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Public and Private Investment and Human Development: analysis of the social efficiency with Data Envelopment Analysis (DEA)

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Public and Private Investment and Human Development: analysis of the social efficiency with Data Envelopment Analysis (DEA)

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ABSTRACT

Economic growth, considered as a means to achieve human development, is not always efficiently converted by countries. Based on this assumption, several studies have analyzed the social efficiency in which nations convert their economic wealth into quality of life. In this context, this study sought to measure countries' efficiency in converting public and private investment in human development. Thus, the following questions were studied: which regions are efficient in converting investments in human development? What is the relationship between investment and human development for several countries? Are countries efficient in converting public investment also efficient in converting private investment? To achieve this objective, an econometric model was applied to analyze the relationship between the variables involved in this study. The Data Envelopment Analysis method was then used in its standard and inverted form to obtain three composite indices: (a) *Public Investment and Human Development Index (HDI-IGOV)*; (b) *Private Investment and Human Development Index (HDI-IPRIV)*; and (c) *Total Investment and Human Development Index (HDI-IPRIV)*. The results confirmed the positive impact of investment (input) on human development's dimensions (outputs). Uzbekistan ranked first among 84 countries for two of the three composite indicators calculated in this study. In addition, other Latin American countries and countries with a socialist past achieved the highest positions. Despite the research limitations, it is believed that this study has contributed to the analysis of social efficiency by investigating the impacts of only one component of economic wealth from the public and private sector perspective.

Keywords: Public and Private Investments; Human Development; Data Envelopment Analysis (DEA); Econometrics; Social Efficiency.

RESUMO

O crescimento econômico, considerado como um meio para se atingir desenvolvimento humano, nem sempre é convertido eficientemente por países. A partir dessa premissa, diversos estudos analisaram a eficiência social em que as nações convertem sua riqueza produzida em qualidade de vida. Neste contexto, este trabalho buscou mensurar a eficiência dos países em converter investimentos públicos e privados em desenvolvimento humano. Dessa forma, buscou-se responder os seguintes questionamentos: quais regiões são eficientes em converter investimentos em desenvolvimento humano? Qual a relação entre investimentos e o desenvolvimento humano para diversos países? Países eficientes em converter investimentos públicos também o são para investimentos privados? Para que esse objetivo fosse alcançado, primeiramente foi utilizada um modelo econométrico para analisar a relação entre as variáveis aplicadas neste estudo. Em seguida, o método *Data Envelopment Analysis* foi utilizado em sua forma padrão e invertida a fim de se obter três indicadores compostos: (a) *Índice de Desenvolvimento Humano e Investimentos Públicos (HDI-IGOV)*; *(b) Índice de Desenvolvimento Humano e Investimentos Privados (HDI-IPRIV)*; e (c) *Índice de Desenvolvimento Humano e Investimentos Totais (HDI-ITOT).* Os resultados confirmaram o impacto positivo dos investimentos (*input*) sobre as dimensões do desenvolvimento humano (*outputs*). Uzbequistão conquistou a primeira colocação em um ranking entre 84 países para dois dos três indicadores compostos obtidos neste estudo. Além disso, outros países latino-americanos e países de passado socialista figuraram entre as melhores colocações. Apesar das limitações de pesquisa, acredita-se que este trabalho contribuiu para a análise da eficiência social ao investigar os impactos de apenas um componente da riqueza produzida sob a óptica dos setores público e privado.

Palavras-chave: Investimentos Públicos e Privados; Desenvolvimento Humano; Análise por Envoltória de Dados (DEA); Econometria; Eficiência Social

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1 INTRODUCTION

Economic growth has been considered as one of the main goals for many countries over the past years. According to Hartmann (2014), the term ‘development’ has been associated with the expansion of production, income, and consumption since the industrial revolution, when an unprecedented steep rise in the standard of living was empirically observed. In this context, a rising per capita income has been used in the early development literature for measuring development in a country. Nevertheless, as the particularities of both economic and human development processes were increasingly studied, this assumption was reformulated.

According to the UNDP (2001), human development can be considered as the process of expanding people’s capabilities to exercise their freedoms to make choices that fulfil their aspirations and values. It is recognized that economic growth or individual incomes are indeed crucial to human development since it generally facilitates social security provision to the more vulnerable sectors of society (SEN; DRÈZE, 1989). However, in the past two decades, development specialists have increasingly recognized that pure economic indicators such as GDP per capita or even income distribution measures do not reflect the multidimensionality of human development (RAAB; KOTAMRAJU; HAAG, 2000). Moreover, as mentioned in the Human Development Report (HDR) of 2000, the linkages between GDP and well-being are less direct and obvious as they might seem. Many aspects that affect the standard of living are omitted.

Based on the fact that pure economic indicators alone could not entirely represent a country’s human development, in 1990, the United Nations Development Program introduced the Human Development Index (HDI), which has been published in the HDR every year. The HDI combines a range of social indicators with pure economic indicators to capture a nation’s development in a single index. This approach to the measurement of development takes a people-centered view by evaluating people’s capabilities to exercise their freedoms to make life choices (SEN, 1999). Nevertheless, the HDI has been questioned for many reasons, including its indices’ aggregation method (MAHLBERG; OBERSTEINER, 2001). Alternatively, the Data Envelopment Analysis (DEA) technique has been employed to assess the human development in regions and countries while overcoming some of the HDI deficiencies.

