLI), the Comparative Fit Index (CFI), and the Root Mean Square Error of Approximation (RMSEA).

A sequence of nested SEM is estimated to test the hypotheses: the first order measurement

[12] The first-order latent factors are measured by the indicators for each factor. The higher order latent factor (e.g. second-order factor) is estimated by the first-order factors, which are measured by the indicators. This means in our case that the four first-order factors (Institutional, Social, Economic, and Environmental) are used to estimate a second-order factor, which represents the sustainability dimension.

models are estimated separately, the second order measurement models and the structural models are based on jointly estimation of the involved equations. The fit of the model will be assessed by CFI, TLI, SRMR, RMSEA, and chi-square test. For the analysis six measurement models and three structural models were estimated. The seven measurement models represent the dimensions: Institutional, Social, Social2[13], Economic, Environmental, and Competitiveness as well as the second-order measurement model (Sustainability). The first structural model is Sustainability with controls; the second model is Competitiveness with controls, and the third model is Sustainability and Competitiveness combined in one model with a covariance between the two factors. Information criteria are used to compare the structural models: BIC - Bayesian Information Criterion (Schwarz, 1978), aBIC - Sample-size adjusted BIC (Sclove, 1987), and the AIC - Akaike Information Criterion (Akaike, 1974). Stata 13.0 was used for the estimation.

3.3 Indicator selection

The foundations for indicator selection are the Brundtland report[14] and the Sustainable Development Goals. The variables are chosen to best represent the corresponding sustainability (Institutional, Social, Economic, and Environmental) and Competitiveness dimensions considering the definitions provided in the literature review. Given that there were, even in 2003, already over 500 indicators available to represent sustainable development (Paris & Kates, 2003), the choice of variables is critical. We selected, for each of the four dimensions, frequently-used variables from the most popular sustainability indices, in particular, the Human Development Index (HDI), the Sustainability Society Index (SSI), and the Environmental Performance Index (EPI) (Gallego-Álvarez et al., 2015; Moran et al., 2008; Saisana & Filippas, 2012). These indicators are widely accepted in the literature and are based on solid foundations, thereby providing a comprehensive basis for our model. To include indicators of the fourth dimension (institutional), we also include the indicators of Hosseini & Kaneko (2011). Given its popularity, broad reach, comprehensive framework, and definition of competitiveness, the twelve pillars of the Global Competitiveness Index are used as indicators for the competitiveness di-

[13] Social2 includes all eleven indicators of the social and institutional dimension to create a new dimension "Social2", to test the first hypothesis, that is, to compare three and four pillars of sustainability.

[14] "In essence, sustainable development is a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development; and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations." (World Commission on Environment and Development, 1987, p. 43)

mension.[15] The countries of interest consist of 138 developing and developed countries (see Table E.1 in the Appendix for a detailed list of countries).

Three further selection criteria were applied[16]: First, data should be available from 2012 or later, to represent the most recent status. Second, some variables could be used to serve as an indicator for two dimensions, in which case we picked the dimension that is most closely associated with the variable. For instance, Renewable energy consumption could be included in the economic dimension given the important role of sustainable energy production. Nevertheless, we selected it for the environmental dimension because energy production is one of the main contributors to greenhouse gas emissions. Water pollution could be in the social pillar, due to its direct impact on people and their way of living. Still, we included it in the environmental dimension given the importance of polluted water on ecosystem health. Our choices coincide with the SSI classification. Third, since the GCI includes over 100 indicators (ranging from macroeconomic variables to executive opinion survey responses), we avoided using the same measure in any sustainability dimension.[17] For example, inflation is used in the GCI and is therefore not considered in the economic dimension of sustainability, thereby reducing a possible bias in the covariance. Indeed, the estimated covariance between sustainability and competitiveness could be artificially increased if the same indicators were used in both dimensions. This issue represents one of the main challenges of the data selection, due to the number of macroeconomic variables used in the GCI and the need to still describe the economic dimension properly.

To enhance the economic dimension in the face of the aforementioned issue, additional indicators of the World Bank have been included. However, it is impossible to completely avoid the use of similar variables. Therefore, after estimating the measurement models the relationship between the economic dimension and competitiveness will be further analyzed to check the strength of the influence via correlation of the factors.

Finally, three influences are controlled for in the model due to their (possible) crucial impact on both sustainability and competitiveness. The first is the countries' income (GNI per

[15] A search for "World Competitiveness Report" on the Web of Science on January 11^{th}, 2017 resulted in 270 articles.

[16] Hosseini & Kaneko (2011) build the foundation of the indicator selection. Here their approach is adapted to take the particular focus of this paper into account.

[17] Table F.1, including all variables of the GCI excluding the executive opinion survey items, can be found in Appendix.

capita), which provides the foundation to account for the different levels of development of the countries (see Moran et al., 2008). The second is whether the country is landlocked or not. Due to sea access, relevant aspects such as fisheries and easier access to cheap international transportation might appear (see e.g. Kashiha et al., 2016). The third is the region the country belongs to. It accounts for the fact that some areas share similar characteristics, due to common history (e.g. wars, cross-country partnerships, common kingdoms), trade agreements (e.g. European Internal Market and North American Free Trade Agreement), and cultural similarities (e.g. western world - Christianity). All variables have the World Bank definition as a foundation.

Table 3.1 depicts the indicators chosen for each dimension and their sources (including data time point).[18]

Table 3.1: Indicators of the distinct component of the model

Model component	**Indicator**	**Source (Data year)**
Institutional Dimension	Political rights	Freedom House, 2016 (2016)
	Civil liberties	(2016)
	Press freedom index	Reporters without Boarders, 2016 (2016)
	Voice and accountability	The World Bank Group, 2016 (2016)
	Political stability & absence of violence/ terrorism	(2016)
	Government effectiveness	(2016)
	Regulatory quality	(2016)
	Rule of law	(2016)
	Control of corruption	World Bank, 2016 (2016)
Social Dimension	Mortality rate, under-5 (per 1,000 live births)	(2015)
	Proportion of seats held by women in national parliaments (%)	(2014)
	Expenditure on education as % of total government expenditure (%)	(2012)
	School enrollment, primary and secondary (gross), gender parity index **	(2012)
	Sufficient Food (Number of undernourished people in % of total population)	Sustainable Society Foundation, 2016 (2016)
	Sufficient to drink (Number of people in % of total population, with sustainable access to an improved water source)	(2016)

[18] Note: Some variables needed a transformation to achieve a coherent theoretical dimension during the estimation process. A * indicates such a variable and Appendix Table G.1 gives a detailed description of the transformation. Further, due to lack of data (for some countries and some years), it was not possible to have the same base year for all indicators (especially world bank indicators). Therefore, we selected the year, having the most number of observations considering all years from 2012 - 2016. Another important aspect to mention is that some indicators of the indices are not listed here because they were already included in another index (to avoid a perfect correlation by having times the same indicator twice). Table H.1 in the Appendix presents the reasons why some variables were excluded *a priori* and the reason for the elimination during the estimation process (see also discussion in Chapter 4.1).

Table 3.1: Indicators of the distinct component of the model

Model component	Indicator	Source (Data year)
	Safe sanitation (Number of people in % of total population, with sustainable access to improved sanitation)	(2016)
	Education (Gross enrollment ratio for primary, secondary, & tertiary education (combined))	(2016)
	Healthy life (Life expectancy at birth in number of healthy life years)	(2016)
	Good Governance	(2016)
	Gender Equality	(2016)
	Income Distribution	(2016)
Economic Dimension	Gross national income (GNI) per capita*	United Nations Development Programme, 2017 (2016)
	Current account balance (% of GDP)	World Bank, 2016 (2013)
	Exports of goods and services (% of GDP)	(2014)
	Household final consumption expenditure, etc. (% of GDP)*	(2014)
	GDP per capita growth (annual %)	(2015)
	Cost of business start-up procedures (% of GNI per capita)	(2015)
	Foreign direct investment, net inflows (% of GDP)	(2015)
	Exports of goods and services (annual % growth)	(2013)
	External balance on goods and services (% of GDP)	(2014)
	Final consumption expenditure, etc. (% of GDP)	(2014)
	General government final consumption expenditure (% of GDP)	(2014)
	Industry, value added (% of GDP)	(2014)
	International tourism, expenditures (% of total imports)	(2014)
	Merchandise trade (% of GDP)	(2015)
	Military expenditure (% of GDP)	(2014)
	Organic Farming	Sustainable Society Foundation, 2016 (2016)
	Genuine Savings	(2016)
	Employment	(2016)
Environmental Dimension	Adjusted savings: carbon dioxide damage (% of GNI)	Wold Bank, 2016 (2014)
	Adjusted savings: energy depletion (% of GNI)	(2014)
	Adjusted savings: mineral depletion (% of GNI)	(2014)
	Adjusted savings: net forest depletion (% of GNI)*	(2014)
	Adjusted savings: particulate emission damage (% of GNI)*	(2014)
	Health Impacts	Hsu, A. et al., 2016 (2016)
	Air Quality	(2016)
	Water and Sanitation	(2016)
	Water Resources*	(2016)
	Agriculture	(2016)
	Forests	(2016)
	Fisheries	(2016)
	Biodiversity and Habitat	(2016)
	Climate and Energy	(2016)
	Biodiversity	Sustainable Society Foundation, 2016 (2016)
	Renewable Water Resources	(2016)
	Consumption*	(2016)
	Energy Use	(2016)
	Energy Savings	(2016)
	Greenhouse Gases*	(2016)
	Renewable Energy*	(2016)
Competitiveness Dimension	1st pillar: Institutions	World Economic Forum, 2016 (2016)

Table 3.1: Indicators of the distinct component of the model

Model component	**Indicator**	**Source (Data year)**
	2nd pillar: Infrastructure	(2016)
	3rd pillar: Macroeconomic environment	(2016)
	4th pillar: Health and primary education	(2016)
	5th pillar: Higher education and training	(2016)
	6th pillar: Goods market efficiency	(2016)
	7th pillar: Labor market efficiency	(2016)
	8th pillar: Financial market development	(2016)
	9th pillar: Technological readiness	(2016)
	10th pillar: Market size	(2016)
	11th pillar: Business sophistication	(2016)
	12th pillar: Innovation	(2016)
Control Variables	World region***	The World Bank Group, 2017 (2017)
	Landlocked	(2017)
	Income economies***	(2017)

Note: * are variables that are transformed during the estimation process, see detailed description in the Appendix Table G.1.