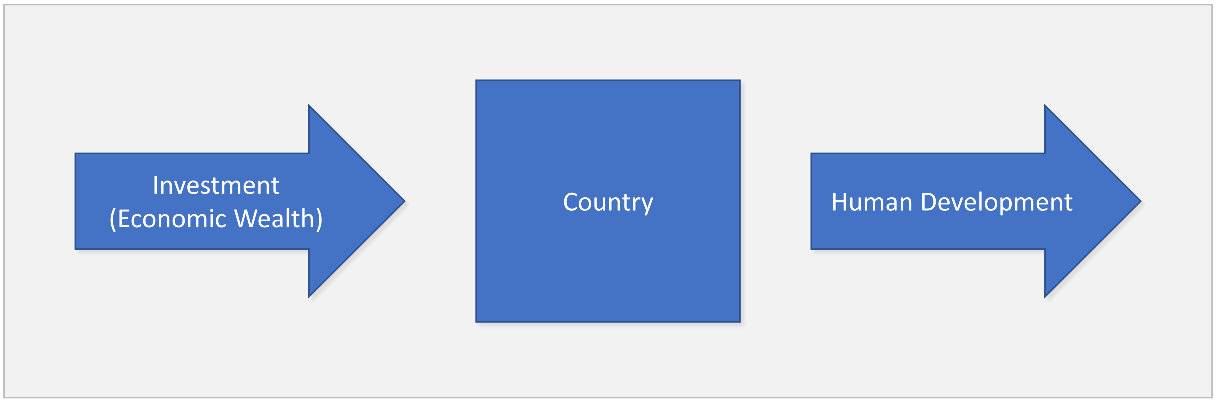
Among the many DEA applications in previous studies, one of them evaluates countries’ efficiency in converting economic growth into human development (DESPOTIS, 2005a, 2005b; MORAIS; CAMANHO, 2011; REIG-MARTÍNEZ, 2013). This approach, denominated Social Efficiency by Mariano et al. (2015), considers economic wealth as a means for expanding individual freedoms. In short, it assesses how economic growth, measured by the gross domestic product (GDP), is transformed into human development.

Although the GDP is an appropriate measurement for economic wealth in the social efficiency analysis, some of its components do not necessarily raise well-being (REIG-MARTÍNEZ, 2013). Based on that, this study proposes a further investigation of the impact of economic wealth on human development by employing the gross fixed capital formation (GFCF), also called "investment" (OECD, 2020), as an input variable on the DEA analysis. To this end, data on public and private investment was gathered to calculate (a) a *Public Investment and Human Development Index (HDI-IGOV);* (b) a *Private Investment and Human Development Index (HDI-IPRIV*); and (c) a *Total Investment and Human Development Index (HDI-IPRIV*) for a set of 84 countries around the world. Thus, those indicators' objective is to determine which nations are efficient in converting public and private investment into human development.

1.1 Research Theme

This research aimed to study the relationship between public or private investment and a nation's human development. However, bearing in mind that this relationship is complex and involves a set of variables, direct analysis is difficult to be made. Thus, this study adopts the concept of efficiency applied to countries, which are treated as production systems and whose objective is to convert investment (input) into human development (output), as represented in Figure 1. Therefore, this research first employs econometric models to validate the relationship between input and output variables used in the efficiency models. The DEA, further explained in chapters 2 and 3, is then applied to analyze those production systems.

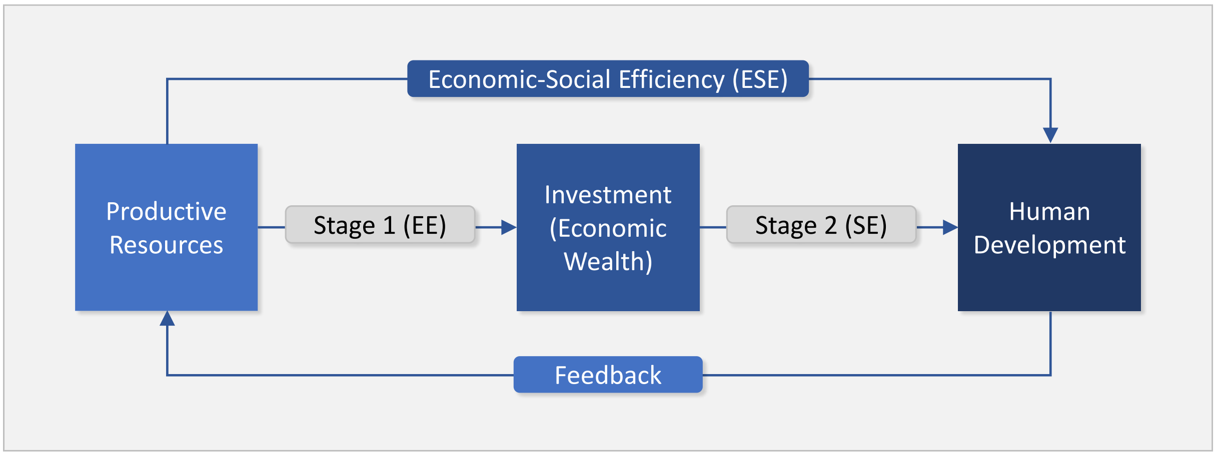
Figure 1 Conception of a country as a productive system



Source: Adapted from Mariano (2012)

According to Mariano (2012), in the context above, some analyses from the literature applied the efficiency concept using both economic and social variables as outputs and the productive resources as inputs. This type of analysis, denominated as economic-social efficiency (ESE) by Mariano et al. (2015), models the development process as a single-stage where productive resources are converted into wealth and social benefits, as shown in Figure 2.

Figure 2 Stages of the human development process



Source: Adapted from Mariano et al. (2015)

However, in this research and previous studies, it is assumed that the development process occurs in two different stages, as shown in Figure 2. In the first stage, also denominated as economic efficiency (EE), productive resources are transformed into economic wealth. In the second stage, called social efficiency (SE), such economic wealth is transformed into human development. Although both stages have their own characteristics and efficiencies, this study focuses only on the second one, which is the most complex and whose efficiency defines countries' capability to convert economic wealth into social benefits (MARIANO; SOBREIRO; REBELATTO, 2015). One should also notice that this study regards investment as economic wealth since it considered, as investment, the gross fixed capital formation (GFCF), which is a component of the expenditure on the GDP.

Another important concept of Figure 2 is the feedback process of converting human development into economic wealth. However, this feedback process is not on this study's scope since it was assumed that economic wealth should be considered a means and not an end (SEN, 1999).

1.2 Research Problem

This study's problem can be formulated as follows: **which countries are efficient in converting public and private investment into human development? What is the relationship between investment and human development in several nations?** Other questions that can be raised from this problem are:

a) Does public and private investment affect human development?
b) Which countries are more efficient in converting investment into human development?
c) Countries with low investment levels are as efficient as other countries?
d) Countries that are efficient in converting public investment into human development are also efficient in converting private investment or vice-versa?
e) Which factors could drive the higher efficiency of some countries analyzed in this study?

1.3 Research Objective

This research's general objective is to measure countries' efficiency in converting public and private investment into human development. Therefore, it also aims to prove the empirical relationship of this phenomenon. To better understand this general objective, it can be decomposed into the following secondary objectives:

a) Analyze the relationship between investment and human development through econometric models;
b) Create a social efficiency index, through DEA, which corresponds to the efficiency of converting investment into human development;
c) Create a composite index that considers the best and worst practices of countries regarding those investments' employment.

1.4 Research Relevance

Many countries have faced the challenges of maintaining sustainable economic growth. Even more difficult is to turn this growth into human development. In this context, the importance of the public sector's support to promote human development through public provisions, policies, or facilities is well-known (RAAB; KOTAMRAJU; HAAG, 2000; SEN, 1999; SEN; DRÈZE, 1989). Nevertheless, given that financial resources are limited, it is crucial to comprehend if they are efficiently employed. Moreover, public investment alone might not be sufficient to achieve some of the Sustainable Development Goals for nations, highlighting the importance of private investment as a development enabler (OECD, 2015).

According to OECD (2015, p. 2), "private investment can be an essential enabler of economic and human development." The paper argues that, when delivered in the right way, investment can improve skills, innovation, create jobs, and provide infrastructure to boost economies. However, it also emphasizes that more investment is not enough. An investment's quality is another essential aspect because local economies might not possess the capacity and policy tools to seize their potential benefits. To overcome the inefficient use of financial resources, countries have worked on policies to improve the enabling environment for investment and promote responsible investment and business conduct. Prior to the development of those policies and tools, however, it is relevant to evaluate the relative efficiency of nations and which of them could be used as benchmarks for others.

1.5 Research Structure

In addition to the introductory chapter, this work contains five other chapters. In chapter 2, a review of the literature on public and private investment is presented. Comparisons from previous studies between the efficiency of investment from both sources are analyzed. Chapter 3 describes the methodology applied in this study, which is based on the DEA method. The chapter also presents the method employed for selecting variables analyzed in this study and the validation of the causal relationship between input and output variables. In chapter 4, the results obtained in the econometric validation and the DEA are presented and examined. Lastly, chapter 5 presents conclusions about this study.

2 LITERATURE REVIEW

This chapter presents the literature review of this research. The first subchapter investigates the literature on economic and human development. It covers the evolution of the concept of development from the traditional economic perspective to a more extensive approach of freedoms. The second subchapter presents the literature on composite indices developed with DEA to measure human development. The third subchapter presents the literature on the application of DEA in the field of social efficiency analysis. I the last subchapter, the study of the relationship between investment and human development is investigated in the literature.

2.1 Economic Growth and Human Development

According to Sen and Drèze (1989), a single index such as GNP is not equivalent to achievements of quality of life because: (a) it measures the economic development as a whole yet its impacts on individual prosperity depend on the distribution of income; and (b) such achievements are influenced by many factors beyond the economic dimension. In fact, for the past decades, the literature has increasingly recognized that pure economic indicators such as GDP per capita are not enough to assess the overall development in a country (RAAB; KOTAMRAJU; HAAG, 2000). The criticism of the use of GDP per capita to represent development is based on the idea that it does not capture the multidimensionality of human development (DESPOTIS, 2005a). According to Mahlberg and Obersteiner (2001), "the GDP indicator does not measure the 'fitness' of a particular country or society as a whole, but rather summarizes the current state of specific activities within a society."

Human development can be comprehended as the process of expanding the freedoms that people enjoy in other words, "the removal of various types of unfreedoms that leave people with little choice and little opportunities of exercising their reasoned agency" (SEN, 1999, p. xii). According to Sen (1999, p. 3), the expansion of individual freedoms depends on other factors than income distribution, such as social and economic arrangement as well as political and civil rights. Development requires the removal of significant sources of unfreedom, such as poverty, tyranny, low economic opportunities and systematic social deprivation, and neglect of public facilities. Sen (1999, p. 10) describes five distinct types of freedom, namely: (a) political freedoms; (b) economic facilities; (c) social opportunities; (d) transparency guarantees; and € protective security. Each of those contributes to the development of a person's capabilities

Based on the capabilities approach, the Human Development Report introduced the HDI in 1990. It measured the capability to live a long and healthy life, acquire knowledge, and earn income for a base standard of living (UNDP, 2019). According to Klasen (2018), development has been accepted as more than an increasing per capita GDP, and the HDI is considered its most serious and comprehensive alternative. However, in recent years, it has been argued that the HDI fails to measure a country's real human development due to the limitation of its social indicators and its methods (DESPOTIS, 2005a; MAHLBERG; OBERSTEINER, 2001)

The next section presents the alternative indices to the traditional HDI found in the literature. Those indices were obtained through DEA and intended to either address some of the criticism of the HDI's methods or analyze new dimensions of human development.

2.2 DEA Composite Indices

Several studies applied DEA to obtain new composite indices to capture the multidimensionality of human development. According to Mariano (2012), in this type of analysis, the undesirable attributes are considered as inputs, which should be reduced, whereas the desirable ones are regarded as outputs, which should be maximized. Moreover, since this application does not require a production relationship between inputs and outputs, the use of Constant Returns to Scale (CRS) models are justified (HASHIMOTO; SUGITA; HANEDA, 2009).

Hashimoto and Ishikawa (1993) proposed using DEA in multi-dimensional evaluation analysis in contrast to the standard DEA efficiency analysis of that time. The authors employed the (CRS) model to analyze the desirability of living in 47 prefectures of Japan by replacing inputs and outputs with negative and positive social indicators. Four dimensions of social indicators were studied: public safety, health, economic stability, and environment. The same four dimensions were examined in Hashimoto and Kodama (1997) to assess Japan's livability during a timeframe of 35 years. The DEA method was regarded as a valuable analytic tool in evaluating life quality, mainly because it can avoid arbitrary weighting schemes. Based on a multi-dimensional measurement, Zhu (2001) proposed five different assessment of the quality of life on the Fortunes' 20 best cities to live in in 1996. Besides the CRS model, the research also applied the variable returns to scale (VRS) model.

Seizing DEA models' advantage of constructing a non-linearly arranged set of weights for both inputs and outputs variables, Mahlberg and Obersteiner (2001) sought to remeasure the HDI. The research used the same social indicators as the HDI before 2010, namely: (a) life expectancy at birth (longevity); (b) adult literacy rate (education); (c) combined enrolment ratio (education); and (d) adjusted per capita income (standard of living). The output-oriented DEA-CRS model was applied. An input equal to one was considered to overcome the absence of input variables. Lastly, the results showed a strong correlation between the HDI and the DEA measure of human development with weight restrictions. However, it was also observed that there were notable differences between the two measurements, which could be explained by the linearity of the benchmark and the subjectivity of weights of HDI.