Note: ** used as equivalent for Ratio of girls to boys in primary and secondary education.

Note: *** Appendix I provides the exact definition of the World Bank for these two control variables.

Chapter 4

Results & Discussion

This chapter focuses on the presentation and discussion of the results. The first part includes a discussion of the indicator selection and the reasons why some variables were excluded from the analysis. The next subchapter includes the measurement models, followed by the structural models. Possible policy recommendations will conclude this chapter.

4.1 Indicators

Paris & Kates (2003) concluded that at the time they wrote there was no widely accepted set of indicators (for sustainable development) available. Their main arguments were that the indicators were not backed by a comprehensive theory, thorough data collection and analysis, and an explanation about the impact on policies. The discussion is still ongoing as can be seen in the selection of the indicators to measure the targets of the SDGs. The latest SDG progress report (2017) states that some targets are still not measurable due to lack of data, while others "are still undergoing methodological development" (United Nations Economic and Social Council, 2017, p. 2). To minimize this problem in our research we used indicators from indices (as the SSI, HDI, EPI, GCI) that are widely applied and discussed by various researchers (Böhringer & Jochem, 2007; Gallego-Álvarez et al., 2015; Moldan et al., 2012; Moran et al., 2008; Saisana & Filippas, 2012; Singh et al, 2009; Singh et al., 2012). The SSI, for example, is a solid tool (from a statistical point of view) that can be widely applied to environmental and human system analysis and it is an essential reference "to compare future progress and inform global society" (Gallego-Álvarez et al., 2015, p. 141).

The resulting indicators (see Table 3.1) established the foundation for the confirmatory factor analysis. However, some variables needed to be subsequently removed due to: insignificance (p-value > 0.1); low loadings (below < 0.45 / 0.5); negative sign (common standard of reliability includes no negative loadings)[19]; the need to simplify the model by deleting highly

[19] However, there might be a substantial reason to transform the scale of the data. If, for example, a high value of the indicator (the one with the negative loading) implies a positive effect for environment, whereas for all other indicators the lowest value implies a positive effect for the environment. Then, it makes sense to transform the scale of the indicator.

correlated variables; or other overlapping reasons (e.g. the SSI includes one indicator that is called Good governance that is measured by the same indicators used to estimate the institutional dimension). Table H.1 in the Appendix presents an overview of the reasons for the removal of variables.

Although gender equality and income distribution were excluded in the operationalized model due to insignificance or too low loadings of the indicators (social dimension), we have chosen to keep them in the analysis to account for their importance in the area of sustainable development (United Nations, 2017). The final results reveal no relationship between sustainability and gender equality and income distribution (see Figure J.1 and Figure J.2). First it needs to be acknowledged that gender equality is a process that takes a long time. For example in 1990 for every 100 boys, only 74 girls were enrolled in primary education in southern Asia (United Nations, 2017c). Twenty-two years later, in 2012, the enrolment ratio was equal. Or "[w]omen in Northern Africa hold less than one in five paid jobs in the non-agricultural sector. The proportion of women in paid employment outside the agriculture sector has increased from 35 per cent in 1990 to 41 per cent in 2015" (United Nations, 2017c). One-third of developing countries still lack gender parity in primary education (United Nations, 2017c) and "In sub-Saharan Africa, Oceania and Western Asia, girls still face barriers to entering both primary and secondary school." (United Nations, 2017c). Furthermore, the time to establish gender equality is long and even if it is achieved, there may be a time lag until its effects are seen. Hence, there needs to be more emphasis on gender equality and more effort to achieve it if the SDGs goals are to be achieved, and no one is to be left behind.

No relationship between income distribution[20] and sustainability can be explained by the fact that income distribution is also a crucial issue but it either needs time or reaches a certain threshold to manifest its impact. For example from 1990 to 2010 the income inequality for developing countries increased by 11% (on average) and there is evidence supporting the belief that if a certain threshold is reached the inequality can also harm (for instance) poverty reduction and economic growth (United Nations, 2017d).

[20] "This indicator assesses the level of equality of the distribution of income of the richest 10% to the poorest 10% of the people in a country. A low level of inequality is supposed to contribute to a stable society, whereas a high level of inequality provokes unrest or worse in a society" (Sustainable Society Foundation, 2016).

4.2 Measurement models

First-order measurement models

The first-order measurement models for the four dimensions of sustainability (Institutional = Inst, Social = Soc, Economic = Eco, Environmental = Env) and the competitiveness dimension (Comp) have a good or very good fit for the variance and covariance structure of the indicators analyzed (see Table 4.1). The measurement model Social2, on the other hand, shows a very weak model fit.

According to Kline (2005), a Standardized Root Mean Square Residual (SRMR) below 0.1 is considered favorable, which is fulfilled by all first-order measurement models except Social2 = Soc2. Hu & Bentler (1999) recommend a CFI higher than 0.9 (good model fit), which is fulfilled for Inst, Soc, Eco and Env with respectively 0.992; 0.993; 0.993 and 0.978. The value for Comp (0.865) is close to 0.9 while that for Soc2 (0.806) is lower. The Tucker-Lewis Index (TLI) is also in the favorable area for Inst, Soc, Eco, and Env. Comp is a slightly less than the recommended threshold of 0.9 and Soc2 has again a low value with 0.749. The RMSEA (Root Mean Square Error of Approximation) with values of 0.064; 0.073 and 0.092 for respectively Soc, Eco and Env are within the recommended threshold of below 0.1 (Brown, 2015; Harrington, 2008; Schumacker & Lomax, 2010; Whitley et al., 2013). Inst is slightly above the threshold, with a value of 0.105. Comp and Soc2 are, regarding RMSEA, also above the recommended limit.

All measures of goodness of fit for Soc, Eco, and Env are in accordance with the literature. The dimension Inst is only slightly above the recommended values in the RMSEA, but given that the other values are within, the goodness of fit can still be accepted. For the Comp dimension, some values are within the recommendation while others are not. Nevertheless, the World Economic Forum established a solid theoretical foundation for the twelve pillars of the WCI, and thereby the substantial arguments lead to an acceptance of the dimension. The model fit of dimension Soc2 is poor, with all values outside of the recommended threshold. Therefore it can be said that the indicators of each dimension (except Social2) have an underlying common factor that we call: Inst = Institutional factor, Soc = Social factor, Eco = Economic factor, Env = Environmental factor, and Comp = Competitiveness factor.

The factors of the five first-order measurement models (Inst, Soc, Eco, Env, and Comp) are

Table 4.1: Goodness of Fit - Measurement models

	Inst	**Soc**	**Soc2**	**Eco**	**Env**	**Comp**	**Sus**
Chi-Square	17.633	12.246	448.061	3.267	16.68	319.307	632.867
DoF (chi2_ms)	7	8	51	2	8	51	201
RMSEA	0.105	0.064	0.244	0.073	0.092	0.201	0.138
CFI	0.992	0.993	0.806	0.993	0.978	0.865	0.85
TLI	0.982	0.988	0.749	0.979	0.96	0.825	0.828
AIC	1019.847	2387.644	3526.925	3968.644	3529.778	2336.727	9225.09
BIC	1078.392	2442.273	3639.058	4002.094	3583.818	2448.561	9426.917
SRMR	0.01	0.019	0.12	0.022	0.042	0.063	0.083

measured by respectively: six, six, four, six and twelve indicators - with significant standardizing loadings ranging from 0.472 to 0.989, which indicate a very strong correlation between indicators and factors. To ensure the reliability of the construct, the factor loading (each indicator) should ideally be >= 0.7 but >= 0.5 is also considered acceptable (e.g. Hair et al., 2014). The tables (including factor loadings, standard errors, p-values, and exact descriptions of each dimension) can be found in the Appendix (see Table K.1 - Table K.5). Additionally, we added covariances between specific indicators used to measure Inst, Soc and Comp because the relationship between the added indicators is stronger than the one provided by the common factor.[21] That is, Inst = covariances between *Voice and accountability* and *Political stability & absence of violence/terrorism*, and *Regulatory quality* and *Control of corruption*; Soc = covariance between *Sufficient food* and *Sufficient to drink*; Comp = covariance's between *1st pillar: Institutions* and *7th pillar: Labor market efficiency*; *4th pillar: Health and primary education* and *5th pillar: Higher education and training*; and *11th pillar: Business sophistication* and *12th pillar: Innovation*.

Institutional dimension

The institutional pillar is well represented by its statistically significant indicators as they express Worldwide Governance Indicators (WGI) (World Bank, 2017a). The greatest impact (highest factor loading) is found for Rule of law, which represents the confidence that agents have in rules (i.e. property rights, contract enforcement, the likelihood of violence and crime, courts, and police) (World Bank, 2017b), thereby establishing the foundations of any society. On the other hand, the weakest impact is for Political stability & absence of violence/terrorism, a variable that captures the perception of the probability of "political instability and/or politically-motivated violence, including terrorism" (World Bank, 2017c). This can severely damage a nation (through direct harm or indirect effects such as reduction of foreign direct investment because of uncertainty) and is therefore important (Li & Resnick, 2003). Yet even when there is political instability in a country, the Rule of law (e.g. property rights) of

[21] See Appendix L for a more general example, why we added covariances.

that country might still be in place. This may explain the low impact of Political stability & absence of violence/terrorism on the institutional pillar compared to the other variables.

Social dimension

For a life in dignity (and an equal basis for welfare distribution) people need at least to have enough to eat, enough water, safe sanitation, education, and overall a healthy life (see United Nations, 2016b). All the corresponding indicators are, indeed, statistically significant. Population growth and Sufficient food have the lowest factor loadings of all social variables. One possible reason for the low loading of population growth is the worldwide tendency for a reduction in Population growth. In 2005, world population growth was 1.24%, but in 2015 it was only 1.18% (United Nations, 2015b). The unexpected low loading of Sufficient food is surprising as one expects a higher impact due to the importance of food as a basic human need. The indicator measures the "number of undernourished people in % of total population" and "is defined as the availability of at least the minimum level of dietary energy for each person" (Sustainable Society Foundation, 2016). One possible explanation can be seen in the data itself (see Figure 4.1). The majority of countries achieve the highest value (10), with a mean of 9.23 (Std. Dev. = 1.14761) and the lowest value of 4.66. Another possible explanation can be that although food is essential for survival, water and safe sanitation are more critical. A person can survive for weeks without food but only a few days without water (see Packer, 2017; Lieberson, 2017). As it was stated in the last progress report of the SDGs (United Nations Economic and Social Council, 2017, p 6) "[a] major risk factor for infectious diseases and mortality is the lack of safe water, sanitation and hygiene (WASH) services" and "[a]ccess to safe water and sanitation and sound management of freshwater ecosystems are essential to human health and to environmental sustainability and economic prosperity." (United Nations Economic and Social Council, 2017, p. 8). These arguments are supported by the high loadings of Sufficient to drink and Safe sanitation (the latter has the highest loading of all social indicators).