Following the research from Mahlberg and Obersteiner (2001), Despotis (2005b) proposed the DEA-CRS model without weight restrictions to evaluate the human development in 27 countries of the regional aggregate of Asia and the Pacific. Singapore, the Republic of Korea, and Hong Kong achieved the highest scores. In Despotis (2005a), the previous analysis was extended to 174 countries worldwide. The results showed that Canada, Norway, United States, Australia, Iceland, Sweden, Belgium, Japan, the United Kingdom, and Finland had HDI equal to 1. Bougnol et al. (2010) pioneered the use of DEA to cluster countries after applying the DEA-CRS model to remeasure the HDI in 15 countries.

Some analyses focused on the economic aspect of development. Murias et al. (2006) applied the DEA-CRS model to assess the economic well-being in 50 Spanish provinces. To this end, a composite index was derived from 8 partial indicators and then compared to the GDP per capita. Malul et al. (2009), on the other hand, focused on income inequality by developing an index to rank 91 countries worldwide. Fernández et al. (2010), in turn, compared the economic well-being of 38 regions in Italy and Spain. Lastly, Poveda (2011) used the DEA-CRS model to analyze economic development and growth in 23 regions of Colombia from 1993 to 2007. In addition to the DEA, the research also applied a panel data analysis with fixed effects to explain economic development.

Regarding the human development indicators, some studies applied DEA with a large number of social indicators (MORAIS; CAMANHO, 2011; MORAIS; MIGUÉIS; CAMANHO, 2013). Morais and Camanho (2011) employed the DEA-CRS model with 29 social variables to evaluate the quality of life of 206 European cities. Morais et al. (2013), in turn, assessed the quality of life in 246 European cities from the human capital perspective. Altogether, 39 social indicators were used to represent eight dimensions: (a) political and social environment, (b) economic environment, (c) health, (d) education, (e) public services and transport, (f) recreation, (g) housing and (h) natural environment.

Finally, it was found in the literature the application of other DEA models. The multiplicative DEA model, for example, was used by Zhou et al. (2010) and Tofallis (2013) to evaluate the HDI in 27 countries in Asia and the Pacific and 169 countries worldwide, respectively. Reig-Martínez (2013) adopted the SBM model for comparing human development in European and Mediterranean Basin countries.

From the previous studies mentioned above, one can conclude that composite indices based on efficiency are an interesting alternative to measure human development. However, although most studies were focused on the same social dimensions of the HDI, there is no consensus on the selection of social indicators. Moreover, those composite indices do not measure the efficient use of financial resources (DESPOTIS, 2005a, 2005b; REIG-MARTÍNEZ, 2013). An alternative to address this issue is described in the next section.

2.3 Social Efficiency Analysis

The shortage of financial resources and their efficient use are essential aspects of countries' development policies. In this context, previous research focused on the social efficiency analysis, which is associated with the transformation of economic wealth into quality of life and human development (MARIANO; SOBREIRO; REBELATTO, 2015).

Despotis (2005a) was a pioneer in social efficiency analysis. The DEA-VRS model was applied to analyze the transformation paradigm, where GDP per capita was adopted as input and the social indicators as outputs. The research examined the social efficiency of 174 countries in 2000. The efficient countries were Canada, Sweden, Japan, United Kingdom, New Zealand, Spain, Greece, Estonia, Cuba, Georgia, Ukraine, Jamaica, Azerbaijan, Tajikistan, Armenia, Solomon Island, Yemen, Tanzania, Malawi, and Sierra Leone. Despotis (2005b) developed the same analysis for 27 countries in the Asia and Pacific regions. In this study, Hon Kong, Fiji, South Korea, Mongolia, Myanmar, Nepal, Vietnam, Philippines, Solomon Island, and Sri Lanka were considered efficient.

Morais and Camanho (2011) applied the DEA-VRS model to analyze 284 European cities' social efficiency. The input variable was the GDP per capita, and the output variables were the same as the used in the composite index construction described in the previous section. Countries with the highest number of efficient cities were Germany, Bulgaria, Romania, Estonia, and Slovakia.

Lastly, Mariano and Rebelatto (2014) evaluated the social efficiency of 101 countries worldwide. The DEA-VRS model was employed with GDP per capita as an input variable and ten social indicators as output variables. The following dimensions were studied: (a) longevity; (b) education; (c) economic; (d) inequality; (e) public safety; and (f) sanitary conditions. The standard frontier was applied along with the cross-sectional and the inverted frontier methods to develop a triple composite index. The results showed that Albania, Armenia, Australia, Bangladesh, Belarus, The Czech Republic, Estonia, Georgia, Germany, Hungary, Japan, Kyrgyzstan, Malta, Moldova, Montenegro, Mozambique, Norway, South Korea, Sweden, Tajikistan, Ukraine, Uzbekistan, and Vietnam.

All the previous analyses mentioned in this subchapter adopt the GDP per capita to indicate economic wealth. It was not identified in the literature research focused on the impact of more specific components of GDP, such as the gross fixed capital formation.

2.4 Investment and Human Development

Most of the research found in the literature focus on the impact of investment on economic growth. Easterly and Rebelo (1993) found that investment in transport and communication is consistently correlated with growth. Khan and Kumar (1997) examined the contribution of public and private investment to GDP per capita growth in a sample of 95 developing countries throughout 1970-1990 using both cross-sectional and panel data. Kostakis (2014) concluded, from a sample of 96 countries from 1990 to 2010, that both public and private investment positively impact GDP per capita. Regarding the relationship between investment and human development, Tudorache (2020) examined human development drivers in the European Union from 2010 to 2017 and found, by econometrics, a positive relationship between gross fixed capital formation and the HDI. Sharma and Gani (2007) obtained the same positive effect on the HDI by foreign domestic investment from 1975 to 1999.

Based on the relationship between economic wealth and human development, this study sought to examine how countries have employed their resources through investments to expand individuals' capabilities. It should be noticed that previous studies have not worked on an index to assess the transformation of public and private investment into human development. The next chapter presents the method applied in this research.

3 METHOD

This section describes the method applied in this study. The first subchapter introduces the DEA technique applied in this analysis. The second subchapter presents the variables selection method and the databases from which they were extracted. The third subchapter presents the econometric model used to validate the relation between inputs and outputs variables. The fourth subchapter describes the DEA model employed to analyze the social efficiency of 84 countries regarding their public and private investment. Finally, the tiebreaker method of the inverted frontier is presented.

3.1 Data Envelopment Analysis (DEA)

Data Envelopment Analysis (DEA) is a nonparametric method that aims to measure the relative efficiency of a set of decision-making units (DMUs). Such analysis is accomplished by employing a linear programming method developed by Charnes, Cooper, and Rhodes (1978). This method consists of building a linear frontier that separates the efficient DMUs, located at the frontier limits, from the inefficient ones, whose distance from the frontier indicates their efficiency level.

A DMU is regarded as an entity that converts a set of inputs into a set of outputs. A DMU's efficiency is determined by applying a set of weights that maximizes its efficiency (COOPER; SEIFORD; TONE, 2000). Therefore, a DMU is efficient when it can maximize the productivity of outputs compared to other DMUs. It should be noted that this technique allows the analysis of multiple inputs and outputs simultaneously, which gives greater flexibility and adaptability to solve a distinct variety of problems, especially the ones regarding alternatives to the human development index, given its multi-dimensional nature (MARIANO; SOBREIRO; REBELATTO, 2015).

There are a series of DEA Models that were developed over time. According to Mariano e Rebelatto (2014), those models can differ based on their assumptions, particularly: (a) the type of returns to scale; (b) the orientation; and (c) the way inputs and outputs are combined. Regarding the first classification, the CRS (Constant Returns to Scale) or CCR and the VRS (Variable Returns to Scale) or BBC. The first one considers that outputs and inputs have a constant relation, whereas the second one assumes that this relation of returns to scale can be increasing, when outputs grow proportionally more than inputs; constant, when the relationship is proportional; and decreasing, when outputs grow proportionally less than inputs.

The second classification considers the orientation, which can be radial or non-radial. CRS and VRS models are classified as radial models because their goal is to minimize the inputs for input-oriented models, or to maximize outputs for output-oriented models, separately (COOPER; SEIFORD; TONE, 2000). The non-radial models, on the other hand, aims to reduce inputs and increase inputs simultaneously and can be classified as additive models, which assumes a linear combination of inputs and outputs, and the multiplicative models, which assumes a non-linear combination (MARIANO, 2012). The additive model was first proposed by Charnes et al. (1985) and the multiplicative by Charnes et al. (1982).

3.2 DEA Research Variables

The first step to perform the DEA was the selection of inputs and outputs variables for this analysis, which was based on previous studies about social efficiency and composite index for social indicators (ADLER; YAZHEMSKY; TARVERDYAN, 2010; DESPOTIS, 2005b, 2005a; FERRAZ, 2019; MAHLBERG; OBERSTEINER, 2012; MARIANO; REBELATTO, 2014; MORAIS; CAMANHO, 2011; MORAIS; MIGUÉIS; CAMANHO, 2013; RAAB; KOTAMRAJU; HAAG, 2000; REIG-MARTÍNEZ, 2013).

From the literature review, one can observe that most of the published papers consider only the economic, education, and health dimensions of human development. This result is expected since those are three dimensions of HDI, which is still the primary reference for human development (MARIANO; SOBREIRO; REBELATTO, 2015). Moreover, the variables employed in those studies to represent the three dimensions of HDI satisfy the approach that considers people's capabilities to exercise their freedoms as the primary ends of the human development of Amartya Sen (1999). Thus, for output variables, this study proposed the following dimensions to represent human development: health (life expectancy – LF); education (mean years of schooling – MYS); employment (employment rate – ER); sanitary conditions (sanitation rate – SR) as indicated in Table 1.

Regarding the input variables selection, this study was based on the "input-output paradigm" proposed for the first time by Despotis (2005b). This approach considers economic wealth as a means to achieve human development, as opposed to the HDI, where income reflects the "basic-commodities" dimension. However, instead of considering the GDP as an input variable, this study intended to contribute to the discussion of social efficiency by employing public and private investment as input variables for the DEA.

Table 1 Summary of input and output variables

Variable	Source	Type	Literature Review
Public Investment per capita (Gross Fixed Capital Formation)	IMF, Investment and Capital Stock Dataset, 1960-2017, version of August 2019	Input	Proposal for this study
Private Investment per capita (Gross Fixed Capital Formation)	IMF, Investment and Capital Stock Dataset, 1960-2017, version of August 2019	Input	Proposal for this study
Life Expectancy at Birth	World Bank – Social Indicators	Output	Despotis (2005b); Reig-Martinez (2013); Ferraz (2019)
Mean Years of Schooling	UNDP – International Human Development Data	Output	Despotis (2005a); Mariano and Rebelatto (2014); Ferraz (2019)
Employment Rate	World Bank – Social Indicators	Output	Morais and Camanho (2011); Reig-Martinez (2013); Ferraz (2019)
Sanitation Rate	World Bank – Social Indicators	Output	Mariano and Rebelatto (2014); Reig-Martinez (2013); Ferraz (2019)

Source: Author

Investment data were collected from the IMF Investment and Capital Stock Dataset (2019), which provides a comprehensive data on public investment and capital stock, private investment and capital stock, as well as investment and capital stock arising from public-private partnerships (PPPs), across 170 countries from 1960 until 2017. The investment data was then divided by the population of each country to obtain the per capita investment variables. Population data was extracted from the World Bank Dataset.

The public and private investment on the dataset are measured by the gross fixed capital formation (GFCF) of the general government and private sector, respectively, expressed in billions of constant 2011 international dollars (purchasing power parity adjusted). According to the International Monetary Fund (2015), this approach allows for the use of the comparable data available for a large number of countries, but some alternative modes of government support for overall investment are ignored, such as (a) investment grants; (b) loan guarantees; (c) tax concessions; (d) the operations of public financial institutions, such as development banks; and (e) government-backed saving schemes. The data comes from three main sources: the OECD Analytical Database (2019 version) for OECD countries, and a combination of the National Accounts of the Penn World Tables (PWT, version 9.1) and the IMF World Economic Outlook (WEO, April 2019 vintage) for non-OECD countries.