Economic dimension

The statistically-significant indicators represent the economic dimension in a proper manner, as they are standard indicators for an economy: GNI per capita (PPP $), Current account balance (% of GDP), Exports of goods and services (% of GDP), and Household final consumption expenditure (% of GDP). These indicators represent respectively, average national income on a comparative basis (PPP), whether the economy is a net lender or borrower to the rest of the world, how much of the GDP is exported, and how much the private households actually spend (or the counterpart: how much they save) (United Nations Development Programme, 2017;

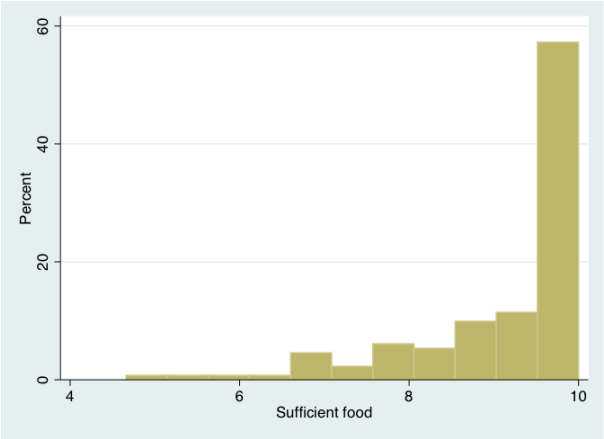

Figure 4.1: Sufficient food

World Bank, 2017). GNI per capita has the highest factor loading within the economic pillar. Taking into account that the GNI per capita is also often used to illustrate the income situation of the people within an economy it seems plausible that this aggregated indicator has the highest loading. Exports of goods and services (% of GDP) has the lowest factor loading, possibly because exports represent a single aspect of an economy, unlike the GNI per capita which takes into account the whole economy.

As mentioned in chapter 4.1 Indicator selection, we tried not to use the same indicators that are already used in the GCI framework. However, that was not always possible. Two indicators of the economic dimension coincide with the indicators used in the GCI framework. To test the effect of this circumstance on the model, we calculated the correlations between the economic and competitiveness dimensions (see Table 4.5). The correlation between the two dimensions is 0.718. For a better understanding of this correlation in the context of this study, we also calculated the correlations between each of the other first-order measurement models and the competitiveness dimension. The results reveal that a high correlation between each first-order measurement dimension and the competitiveness dimension is normal. Still, it must be noted that the correlation between the economic and the competitiveness dimension is the lowest of all correlations. Taking into account also that the economic dimension represents only one of the four factors that measure the sustainability dimension (second-order measurement model), the effect of the two indicators can be neglected and the model can be used as it is.

Environment dimension[22]

The environmental dimension includes statistically significant indicators to account for the different facets of the environment, i.e. climate change, resource use, renewable energy, consumption, and water pollution. Greenhouse gases (CO_2 emissions per person per year) and Adjusted Net Savings: particular emission damage account for climate change. The latter one expresses "the willingness to pay to avoid mortality and morbidity attributable to particulate emissions" (United Nations, 2017a). Adjusted net savings: net forest depletion[23] account for a sustainable depletion of resources. The indicator Renewable energy measures how much of the energy consumption in % of total consumption is produced by renewables. Water resources measures "the proportion of wastewater from households and industrial sources that is treated before it is released into the environment" (Hsu et al., 2016). The indicator Consumption is a proxy (for consumption), as it subtracts the carbon footprint from the ecological footprint (Sustainable Society Foundation, 2016). It has to be noted that the carbon footprint is, however, already integrated into the indicator Greenhouse gases. This fact may explain the low loading (lowest in the environmental dimension) of the indicator Consumption. Water resource, on the other hand is the indicator with the highest loading. A possible explanation can be seen in the fact that good water treatment is necessary to preserve water "ecosystem health, to protect local residents from waterborne disease vectors, and to ensure that clean water is available for reuse" (Hsu et al., 2016). Therefore, good management of wastewater treatment is crucial for countries, especially considering climate change and population growth.

Competitiveness dimension

In our results, all pillars of the World Competitiveness Index (WCI) are statistically significant. The twelve pillars of the WCI were also used by Thore & Tarverdyan (2016) to analyze sustainable competitiveness. This can be attributed to the rigorous theoretical framework underlying the index. The indicator Market size has the lowest loading. This includes the Domestic market size index; Foreign market size index; GDP (PPP); and Exports as a percentage of GDP (World Economic Forum, 2016). A possible explanation is that the indicator Market size in itself is less important than other factors such as the infrastructure of a country (which has the highest loading). For example, the SDGs Progress report 2017 states that "[e]fficient transportation services generate employment and wealth and drive economic development" (United Nations

[22] Recall that all environmental variables are transformed except Water resources, see therefore Table G.1 in the Appendix.

[23] "Net forest depletion is the product of unit resource rents and the excess of roundwood harvest over natural growth" (United Nations, 2017a).

Economic and Social Council, 2017, p. 11), highlighting air travel, which contributed to 3.5% of global GDP in 2015. This underscores the importance of Infrastructure for competitiveness (and can explain that this indicator has the highest loading), due to the transportation possibilities for people and goods (decent roads, sea access, or train network), and thereby facilitating trade. In this sense, different researchers show that trade liberalization encourages economic growth (e.g. Harrison, 1996; Mustafa et al., 2017; Onafowora & Owoye, 1998).

Second-order measurement models (Sustainability)

The second-order measurement model (Sus) (including the dimensions Inst, Soc, Eco, and Env) shows a good model fit (see Table 4.1). CFI and TLI are close to 0.9, RMSEA is slightly above the recommended threshold and the SRMR is, at 0.083, below the recommended limit. Thus, the factors of the dimensions (Inst, Soc, Eco, and Env) underline a common factor that we call Sustainability factor.[24]

The second-order measurement model, including Social2, Economic and Environmental, shows convergence problems, probably caused by the poor model fit of Social2. Therefore, it is not possible to use the results of the estimation, and it can be concluded that the model does not suitably represent sustainability. These results support our first hypothesis, that sustainability is better represented by four pillars rather than three.

The Sustainability factor is measured by four dimensions - Institutional, Social, Economic and Environmental - with significant standardized loadings ranging from 0.517 to 0.992 (Table K.6 Appendix), which shows a very strong correlation between indicators and the factor. In particular, the loadings of the factors Inst, Soc, Eco and Env on the Sustainability factor are very high and statistically significant at a 1% level with respectively, 0.793; 0.927; 0.779; and 0.992. Additionally, we added covariances between: Inst = covariances between *Voice and accountability* and *Political stability & absence of violence/terrorism*, and *Regulatory quality* and *Control of corruption*; Soc = covariance between *Sufficient food* and *Sufficient to drink*; as the relationship between each of the two indicators is stronger than the one provided by the common factor.

[24] Same reasoning as for the factors of the indicators for each dimension.

4.3 Structural models

Model 1 (sustainability with controls, MIMIC 1)

The control variables were included in the model (reference categories were: not being landlocked, Europe and Central Asia, and Low Income) and stepwise eliminated if they were insignificant. Omitted variables are: East Asia-Pacific, Middle East / North Africa, North America, and Landlocked.

The goodness of fit of the sustainability dimension decreased slightly by controlling for world regions and income level (significant control variables), in particular, RMSEA (0.14), CFI (0.790), TLI (0.766) and SRMR (0.098) (Table 4.2). The model can still be accepted with an SRMR below 0.1 and all other values close to the threshold.

Significant controls are Latin America and Caribbean, Sub-Saharan Africa, South Asia, Lower middle income, Upper middle income, and High income. Three factor loadings of the four dimensions decreased slightly after including control variables in the model: Inst from 0.793 to 0.778, Eco from 0.779 to 0.776 and Env from 0.992 to 0.963, whereas the loading for Soc increased from 0.927 to 0.958 (see Table K.6 and Table K.7 Appendix). Some loadings included in the four dimensions remained the same (e.g. Voice and accountability or Regulatory quality), while others decreased (e.g. Consumption and Healthy Life) or increased (e.g. Safe sanitation and Renewable energy).

Table 4.2: Goodness of Fit - MIMIC models and Sus and Comp without controls

	MIMIC 1 (Sus with controls)	**MIMIC 2 Comp with controls (similar to Sus controls)**	**MIMIC 3 Comp with controls (individual controls)**	**Sus and Comp without controls**
Chi-Square	1048.475	624.967	492.396	1912.055
DoF (chi2_ms)	327	117	106	515
RMSEA	0.140	0.183	0.167	0.158
CFI	0.790	0.786	0.829	0.737
TLI	0.766	0.748	0.797	0.714
AIC	9339.782	2610.503	2411.337	10609.563
BIC	9557.973	2739.542	2537.508	10916.376
SRMR	0.098	0.079	0.066	0.098

Model 2 (competitiveness with control variables, MIMIC 2 and MIMIC 3)

Two different sets of control variables were used to assess competitiveness. The first set represents the same control variables that were used for the sustainability dimension (Latin America / Caribbean, Sub-Saharan Africa, South Asia, Lower middle income, Upper middle income, and High income) resulting in model MIMIC 2 (see Table K.8 Appendix). Model MIMIC 3 (see Table 4.3) included all (primary) control variables initially, with a stepwise elimination of the statistically insignificant ones, which yielded a different set of controls (East Asia-Pacific, North America, Lower middle income, Upper middle income, and High income). The difference between the two sets of control variables is the inclusion of different world regions. Nevertheless, the control variables of both MIMIC models are statistically significant at a 10% level, except of South Asia in MIMIC 2.