Data for the output variables comes from two sources. From the World Bank Dataset (2020), the following indicators were collected: (a) Life Expectancy at Birth (LEB), representing the health dimension; (b) Employment Rate (ER), which is the proportion of a country’s population of 15 or older age that is employed; and (c) Sanitation Rate, representing the percentage of people using at least basic sanitation services, that is, improved sanitation facilities that are not shared with other households. Lastly, the Mean Years of Schooling (MYS) indicator, which expresses the average number of years of education received by people ages 25 and older, comes from the International Human Development Data (UNDP, 2019).

To perform the econometric validation prior to DEA, the inputs and outputs were organized into a panel data structure. The data was then restricted to the period from 2000 to 2017 because previous or later periods presented an excessive amount of missing values. Also, 78 countries with missing data were eliminated from the database to avoid any subjectivity by assuming arbitrary values. Finally, to filter tiny countries comparable to medium-size cities, only those with a population larger than 1.3 million and a GDP of over 22.1 billion dollars were considered. Thus, the resulting dataset included 83,5% of the total world population and 88,9% of the total world GDP in 2017.

3.3 Preliminary Analysis of Variables

Bearing in mind that the DEA is a nonparametric method, to empirically validate the causal relationship between the inputs and outputs, this study applied the econometry analysis. It was observed in previous analyses the use of the Pearson correlation matrix and linear regression models for this purpose (FERRAZ, 2019). Thus, besides the correlation matrix, three econometric models were estimated for each social indicator, considering the expression bellow:

$$\ln y_{it}^{social\ indicator} = \beta_0 + \beta_1 \ln IGOV_{it} + \beta_2 \ln IPRIV_{it} + \beta_3 \ln ECI_{it} + \beta_4 \ln IURB_{it} + \beta_5 \ln b\_group_{it} + \varepsilon_{it} \quad (1)$$

wherein $\ln y_{it}^{social\ indicator}$ represents the natural logarithm of one of the social indicators for human development; β_0 is the intercept of the model; $\beta_1 \ln IGOV_{it}$ is the natural logarithm of public investment; $\beta_1 \ln IPRIV_{it}$ is the natural logarithm of private investment; $\beta_1 \ln ECI_{it}$ is the Economic Complexity Index (2018); $\beta_1 \ln IURB_{it}$ is the ratio of people living in urban areas to the total population; $\beta_1 \ln b\_group_{it}$ is a binary variable which assumes the value of 1 when a country is a developed economy and 0 when it is not; and ε_{it} is the error term. Note that the ECI, IURB and b_group were used in the model as control variables.

To avoid heteroscedasticity issues, the *log-log* model was applied to interpret the coefficients as elasticities (GREENE, 2012). The data from the period of 2000 to 2017 was analyzed through panel data. Then, following the study of Ferraz (2019), the Breusch-Pagan test was used to verify if data should be analyzed in panel or pooled. Hausman test was applied to choose between FE and RE models. Also, to investigate if none of the initial hypothesis of the econometric model would be violated, the Wald and Wooldridge tests were used to verify the presence of heteroskedasticity and autocorrelation, respectively. Finally, to examine the presence of multicollinearity, the Variance Inflation Factors (VIF) was calculated, considering a VIF higher than ten as an indication of multicollinearity presence (WOOLDRIDGE, 2002).

3.4 DEA and Social Efficiency

As mentioned before, this study applied DEA to analyze the efficiency of 84 countries to convert public and private investment into human development in the year 2017. This analysis was achieved through a package for conducting DEA in Python programming, the pyDEA. Thus, three rankings of best practices among those countries were obtained, one for each of the following inputs: (a) public investment per capita; (b) private investment per capita; and (c) total investment per capita, which was represented by both public and private investment separately. For the latter, a similar result to those from (a) and (b) were expected since public and private investment had a high correlation, which could imply redundancy in our input variables. Lastly, the results from those rankings were analyzed to evaluate similarities among DMUs that stood out and assess what factors could explain those results.

Since the inputs considered in this study are the investment from the public and private sectors, representing a percentage of GDP, the output-oriented model was chosen since a country will likely improve its social indicators rather than reduce its investment (MARIANO; SOBREIRO; REBELATTO, 2015). Besides, considering that countries with contrasting investment levels were analyzed, the BBC model was chosen instead of the CCR model (MARIANO; REBELATTO, 2014).

3.5 The Inverted Frontier Method

According to Angulo-Meza and Lins (2002), the lack of discrimination among efficient DMUs is one of the issues in DEA, particularly when the number of DMUs is small compared to the number of variables since the DEA works with a set of weights that are most beneficial for each of them. This lack of discrimination can be a significant problem for social efficiency analysis, given that ties are not useful for public policies or the creation of rankings (FERRAZ et al., 2020). Therefore, this study proposed the application of the inverted frontier method to improve discrimination in DEA, which was employed in previous analyses (MARIANO; REBELATTO, 2014).

The tiebreaker method of the inverted frontier was first proposed by Yamada et al. (1994) and further developed by Leta et al. (2005). This technique consists of exchanging inputs for outputs in the analysis to build an inverted frontier of worst practices. Thus, the further a DMU is from the frontier, the better. After that, a composite index is calculated by the arithmetic normalized mean of (a) the efficiency calculated with the standard frontier; and (b) one minus the efficiency calculated by the inverted frontier. The formulas for each composite index are shown in expressions (2), (3), and (4):

$$HDI\text{-}IGOV_i = \frac{\left[Eigov_i + \left(1 - Eigov_i^{-1}\right)/2\right]}{max\left\{\left[Eigov_i + \left(1 - Eigov_i^{-1}\right)\right]/2\right\}} \quad (2)$$

$$HDI\text{-}IPRIV_i = \frac{\left[Eipriv_i + \left(1 - Eipriv_i^{-1}\right)/2\right]}{max\left\{\left[Eipriv_i + \left(1 - Eipriv_i^{-1}\right)\right]/2\right\}} \quad (3)$$

$$HDI\text{-}ITOT_i = \frac{\left[Eitot_i + \left(1 - Eitot_i^{-1}\right)/2\right]}{max\left\{\left[Eitot_i + \left(1 - Eitot_i^{-1}\right)\right]/2\right\}} \quad (4)$$

wherein $HDI\text{-}IGOV_i$, $HDI\text{-}IPRIV_i$, and $HDI\text{-}ITOT_i$ represent the composite index of the DMU_k for public, private, and total investment, respectively; $Eigov_i$, $Eipriv_i$, and $Eitot_i$ represent the efficiency of the DMU_k calculated with the standard frontier for public, private and total investment, respectively; and $Eigov_i^{-1}$, $Eipriv_i^{-1}$, and $Eitot_i^{-1}$ represent the efficiency of the DMU_k calculated with the inverted frontier for public, private and total investment, respectively.