In general, by including the control variables, the Goodness of Fit of both models decreased in respect to CFI, TLI, and SRMR compared to the original competitiveness dimension without controls, whereas the RSMEA increased slightly in both cases (see Table 4.2). From a statistical point of view (Goodness of Fit), then, MIMIC 3 is better than MIMIC 2. However, models must also be compared with the information criteria (AIC and BIC). This comparison reveals that MIMIC 3 is even better than MIMIC 2 with respectively, AIC = 2411.337 and BIC = 2537.508 compared to AIC = 2610.503 and BIC = 2739.542. Therefore MIMIC 3 is selected and used from now on without further explicit mention.

The inclusions of control variables resulted in a decrease of some loadings and an increase in others (Table 4.3,).

For a true representation of the dimensions, it is also important to control for other influences. With this in mind, we controlled for income economies, landlocked, and world regions. In the first MIMIC (1) model the significance and negative loadings of the regions Latin America and Caribbean, South Asia, and Sub-Saharan Africa can be explained by the fact that these three regions still need to improve essential aspects of human survival before they can concentrate on the whole concept of sustainability. As the Progress Report of the SDGs illustrates, Sub-Saharan Africa still has great room for improvements: in 2013, 42% of people still lived in extreme poverty (less than 1.90$ per day) compared to a world average of 11%. “The mortality rate for children under 5 years of age globally was 43 deaths per 1,000 live births in 2015”, while in Sub-Saharan Africa it was almost twice that (United Nations Economic and Social

Table 4.3: Competitiveness with (individual) controls (MIMIC 3)

Dimension	Indicators	Coefficient	S.E.
Competitiveness	1st pillar: Institutions	0.818***	0.028
	2nd pillar: Infrastructure	0.957***	0.008
	3rd pillar: Macroeconomic environment	0.529***	0.062
	4th pillar: Health and primary education	0.787***	0.032
	5th pillar: Higher education and training	0.914***	0.014
	6th pillar: Goods market efficiency	0.873***	0.021
	7th pillar: Labor market efficiency	0.656***	0.049
	8th pillar: Financial market development	0.736***	0.039
	9th pillar: Technological readiness	0.956***	0.009
	10th pillar: Market size	0.474***	0.067
	11th pillar: Business sophistication	0.910***	0.015
	12th pillar: Innovation	0.864***	0.022
Controls	East Asia-Pacific	0.190***	0.046
	North America	0.085*	0.046
	Lower middle income	0.196***	0.071
	Upper middle income	0.484***	0.068
	High income	1.064***	0.056

Note: *** p-value < 0.01; ** p-value <0.05; * p-value <0.1

Council, 2017 p. 5). The HIV new infection rate was also five times higher than globally "with 1.5 new infections per 1,000 uninfected people in 2015" (United Nations Economic and Social Council, 2017, p. 5). Sub-Saharan Africa and South Asia account for the highest percentage of children under 5 years old with stunted growth.[25] Both regions "accounted for three quarters of the children under 5 with stunted growth in 2014" worldwide (United Nations Economic and Social Council, 2017 p. 4). Latin American countries also demonstrate the need for improvements in regard to education and homicide rates. In Latin America and Sub-Saharan Africa, "fewer than half of the students at the end of primary education had attained minimum proficiency levels in mathematics" (United Nations Economic and Social Council, 2017, p. 7). Over the past decade, the global rate of homicide victims per 100,000 people fell whereas there are countries in Latin America and Sub-Saharan Africa where it increased (United Nations Economic and Social Council, 2017, p. 16). This can explain the negative impact of these regions on sustainability. The significant positive loadings of lower middle, upper middle and high-income economies demonstrate that being one of these countries has a positive effect on sustainability. Generally, essential human needs are already provided and these countries can, therefore, focus on all aspects of sustainability. For the environmental dimensions, in particular, it is useful to refer to the Environmental Kuznets Curve hypothesis, which indicates that pollution rises with an increasing level of development only up to a certain point, decreasing thereafter (inverted u-shape relationship) (see Atkinson et al., 2007, p. 240 ff.; Perman et al., 2003, p. 36 ff.).

[25] "Stunting is defined as inadequate height for age, an indicator of the cumulative effects of undernutrition and infection." (United Nations Economic and Social Council, 2017 p. 4)

Considering the competitiveness model with controls (MIMIC 3): the lower middle, upper middle, and high-income economies are also positive and significant. A possible explanation is that with higher income the twelve pillars of competitiveness of the GCI are also higher, e.g. good infrastructure, good education, and high GDP, thereby creating a competitive edge for these nations.[26]

Model 3 (sustainability and competitiveness without controls)

The structural model containing the second-order measurement model Sus and the first-order measurement model Comp, has a good model fit, given the complexity of the model with an SRMR below 0.1, and RMSEA, CFI, and TLI slightly above the threshold. The standardized loadings are all significant and range between 0.473 and 0.990. The covariances of the measurement models were also added to the model.[27]

Compared to the second-order measurement model, adding Comp and the covariance between Sus and Comp leads to a change in the factor loadings: Env (from 0.992 to 0.900) and S (from 0.927 to 0.863) decreased whereas Eco (from 0.779 to 0.806) and I (from 0.793 to 0.900) increased (Table 4.4, Table K.7). Some loadings of the single factors changed slightly, e.g. GNI p.c. increased, Renewable energy decreased but Political stability & absence of violence/terrorism stayed the same. The covariance between Sus and Comp is statistically significant and positive with 0.969, indicating a positive relationship between the two dimensions. The relationship between sustainability with controls and competitiveness with controls is tested by taking the scores of both MIMIC models (1 and 3) and correlating the corresponding values. Figure 4.2 shows a scatterplot with the scores[28] of each model (MIMIC 1 and 3). The correlation is positive with 0.859 (see Table 4.5). The scores of both dimensions, sustainability and competitiveness without controls, leads to a correlation of 0.845 so that the correlation increases by controlling for world regions and income level. Therefore the second hypothesis is supported, namely, we find a positive relationship between sustainability and competitiveness,

[26] The world regions East Asia-Pacific and North America are now the significant variables. This can be attributed to the fact that in Asia they have the competitive edge of cheap labor and a good infrastructure (e.g. see China) compared to other countries (e.g. South Sudan), which adds a positive impact on the competitiveness of these countries. Regarding North America, considering the time points of the data, the e.g. USD was comparatively low to the Euro and thereby possibly providing a competitive edge due to lower prices in foreign currencies (XE, 2017).

[27] Table M.1, Appendix provides an overview of the covariances between the single dimensions.

[28] The description of the calculation method can be found in Appendix N.

Table 4.4: Without controls, Sustainability and Competitiveness

Dimension	Indicators	Coefficient	S.E.
	Institutional	0.900***	0.023
	Social	0.863***	0.032
	Economic	0.806***	0.040
	Environmental	0.900***	0.029
Institutional	Voice and accountability	0.783***	0.037
	Political stability & absence of violence/terrorism	0.771***	0.039
	Government effectiveness	0.973***	0.006
	Regulatory quality	0.948***	0.011
	Rule of law	0.990***	0.003
	Control of corruption	0.971***	0.006
Social	Sufficient Food	0.699***	0.052
	Sufficient to Drink	0.844***	0.031
	Safe Sanitation	0.920***	0.019
	Education	0.856***	0.029
	Healthy Life	0.923***	0.018
	Population Growth	0.642***	0.059
Economic	Gross national income (GNI) per capita	0.960***	0.024
	Current account balance (% of GDP)	0.703***	0.052
	Exports of goods and services (% of GDP)	0.503***	0.076
	Household final consumption expenditure, etc. (% of GDP)	0.748***	0.049
Environmental	Adjusted savings: net forest depletion (% of GNI)	0.579***	0.067
	Adjusted savings: particulate emission damage (% of GNI)	0.783***	0.041
	Water Resources	0.908***	0.022
	Consumption	0.592***	0.066
	Greenhouse Gases	0.846***	0.031
	Renewable Energy	0.734***	0.049
Competitiveness	1st pillar: Institutions	0.823***	0.033
	2nd pillar: Infrastructure	0.947***	0.011
	3rd pillar: Macroeconomic environment	0.521***	0.071
	4th pillar: Health and primary education	0.803***	0.036
	5th pillar: Higher education and training	0.931***	0.014
	6th pillar: Goods market efficiency	0.874***	0.024
	7th pillar: Labor market efficiency	0.617***	0.061
	8th pillar: Financial market development	0.689***	0.052
	9th pillar: Technological readiness	0.958***	0.010
	10th pillar: Market size	0.473***	0.076
	11th pillar: Business sophistication	0.904***	0.019
	12th pillar: Innovation	0.868***	0.025
Covariance	Cov: Sustainability and Competitiveness	0.969 ***	0.015

Note: *** p-value < 0.01; ** p-value <0.05

both with and without controls.

Our results support the hypothesis that sustainability is better represented by four pillars than by three, given our model and empirical variables. These results are in line with authors who argue that the social dimension is divided into an institutional and a social dimension (see Commission on Sustainable Development, 2001; Hosseini & Kaneko, 2011; Spangenberg, 2007; Waas et al., 2011). One possible explanation can be found in Rindermann et al. (2015). They state that good governance is crucial for the wealth of nations due to its role in shaping economic and political institutions, which affects the performance of the economy. Thus institutions play an "independent" (own pillar) role in sustainable development. The EU also emphasizes

good governance and even has principles that should guide the policies to achieve it. These principles range from "open and democratic society" and "involvement of citizens" to "make polluters pay" (Eurostat, 2015). During the *International Workshop on Governance* "of" and "for" Sustainable Development Goals researchers discussed the possibility of including governance as an own SDG, but there was no consensus on its function and meaning (regarding the context of SDG) (Kanie et al., 2014). Nevertheless, the importance of governance to achieve the SDGs was highlighted.

We recognize that it is challenging to define the concept of sustainability, as mentioned in the Literature Review. We are not claiming that a four-pillar representation is the only correct view of sustainable development. For a dynamic process such as sustainable development, it is important to be open-minded and seek to include as many different opinions as possible. Robinson (2004, p. 375) states: "[w]hile intellectually frustrating from the point of view of science, this may be the appropriate approach in the messy world of the politics and policies of sustainable development. In other words, the lack of definitional precision of the term sustainable development may represent an important political opportunity".

As noted in Fonseca & Lima (2015), research on the relationship between sustainability and competitiveness at a national level is rare. Nevertheless, the results of this study are in line with other authors (e.g. Fonseca & Lima, 2015; dos Santos & Brandi, 2014; Weis, 1993) in pointing toward a positive relationship between sustainability and competitiveness, including the models with and without controls. Fonseca & Lima (2015) illustrate "a high correlation between social sustainability, innovation, and world competitiveness", and dos Santos & Brandi (2014) indicate a positive relationship between competitiveness and environmental sustainability.

There are grounds for policy recommendations that are based on the results of this thesis at different levels:

Table 4.5: Correlation of the different models

	Score Inst	**Score Soc**	**Score Eco**	**Score Env**	**Score Sus**	**Score MIMIC 1**
Score Comp	0.882	0.762	0.718	0.798	0.845	0.821
Score MIMIC 2	0.885	0.801	0.730	0.830	0.878	0.862
Score MIMIC 3	0.885	0.797	0.729	0.828	0.875	0.859

First, at a country level, additional investment in public infrastructure projects would establish a better foundation for country competitiveness, since the pillar infrastructure has the highest loading in MIMIC 3 and the second highest in the model "Without controls, Sustain-

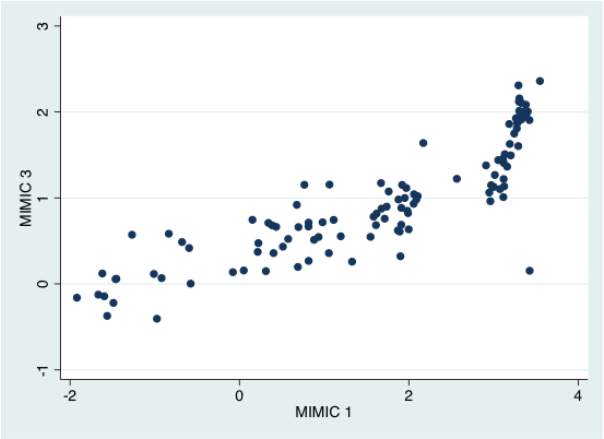

Figure 4.2: Scatterplot MIMIC 1 and MIMIC 3

ability (Sus) and Competitiveness" for the competitiveness dimension. However, all projects, including the current ones, ought to be assessed in terms of their impact, to ensure that all investment is efficient. Additionally, an improvement of the educational system, as well as measures to increase the expected age at birth would further increase the sustainable competitiveness of the country, as these two factors are among the highest loadings in the social pillar.

Second, at a bilateral level, provide technical support and knowledge transfer to countries that are challenged with achieving safe sanitation, sufficient water to drink and proper wastewater treatment. The water resources indicator has the highest loading in MIMIC 1 and "Without controls, Sustainability (Sus) and Competitiveness" in the environmental pillar, whereas, sufficient to drink and safe sanitation are among the highest loadings in the social pillar. These efforts can take place at an international level, while the author supports the view that bilateral agreements including company cooperation achieves good results in a shorter amount of time.

Third, at a bilateral and international regional level, foster agreements and support that lead to an increase of GNI p.c. This can include, for example, reduction of trade barriers and knowledge transfer. Since GNI p.c. has the highest loading in the economic pillar in all models.

Fourth, at an international level, increase the efforts to establish the rule of law in countries that are still lacking (emphasis on developing countries), since rule of law has the highest loading throughout the models in the institutional pillar. This includes more support from international organizations such as the United Nations and other non-governmental organizations, as a lack of rule of law is an indication that the country is having serious problems and needs outside support.

Chapter 5

Conclusion

Although the literature about sustainability and competitiveness, taken separately, is vast, the interconnection between these two goals has not been well explored at a national level. This master thesis contributes to the discussion by exploring the relationship between sustainability and competitiveness using data for 138 countries. We further tested whether, given our empirical data, three pillars or four of sustainability provide a better representation of the concept.

The master thesis presents three major contributions. First, it provides further empirical support for the four-dimensional sustainability approach, compared to the more traditional three-dimensional definition. Our results reveal the importance of institutions as an independent pillar. Second, a new methodological model is applied in the area of competitive sustainability (MIMIC model). The results of the MIMIC model strengthen the concept of competitive sustainability and increase the robustness of it, due to the confirmation of the model in another statistical context. Further, the interdisciplinary understanding of the topic is increased with the MIMIC model, given that latent variable models are often applied in social sciences such as management and psychology.[29] Third, the derived policy recommendations can lead to a positive shift toward a more sustainable path of development. By integrating the policy recommendations, each dimension of competitiveness and sustainability is strengthened, and therefore the overall competitive sustainability is increased.

In this thesis, we decided to use the term competitive sustainability, which is in line with the European Union. However, this choice is not entirely value-neutral. Note the difference between "sustainable competitiveness" and "competitive sustainability": do countries want to compete sustainably or do they want to be sustainable in a way that retains their productivity/competitiveness? We choose the latter as we think it is crucial that countries take a long-term view, with sustainability first and foremost, while we reject the notion, implicit when the focus is on competitiveness, that some countries can benefit only at others' expense. Globally, development is not a zero-sum game.

[29] This may enhance the interdisciplinary understanding of the concept of competitive sustainability of a broader community (especially social science), because they have a good understanding of the statistical model and the application of it in another context, resulting in a facilitated comprehension of this paper and concept of sustainable competitiveness.

A limitation of our method is the inherent subjectivity in the indicator selection and attribution to a particular dimension. New insights and data may arise in the future that lead to a new selection of indicators for each dimension. Further research could use, for example, the SDGs indicators to model the sustainability dimensions, which is currently not possible due to many missing data or methodological issues (see United Nations Economic and Social Council, 2017). Various authors mention that sustainable development is not a static but rather a dynamic process (Baumgartner, 2011; Thore & Tarverdyan, 2016), which represents the third limitation of this study, as its focus is on cross-sectional data. Further research can extend this study by looking at competitive sustainability from a longitudinal perspective. This could lead to even deeper insights regarding how competitive sustainability has developed over the years, thereby showing which countries performed best and highlighting ideas on how the most competitive countries have progressed, potentially helping other nations to follow a similar path.

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Appendix A

Publications sustainability

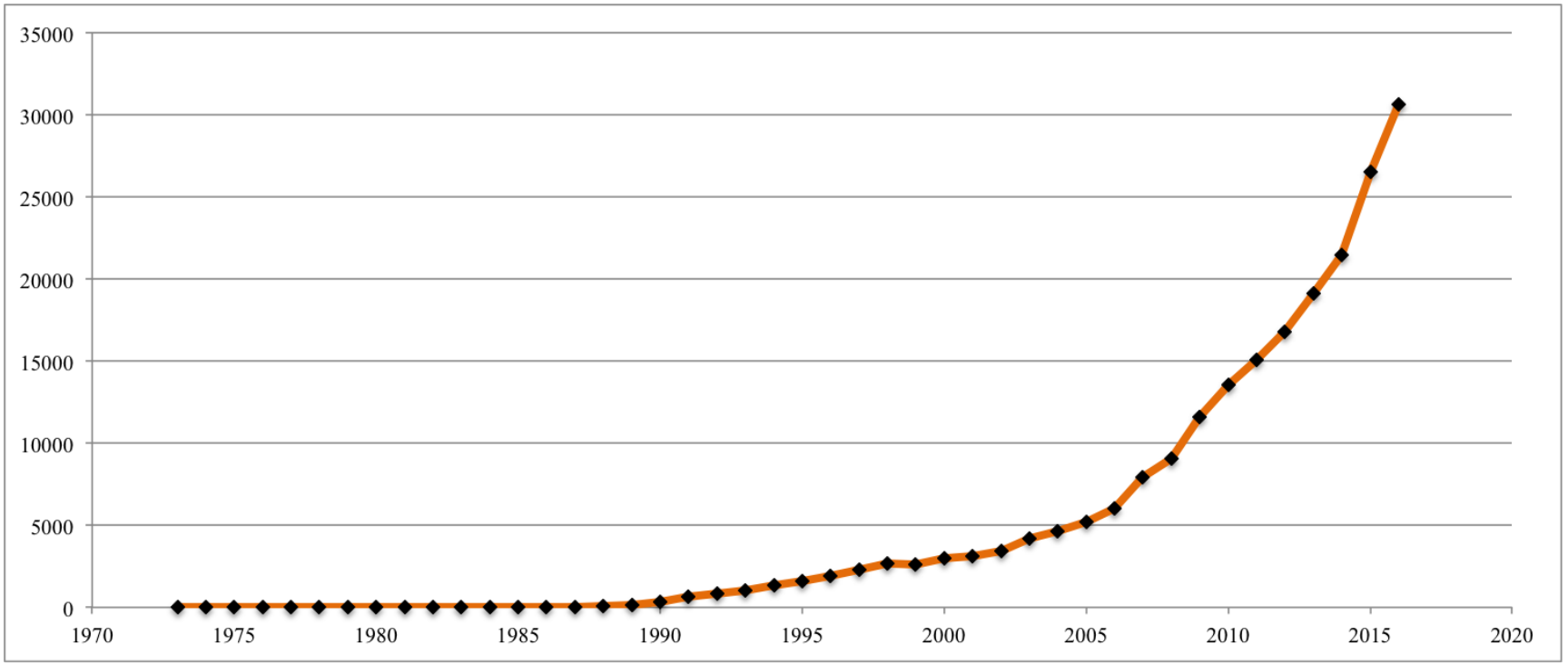

Figure A.1: Publications on sustainability

Source: Web of Science (2017)

Appendix B

Strong and weak sustainability definition according to the OECD glossary

Weak sustainability:
"All forms of capital are more or less substitutes for one another; no regard has to be given to the composition of the stock of capital. Weak sustainability allows for the depletion or degradation of natural resources, so long as such depletion is offset by increases in the stocks of other forms of capital (for example, by investing royalties from depleting mineral reserves in factories)"

Source: OECD (2005)

Strong sustainability:
"All forms of capital must be maintained intact independent of one another. The implicit assumption is that different forms of capital are mainly complementary; that is, all forms are generally necessary for any form to be of value. Produced capital used in harvesting and processing timber, for example, is of no value in the absence of stocks of timber to harvest. Only by maintaining both natural and produced capital stocks intact can non-declining income be assured."