The composite index of standard and inverted frontier considers both the strengths and the weaknesses of each country.

4 RESULTS

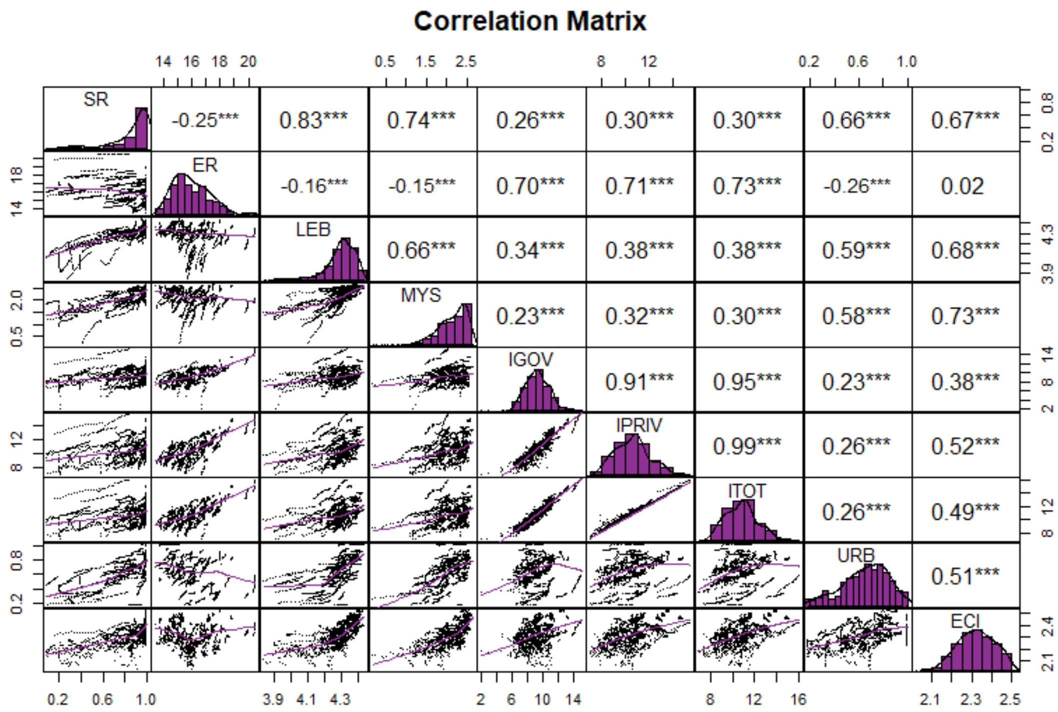
This chapter is divided into two subchapters. The first one presents the econometric results for the validation of inputs and outputs relation. The second part reports the efficiency analysis for the 84 countries chosen for this study.

4.1 Econometric Results

The econometric analysis was applied in this study to assess the causal relationship between inputs and outputs. Besides the literature review presented in chapter 2, the correlation matrix in Figure 3 presented the first causality evidence. The results exhibit a positive and significant correlation between investment and social indicators. Regarding the public investment, the employment rate (70,48%) had the highest correlation, followed by the life expectancy at birth (33,50%), the sanitation rate (26,09%), and mean years of schooling (23,36%). For private investment, the employment rate also had the highest correlation (71,39%), followed by the life expectancy at birth (38,46%), sanitation rate (30,50%), and the mean years of schooling (32,33%). Note that private investment presented a slightly higher correlation for the employment rate and a moderate increase in the other social variables compared to the public counterpart. Lastly, a strong correlation was also found between the sanitation rate and life expectancy, which is reasonable since the access to poor sanitation services weakens health systems and contributes to the rise of death rates in some regions (WORLD HEALTH ORGANIZATION, 2016). Correlations for the sum of public and private investment were also displayed in Figure 3 as ITOT.

Figure 3 shows the correlation between the control variables and the input and output variables. The inputs (private, public and total investments) are positively correlated with the outputs (sanitation rate, employment rate, life expectancy, and mean years of schooling). In other words, the correlation matrix shows evidence that the DEA model could be applied. For example, sanitation rate is slightly more correlated with private (30%) and total (30%) investments than with public investments (26%). For the ECI, all variables had a positive and significant correlation, except for the employment rate, which was not statistically significant.

Figure 3 Correlation Matrix for Input and Output Variables



***p<0.01, **p<0.05, *p<0.1.
Source: Author.

Econometric models were estimated to observe the impact of public and private investments on social variables. The econometric estimates are important to reveal the isolated effect of one explanatory variable. First, the Breusch-Pagan test indicated that panel models are preferable to pooled data. Hausman test showed the preference for fixed effect estimations. Wald test indicated that the estimations should treat heteroskedasticity. Finally, the Wooldridge test indicated first-order autocorrelation. Thus, based on previous studies, the Feasible Generalized Least Squares (FGLS) model was proposed to handle both heteroskedasticity and autocorrelation (FERRAZ, 2019). Moreover, results from the VIF test were always below 10, which indicates the absence of multicollinearity. Table 2 presents the FGLS estimations.

Models (1), (2) and (3) in Table 2 represents the regressions of MYS on private, public, and total investments, respectively. The coefficients of all three independent variables are positive and statistically significant at 1% level. In the first model, the results show that an increase of 1% in the private investment causes a MYS growth of 0.0158%. On the second model, the impact of public investment on MYS was slightly lower (0.0142%). The greatest impact on MYS was obtained with total investments (0.203%).

Models (4), (5) and (6) in Table 2 represents the regressions of SR on private, public, and total investments, respectively. The coefficients of all three independent variables are positive and statistically significant at 1% level. In the first model, the results show that an increase of 1% in the private investment is related to an increase in SR of 0.00469%. On the second model, the impact of public investment on SR was reasonably lower (0.00296%). Lastly, an increase of 1% in total investments caused the highest increase in SR (0.0203%).