Source: OECD (2005a)

Appendix C

Sustainable Development Goals

Goal 1. End poverty in all its forms everywhere
Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture
Goal 3. Ensure healthy lives and promote well-being for all at all ages
Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
Goal 5. Achieve gender equality and empower all women and girls
Goal 6. Ensure availability and sustainable management of water and sanitation for all
Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all
Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
Goal 10. Reduce inequality within and among countries
Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable
Goal 12. Ensure sustainable consumption and production patterns
Goal 13. Take urgent action to combat climate change and its impacts
Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development
Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
Goal 17. Strengthen the means of implementation and revitalize the global partnership for sustainable development

Source: United Nations (2016a)

Appendix D

Overview of the most popular sustainability indices

Table D.1: Overview of the most popular sustainability indices

Sustainability indices	What is measured	Limitation	Website	Year
Index of Sustainable Economic Welfare (ISEW)	The main purpose of the ISEW is to measure economic activities (and its components) in the light of what leads to the welfare of the society. It is intended to replace GDP. (Daly & Cobb Jr., 1989)	Important facets of the quality of life are not included; also, the index does not provide an overview of the country sustainability level. Besides, the ISEW is not available for the majority of countries.	—	1989*
Human Development Index (HDI)	To measure the human development, the Human Development Index goes beyond the GDP. It contains three dimensions: "a long and healthy life, being knowledgeable and have a decent standard of living". (United Nations Development Programme, 2017)	The facets covered by the HDI of sustainable development are not complete, and critics say that the HDI is redundant in regard to inter-country development due to little additional new information.	http://hdr.undp.org/en/content/human-development-index-hdi	1990 - 2016
Genuine Progress Indicator (GPI)	This index goal is similar to the ISEW. The GPI includes following components of economic activity: costs of environmental degradation, public non-defensive expenditures, personal consumption, capital formation, and private defensive expenditures. (Redefined Progress, 1995)	Similar to ISEW	http://rprogress.org/sustainability_indicators/genuine_-progress_indicator.htm	*1995
Wellbeing of Nations	All facets of sustainability are covered. The index consists of ecosystem and human well-being indexes. (OECD, 2001)	The amount of data that are provided is enormous, which leads to a very complex construct, and it was only published once.	http://www.oecd.org/site/worldforum/33703 702.pdf	2001*
Environmental Sustainability Index (ESI)	The idea behind the ESI is to measure environmental sustainability and its progress towards it. The ESI includes: reducing stresses, social and institutional capacity, environmental systems, global stewardship, and reducing human vulnerability. (Yale Center for Environmental Law + Policy - YCELP - Yale University, Center for International Earth Science Information Network - CIESIN - Columbia University, World Economic Forum - WEF, & Joint Research Centre - JRC - European Commission. (2005))	Gender equality is not mentioned, and a further important aspect of good governance receives too little attention. Due to the high amount of data used, the transparency can be questioned.	http://sedac.ciesin.columbia.edu/data/ collection/esi/	2000*
Sustainable Society Index (SSI)	The SSI is very comprehensive in regard to sustainable development including the three pillars of the Brundtland definition (social, economic and environmental). (Sustainable Society Foundation, 2016)	The main drawback of the index is subjectivity associated with: "assumptions made in estimating the measurement error in data", "the choice of imputation algorithm", "the choice of weights", "the choice of aggregation system"	Gallego - Álvarez et al. (2015) http://www.ssfindex.com/ssi/ssi-2016/	2006 - 2016
Environmental Performance Index (EPI)	The EPI ranks the environmental high priority issue performance of countries with two distinct objectives: protection of ecosystems and human health. It provides an overview of the environmental performance of each nation. (Hsu et al., 2016)	The broad context of sustainable development is not covered. Measurement outcomes are on indicators (e.g. deforestation rates and emissions) and not policy input.	http://epi.yale.edu	2006*
Commitment to Development Index (CDI)	21 wealthy countries are analyzed in regard to the support they provide poor countries, in areas as good governance, promote prosperity and security. The CDI includes trade, migration, security, aid, investment, technology, and environment. (Center for Global Development, 2015)	Only 21 countries are assessed and sustainable development is only partially covered.	https://www.cgdev.org/commitment-development-index	2015

Table D.1: Overview of the most popular sustainability indices

Sustainability indices	What is measured	Limitation	Website	Year
Ecological Footprint (EF)	The EF measures the consumption of a person (recreation, energy, food, mobility, house, among others) and calculates what is needed to produce it, expressing the result and in terms of the area required on earth (hectare per capita). (Global Footprint Network, 2016)	It helps to give a quick overview about how sustainable the society in terms of resource use. Nevertheless, sustainability in the broader sense of sustainability is not covered.	Global Footprint Network http://www.footprintnetwork.org/our-work/ecological-footprint/	2016
Living Planet Index	The biological diversity of the world is measured by the index. Its foundation is "population trends of vertebrate species from terrestrial, freshwater and marine habitats." (WWF, 2016)	Broader aspects of sustainable development are neglected as it only focuses on one aspect.	http://www.livingplanetindex.org/home/index	2016
Environmental Vulnerability Index (EVI)	50 indicators build the foundation of the index to evaluate how vulnerable the environment of a country is given a future shock. (SPOCA, & United Nations Environment Program, 2005)	The index focuses only on the environmental vulnerability of a country, the broader context of sustainability is missing. However, in combination with social and economic vulnerability indices, it provides a good, comprehensive overview.	http://www.vulnerabilityindex.net	2005

Note: * first published

Appendix E

Country list

Table E.1: Country list

Albania	Cote d'Ivoire	Iran, Islamic Rep.	Mongolia	Singapore
Algeria	Croatia	Ireland	Montenegro	Slovak Republic
Angola	Cyprus	Israel	Morocco	Slovenia
Argentina	Czech Republic	Italy	Mozambique	South Africa
Armenia	Denmark	Jamaica	Namibia	Spain
Australia	Dominican Republic	Japan	Nepal	Sri Lanka
Austria	Egypt, Arab Rep.	Jordan	Netherlands	Suriname
Azerbaijan	El Salvador	Kazakhstan	New Zealand	Swaziland
Bahrain	Estonia	Kenya	Nicaragua	Sweden
Bangladesh	Ethiopia	Korea, Rep.	Nigeria	Switzerland
Barbados	Finland	Kuwait	Norway	Tajikistan
Belgium	France	Kyrgyz Republic	Oman	Tanzania
Bhutan	Gabon	Lao PDR	Pakistan	Thailand
Bolivia	Gambia, The	Latvia	Panama	Trinidad and Tobago
Botswana	Georgia	Lebanon	Paraguay	Tunisia
Brazil	Germany	Lesotho	Peru	Turkey
Bulgaria	Ghana	Lithuania	Philippines	Uganda
Burkina Faso	Greece	Luxembourg	Poland	United Arab Emirates
Burundi	Guatemala	Macedonia, FYR	Portugal	United Kingdom
Cambodia	Guinea	Madagascar	Qatar	United States
Cameroon	Guyana	Malawi	Romania	Uruguay
Canada	Haiti	Malaysia	Russian Federation	Venezuela, RB
Cabo Verde	Honduras	Mali	Rwanda	Vietnam
Chad	Hong Kong SAR, China	Malta	Saudi Arabia	Yemen, Rep.
Chile	Hungary	Mauritania	Senegal	Zambia
China	Iceland	Mauritius	Serbia	Zimbabwe
Colombia	India	Mexico	Seychelles	
Costa Rica	Indonesia	Moldova	Sierra Leone	

Appendix F

Global competitiveness indicators

Table F.1: Global competitiveness indicators (no executive survey items included, edition 2016/17)

Dimension GCI	Name
1.21	Strength of Investor Protection Index on a 0 - 10 (best) scale
2.06	Airline seat kilometers (in millions) available on all flights (domestic and international service) originating in country per week (year average)
2.08	Number of mobile-cellular telephone subscriptions per 100 population
2.09	Number of fixed-telephone lines per 100 population
3.01	General government budget balance as a percentage of GDP
3.02	Gross national savings as a percentage of GDP
3.03	Annual percent change in consumer price index (year average)
3.04	Gross general government debt as a percentage of GDP
3.05	Institutional Investor's Country Credit Ratings^{TM} assessing the probability of sovereign debt default on a 0-100 (lowest probability) scale
4.01	Estimated number of malaria cases per 100,000 population
4.03	Estimated number of tuberculosis cases per 100,000 population
4.05	HIV prevalence as a percentage of adults aged 15 - 49 years
4.07	Infant (children aged 0 - 12 months) mortality per 1,000 live births
4.08	Life expectancy at birth (years)
4.1	Net primary education enrollment rate
5.01	Gross secondary education enrollment rate
5.02	Gross tertiary education enrollment rate
6.05	This variable is a combination of profit tax (% of profits), labor tax and contribution (% of profits), and other taxes (% of profits)
6.06	Number of procedures required to start a business
6.07	Number of days required to start a business
6.1	Trade-weighted average tariff rate
6.14	Imports of goods and services as a percentage of gross domestic product
7.04	Redundancy costs in weeks of salary
7.1	Ratio of women to men in the labor force
8.08	Degree of legal protection of borrowers' and lenders' rights on a 0 - 12 (best) scale
9.04	Percentage of individuals using the Internet
9.05	Fixed-broadband Internet subscriptions per 100 population
9.06	International Internet bandwidth (kb/s) per Internet user
9.07	Active mobile-broadband subscriptions per 100 population
10.01	Sum of gross domestic product plus value of imports of goods and services, minus value of exports of goods and services, normalized on a 1 - 7 (best) scale
10.02	Value of exports of goods and services, normalized on a 1 - 7 (best) scale
10.03	Gross domestic product valued at purchasing power parity in billions of international dollars
10.04	Exports of goods and services as a percentage of gross domestic product
12.07	Number of applications filed under the Patent Cooperation Treaty (PCT) per million population

Source: World Economic Forum (2016)

Appendix G

Transformed variables

Table G.1: Transformed variables

Variable	Transformation	Reason
Gross national income (GNI) per capita	Y1= Yo/1000	Adjustment of the value to the other indicators.
Household final consumption expenditure, etc. (% of GDP)	Y1= J - Yo	The inclusion of household final savings (% of GDP).
Adjusted savings: net forest depletion (% of GNI)	Y1= J - Yo	A decrease in the value of Waster resources results in a positive effect on the environment. For Adjusted savings: net forest depletion it is the opposite, a high value is positive.
Adjusted savings: particulate emission damage (% of GNI)	Y1= J - Yo	A decrease in the value of Waster resources results in a positive effect on the environment. For Adjusted savings: particulate emission damage (% of GNI)it is the opposite, a high value is positive.
Consumption	Y1= J + 1 - Yo	A decrease in the value of Waster resources results in a positive effect on the environment. For Consumption it is the opposite, a high value is positive.
Greenhouse gases	Y1= J + 1 - Yo	A decrease in the value of Waster resources results in a positive effect on the environment. For Greenhouse gases it is the opposite, a high value is positive.
Renewable energy	Y1= J + 1 - Yo	A decrease in the value of Waster resources results in a positive effect on the environment. For Renewable energy it is the opposite, a high value is positive.

Note: J = max value; Y1 = new value; Y0 = old value

Appendix H

Reasons for elimination of the variables in the estimation process

Table H.1: Reasons for elimination of the variables in the estimation process

Dimension	Name	Insignificant	Low loadings	Negative sign	Improve model fit	Others
Institutional*	Political rights			x		
	Civil liberties			x		
	Press freedom index			x		
Social	Mortality rate, under-5 (per 1,000 live births)			x		
	Proportion of seats held by women in national parliaments (%)	x				
	Education indicators from the HDI					Included in the SSI
	Life expectancy					Included in the GCI
	Expenditure on education as % of total government expenditure (%)		x			
	School enrollment, primary and secondary (gross), gender parity index		x			
	Good Governance					Included in the Institutional pillar
	Gender Equality		x			
	Income Distribution		x			
Economic	Foreign direct investment, net inflows (% of GDP)	x				
	Genuine Savings					Household final consumption is included (highly correlated, deleted)
	International tourism, expenditures (% of total imports)	x				
	Employment	x				
	Merchandise trade (% of GDP)		x			
	Military expenditure (% of GDP)		x			
	Exports of goods and services (annual % growth)		x			
	Organic Farming		x			
	General government final consumption expenditure (% of GDP)		x			
	Genuine Savings		x			
	Cost of business start-up procedures (% of GNI per capita)		x			
	Industry, value added (% of GDP)		x			
	External balance on goods and services (% of GDP)				x	
Environmental	EH - Air Quality	x				Redundant (SSI and EPI)
	Renewable Water Resources	x				Redundant (SSI and EPI)
	Fisheries	x				
	Climate and Energy	x				
	Forests	x				
	Adjusted savings: carbon dioxide damage (% of GNI)	x				
	Adjusted savings: energy depletion (% of GNI)	x				
	Renewable Water Resources		x			
	Adjusted savings: mineral depletion (% of GNI)		x			
	Energy Use		x			
	Biodiversity		x			
	Biodiversity and Habitat		x			
	Agriculture		x			

Table H.1: Reasons for elimination of the variables in the estimation process

Dimension	Name	Insignificant	Low loadings	Negative sign	Improve model fit	Others
	Air Quality		x			
	Health Impacts				x	
	Water and Sanitation				x	
	Energy Use				x	

Note: * The three eliminated variables had an opposite sign compared to all other institutional variables and were therefore removed.

Appendix I

Definition of control variables by the World Bank

I.1 Income economies

"Each year on July 1, the World Bank revises the analytical classification of the world's economies based on estimates of gross national income (GNI) per capita for the previous year. The updated GNI per capita estimates are also used as input to the World Bank's operational classification of economies that determines lending eligibility. As of 1 July 2015, low-income economies are defined as those with a GNI per capita, calculated using the World Bank Atlas method, of $1,045 or less in 2014; middle-income economies are those with a GNI per capita of more than $1,045 but less than $12,736; high-income economies are those with a GNI per capita of $12,736 or more. Lower-middle-income and upper-middle-income economies are separated at a GNI per capita of $4,125."

Source: World Bank (2017)

I.2 Regions

"Please note: Regions in this table include economies at all income levels. The term country, used interchangeably with the economy, does not imply political independence but refers to any territory for which authorities report separate social or economic statistics. Click here for information about how the World Bank classifies countries."

Source: World Bank (2017)

Appendix J

Figures MIMIC 1 and gender equality / income distribution

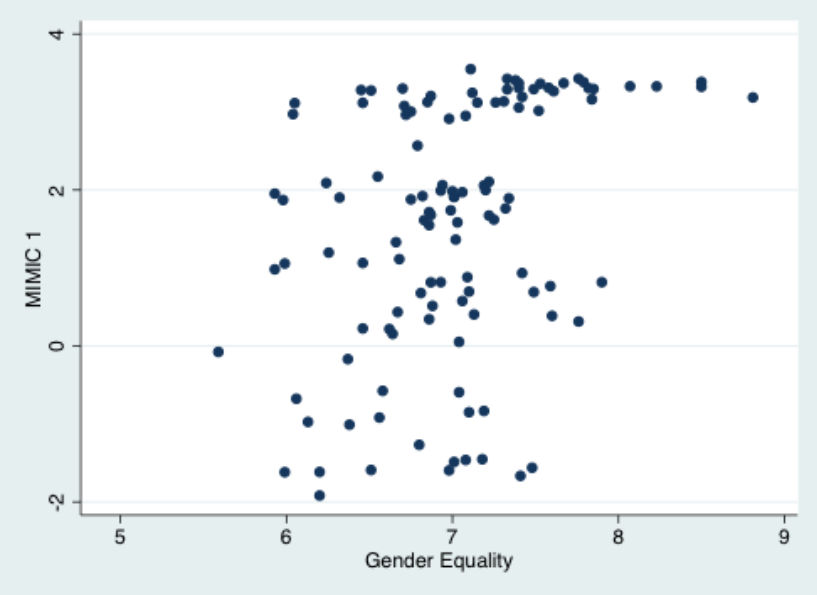

Figure J.1: MIMIC 1 and gender equality

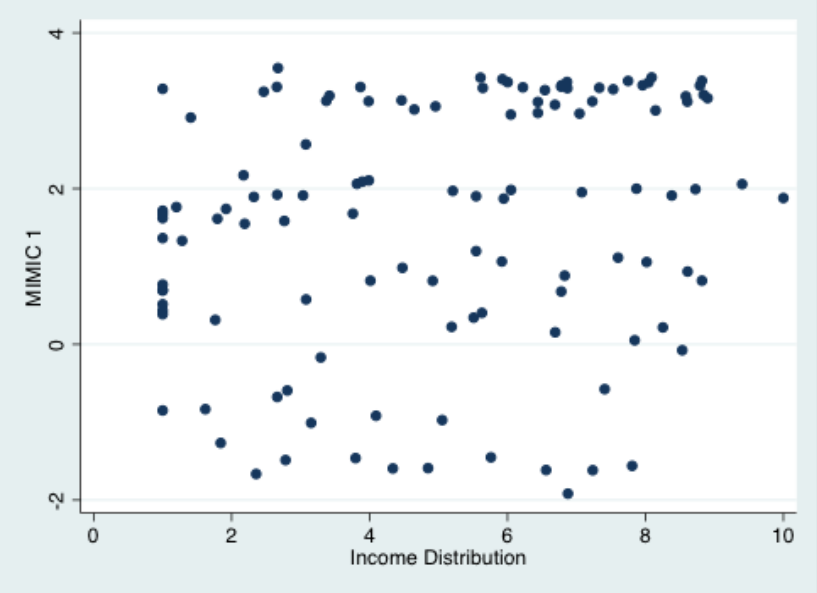

Figure J.2: MIMIC 1 and income distribution

Appendix K

Measurement and structural models

K.1 Measurement model: Institutional

Table K.1: Institutional dimension

Indicators	Coefficient	S.E.
Voice and accountability	0.777***	0.034
Political stability & absence of violence/terrorism	0.767***	0.035
Government effectiveness	0.964***	0.007
Regulatory quality	0.948***	0.010
Rule of law	0.989***	0.003
Control of corruption	0.970***	0.006

Note: *** p-value < 0.01

Institutional factor is measured by six indicators - Voice and accountability, Political stability & absence of violence/terrorism, Government effectiveness, Regulatory quality, Rule of law, and Control of corruption - with significant standardizing loadings ranging from 0.767 to 0.989 (Table K.1), which shows a very strong correlation between indicators and the factor. Additionally, we add a covariance's between *Voice and accountability* and *Political stability & absence of violence/terrorism*, and *Regulatory quality* and *Control of corruption* as the relation between the two indicators is stronger than the one provided by the common factor.

K.2 Measurement model: Social

Table K.2: Social dimension

Indicators	Coefficient	S.E.
Sufficient food	0.702***	0.047
Sufficient to drink	0.843***	0.028
Safe sanitation	0.927***	0.017
Education	0.840***	0.029
Healthy life	0.926***	0.017
Population growth	0.702***	0.047

Note: *** p-value < 0.01

The Social factor is measured by six indicators - Sufficient food, Sufficient to drink, Safe sanitation, Education, Healthy life, and Population growth - with significant standardizing loadings ranging from 0.702 to 0.927 (Table K.2), which shows a very strong correlation between

indicators and the factor. Additionally, we add a covariance between covariance between *Sufficient food* and *Sufficient to drink* as the relation between the two indicators is stronger than the one provided by the common factor.

K.3 Measurement model: Economic

Table K.3: Economic dimension

Indicators	Coefficient	S.E.
Gross national income (GNI) per capita	0.893***	0.040
Current account balance (% of GDP)	0.751***	0.050
Exports of goods and services (% of GDP)	0.512***	0.074
Household final consumption expenditure, etc. (% of GDP)	0.767***	0.050

Note: *** p-value < 0.01

Economic factor is measured by four indicators - Gross national income (GNI) per capita (HDI), Current account balance (% of GDP), Exports of goods and services (% of GDP), and Household final consumption expenditure, etc. (% of GDP) - with significant standardizing loadings ranging from 0.512 to 0.893 (Table K.3), which shows a very strong correlation between indicators and the factor.

K.4 Measurement model: Environmental

Table K.4: Environmental dimension

Indicators	Coefficient	S.E.
Adjusted savings: net forest depletion (% of GNI)	0.576***	0.063
Adjusted savings: particulate emission damage (% of GNI)	0.741***	0.044
Water resources	0.891***	0.025
Consumption	0.575***	0.065
Greenhouse gases	0.843***	0.031
Renewable energy	0.815***	0.037

Note: *** p-value < 0.01

Environmental factor is measured by six indicators - Adjusted savings: net forest depletion (% of GNI), Adjusted savings: particulate emission damage (% of GNI), Water resources, Consumption, Greenhouse gases, and Renewable energy - with significant standardizing loadings ranging from 0.575 to 0.891 (Table K.4), which shows a very strong correlation between indicators and the factor.

K.5 Measurement model: Competitiveness

Table K.5: Competitiveness dimension

Indicators	Coefficient	S.E.
1st pillar: Institutions	0.843***	0.028
2nd pillar: Infrastructure	0.948***	0.012
3rd pillar: Macroeconomic environment	0.538***	0.064
4th pillar: Health and primary education	0.763***	0.039
5th pillar: Higher education and training	0.897***	0.020
6th pillar: Goods market efficiency	0.895***	0.020
7th pillar: Labor market efficiency	0.682***	0.049
8th pillar: Financial market development	0.761***	0.039
9th pillar: Technological readiness	0.937***	0.014
10th pillar: Market size	0.472***	0.070
11th pillar: Business sophistication	0.929***	0.015
12th pillar: Innovation	0.885***	0.021

Note: *** p-value < 0.01

Competitiveness factor is measured by twelve indicators representing the twelve dimension of the World Competitiveness Index - with significant standardizing loadings ranging from 0.472 to 0.948 (Table K.5), which shows a very strong correlation between indicators and the factor. Additionally, we added covariance's between: *1st pillar: Institutions* and *7th pillar: Labor market efficiency*; *4th pillar: Health and primary education* and *5th pillar: Higher education and training*; and *11th pillar: Business sophistication* and *12th pillar: Innovation* as the relation between the each of the two indicators is stronger than the one provided by the common factor.

K.6 Measurement model: Second-order measurement model (Sustainability - 4 pillars)

Table K.6: Second-order measurement model (Sustainability - 4 pillars)

Dimension	Indicators	Coefficient	S.E.
	Institutional	0.793***	0.041
	Social	0.927***	0.022
	Economic	0.779***	0.046
	Environmental	0.992***	0.019
Institutional	Voice and accountability	0.789***	0.036
	Political stability & absence of violence/terrorism	0.771***	0.039
	Government effectiveness	0.972***	0.006
	Regulatory quality	0.948***	0.010
	Rule of law	0.992***	0.003
	Control of corruption	0.971***	0.006
Social	Sufficient Food	0.718***	0.048
	Sufficient to Drink	0.834***	0.031
	Safe Sanitation	0.922***	0.017
	Education	0.869***	0.026
	Healthy Life	0.922***	0.017
	Population Growth	0.658***	0.056
Economic	Gross national income (GNI) per capita	0.934***	0.028
	Current account balance (% of GDP)	0.721***	0.051
	Exports of goods and services (% of GDP)	0.517***	0.074
	Household final consumption expenditure, etc. (% of GDP)	0.758***	0.048
Environmental	Adjusted savings: net forest depletion (% of GNI)	0.577***	0.066
	Adjusted savings: particulate emission damage (% of GNI)	0.817***	0.035
	Water Resources	0.896***	0.022
	Consumption	0.595***	0.064
	Greenhouse Gases	0.839***	0.032
	Renewable Energy	0.755***	0.044

Note: *** p-value < 0.01

K.7 MIMIC 1 model: Sustainability with controls

Table K.7: Sustainability with controls (MIMIC 1)

Dimension	Indicators	Coefficient	S.E.
	Institutional	0.778***	0.036
	Social	0.958***	0.013
	Economic	0.776***	0.041
	Environmental	0.963***	0.015
Institutional	Voice and accountability	0.789***	0.034
	Political stability & absence of violence/terrorism	0.771***	0.037
	Government effectiveness	0.972***	0.005
	Regulatory quality	0.948***	0.01
	Rule of law	0.992***	0.003
	Control of corruption	0.971***	0.006
Social	Sufficient Food	0.725***	0.042
	Sufficient to Drink	0.823***	0.029
	Safe Sanitation	0.933***	0.013
	Education	0.865***	0.023
	Healthy Life	0.916***	0.015
	Population Growth	0.657***	0.051
Economic	Gross national income (GNI) per capita	0.928***	0.027
	Current account balance (% of GDP)	0.729***	0.048
	Exports of goods and services (% of GDP)	0.52***	0.073
	Household final consumption expenditure, etc. (% of GDP)	0.760***	0.046
Environmental	Adjusted savings: net forest depletion (% of GNI)	0.600***	0.058
	Adjusted savings: particulate emission damage (% of GNI)	0.816***	0.031
	Water Resources	0.893***	0.02
	Consumption	0.581***	0.061
	Greenhouse Gases	0.834***	0.028
	Renewable Energy	0.768***	0.038
Controls	Latin America and Caribbean	- 0.082**	0.035
	Sub-Saharan Africa	- 0.378***	0.046
	South Asia	- 0.09***	0.034
	Lower middle income	0.213***	0.057
	Upper middle income	0.545***	0.061
	High income	0.954***	0.069

Note: *** p-value < 0.01; ** p-value <0.05

K.8 MIMIC 2 model: Competitiveness with controls (similar to Sus)

Table K.8: Competitiveness with controls (similar to Sus) (MIMIC 2)

Dimension	Indicators	Coefficient	S.E.
Competitiveness	1st pillar: Institutions	0.818***	0.028
	2nd pillar: Infrastructure	0.957***	0.008
	3rd pillar: Macroeconomic environment	0.526***	0.062
	4th pillar: Health and primary education	0.79***	0.032
	5th pillar: Higher education and training	0.916***	0.014
	6th pillar: Goods market efficiency	0.872***	0.021
	7th pillar: Labor market efficiency	0.652***	0.049
	8th pillar: Financial market development	0.731***	0.04
	9th pillar: Technological readiness	0.958***	0.009
	10th pillar: Market size	0.470***	0.068
	11th pillar: Business sophistication	0.908***	0.016
	12th pillar: Innovation	0.862***	0.022
Controls	Latin America / Caribbean	- 0.127**	0.051
	Sub-Saharan Africa	- 0.134*	0.07
	South Asia	- 0.024	0.053
	Lower middle income	0.180**	0.086
	Upper middle income	0.442***	0.092
	High income	0.979***	0.098

Note: *** p-value < 0.01; ** p-value <0.05; * p-value <0.1

Appendix L

Reason for adding covariances between error terms

We added covariances between the error terms of selected indicators within one dimension to account for the fact that they have a very strong relation (also called within-construct error covariance (see Hair et al., 2014, p. 606 ff.)). This relation is even stronger than the one provided by the common factor.
A more general example: We want to measure the overall customer perception of a supermarket (customer perception can only indirectly be measured). A questionnaire provides the customers opinion regarding product prices, quality of the products, quality of the service, cleanness of facilities, and parking possibilities. The proposed model can be seen in Figure L.1. Now we can assume that the two indicators product prices and quality of the product (assumption higher price = better quality) have a very strong relation, as both are related to the product. This relationship between the two is even stronger than the one provided by the common factor. Therefore we would add a covariance between the two error terms to account for this strong relationship.

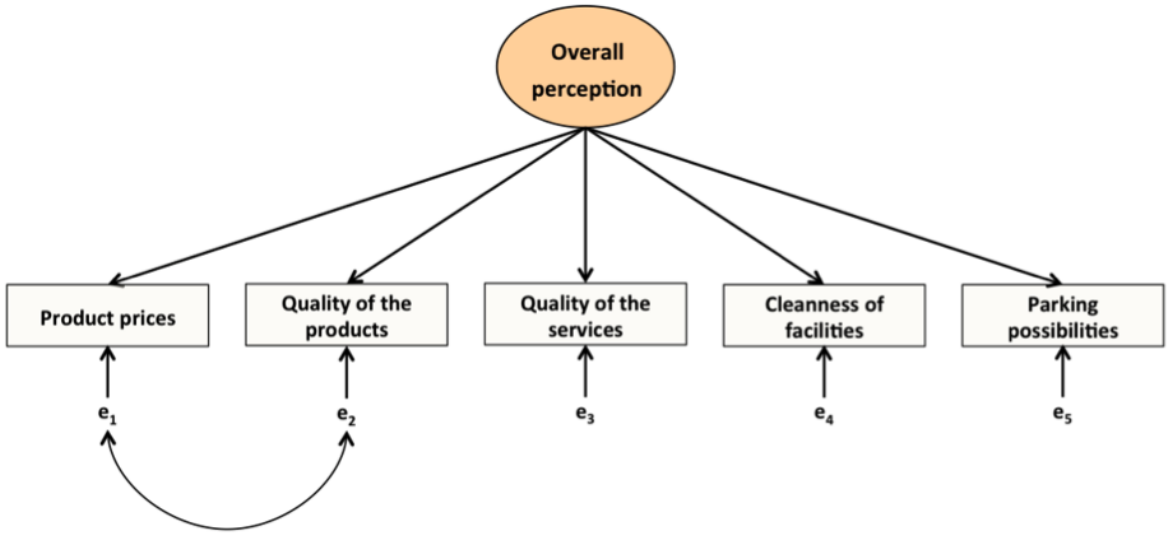

Figure L.1: Example covariance between error terms

Appendix M

Covariance's between the five first order measurement models

To test the covariances between each of the first order measurement models and competitiveness, a model was estimated including each first-order measurement model (except Social2) and the covariances between them. The Goodness-of-fit for the estimated model in this section can be confirmed with a low SRMR (0.095) and close value of RMSEA (0.159). TLI (0.745) and CFI (0.720) are low, but the model and therefore the covariances can be used.

Table M.1: Covariance's between the five measurement models

Covariance	**Coefficient**	**S.E.**
Cov (Inst, Env)	0.75***	0.05
Cov (Inst, Soc)	0.75***	0.05
Cov (Inst, Eco)	0.74***	0.05
Cov (Inst, Comp)	0.90***	0.02
Cov (Env, Soc)	0.92***	0.02
Cov (Env, Eco)	0.77***	0.05
Cov (Env, Comp)	0.85***	0.03
Cov (Soc, Eco)	0.64***	0.06
Cov (Soc, Comp)	0.82***	0.04
Cov (Eco, Comp)	0.78***	0.04

Note: *** p-value < 0.01

Appendix N

Stata definition of the score calculation method

"The calculation method is an analog of regression scoring; namely, it produces the means of the latent variables conditional on the observed variables used in the model. If missing values are found among the observed variables, conditioning is on the variables with observed values only."

Source: Stata (2017)