Models (7), (8) and (9) in Table 2 represents the regressions of LEB on private, public, and total investments, respectively. The coefficients of all three independent variables are positive and statistically significant at 1% level. In the first model, the results show that an increase of 1% in the private investment causes a LEB growth of 0.00529%. On the second model, the impact of public investment on LEB was slightly lower (0.00407%). The greatest impact on LEB was obtained with total investments (0.00782%).

Finally, models (10), (11) and (12) in Table 2 represents the regressions of ER on private, public, and total investments, respectively. The coefficients of all three independent variables are positive and statistically significant at 1% level. In the first model, the results show that an increase of 1% in the private investment is related to an increase in ER of 0.382%. On the second model, the impact of public investment on ER was reasonably lower (0.214%). Total investment was responsible for the highest increase in ER (0.416%). Lastly, ER obtained the highest impact from investment variables.

As for the control variables, the urbanization rate was statistically significant at 1% level for all dependent variables. The coefficients of IURB for MYS, SR and LEB were positive. The ER was the only variable negatively impacted by the IURB. ECI, as expected, showed a positive correlation in all models and a statistical significance at 1% level for all of them, except for models 10 and 12 (FERRAZ, 2019; HARTMANN, 2014; HAUSMANN et al., 2014). Lastly, b_group was statistically significant at 1% for all output variables and its coefficients assumed a positive value for MYS, SR and LEB.

The results from this chapter confirms the hypothesis that public and private investment have a positive impact on human development.

Table 2 Econometric Estimations

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Education (MYS)			**Sanitation (SR)**			**Health (LEB)**			**Employment (ER)**		
IURB	0.761***	0.776***	0.767***	0.562***	0.559***	0.562***	0.252***	0.256***	0.250***	-1.863***	-1.469***	-1.905***
	(0.0394)	(0.0390)	(0.0394)	(0.0138)	(0.0145)	(0.0143)	(0.00762)	(0.00804)	(0.00753)	(0.0990)	(0.101)	(0.0946)
ECI	0.335***	0.328***	0.316***	0.0869***	0.0744***	0.0773***	0.0350***	0.0247***	0.0272***	0.190	0.682***	0.116
	(0.0569)	(0.0566)	(0.0570)	(0.0144)	(0.0138)	(0.0145)	(0.00906)	(0.00919)	(0.00882)	(0.145)	(0.155)	(0.118)
b_group	0.257***	0.267***	0.259***	0.0966***	0.102***	0.0952***	0.0593***	0.0616***	0.0574***	-0.778***	-0.747***	-0.716***
	(0.0153)	(0.0152)	(0.0153)	(0.00443)	(0.00455)	(0.00459)	(0.00301)	(0.00306)	(0.00301)	(0.0415)	(0.0462)	(0.0403)
IPRIV	0.0158***			0.00469***			0.00529***			0.382***		
	(0.00286)			(0.000803)			(0.000556)			(0.0111)		
IGOV		0.0142***			0.00296***			0.00407***			0.214***	
		(0.00231)			(0.000658)			(0.000456)			(0.00944)	
ITOT			0.0203***			0.00610***			0.00782***			0.416***
			(0.00300)			(0.000914)			(0.000618)			(0.0108)
Constant	0.603***	0.642***	0.586***	0.186***	0.237***	0.192***	3.974***	4.014***	3.966***	12.97***	13.61***	12.68***
	(0.123)	(0.124)	(0.123)	(0.0343)	(0.0326)	(0.0346)	(0.0206)	(0.0205)	(0.0200)	(0.322)	(0.349)	(0.269)
Breusch-Pagan test	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Hausman test	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Wooldridge test for autocorrelation	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Modified Wald test for groupwise heteroskedasticity	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Observations	1,494	1,494	1,494	1,494	1,494	1,494	1,494	1,494	1,494	1,494	1,494	1,494
Number of num	83	83	83	83	83	83	83	83	83	83	83	83
Country FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Standard errors in parentheses.
***p<0.01, **p<0.05, *p<0.1
Source: Author.

4.2 Public Investment Efficiency Analysis in 2017

This subchapter presents the efficiency analysis for public investment. DEA results are shown in Table 3. The VRS efficiency and the HDI-IGOV were normalized by the min-max technique and presented as VRS Efficiency$_n$ and HDI-IGOV$_n$.

Table 3 DEA results for the social efficiency of public investment

Country	VRS Efficiency$_n$	Rank	HDI-IGOV$_n$	Rank	Change in Rank
Uzbekistan	1.00000	1	1.00000	1	0
Guatemala	1.00000	1	0.99510	2	-1
Honduras	1.00000	1	0.98668	3	-2
El Salvador	0.98829	40	0.98544	4	36
Paraguay	1.00000	1	0.98539	5	-4
Brazil	0.99701	29	0.98175	6	23
Ukraine	0.98686	43	0.98025	7	36
Peru	1.00000	1	0.97170	8	-7
Chile	1.00000	1	0.96432	9	-8
Costa Rica	1.00000	1	0.96276	10	-9
Vietnam	1.00000	1	0.96084	11	-10
Kazakhstan	1.00000	1	0.95505	12	-11
Sri Lanka	0.98138	47	0.95003	13	34
Portugal	1.00000	1	0.94417	14	-13
Cambodia	1.00000	1	0.94391	15	-14
Mexico	0.95604	63	0.94362	16	47
Russia	0.96599	54	0.94040	17	37
Philippines	0.92923	75	0.93323	18	57
Argentina	0.95669	61	0.93029	19	42
Israel	1.00000	1	0.92976	20	-19
Egypt	0.95106	65	0.92563	21	44
Indonesia	0.92236	76	0.92443	22	54
Dominican Republic	0.93507	72	0.92430	23	49
Colombia	0.96249	58	0.92285	24	34
Bangladesh	0.94220	68	0.92059	25	43
Slovak Republic	0.98017	48	0.92032	26	22
Azerbaijan	0.95627	62	0.92016	27	35
Uruguay	0.96711	52	0.91980	28	24
Germany	1.00000	1	0.91858	29	-28
Thailand	1.00000	1	0.91777	30	-29
Poland	0.98797	41	0.91562	31	10
Ecuador	0.96499	55	0.91497	32	23
Czech Republic	0.99134	37	0.91266	33	4
Pakistan	0.89103	81	0.90983	34	47
Lithuania	0.96031	59	0.90872	35	24
Panama	0.96401	56	0.90862	36	20
Slovenia	0.99110	39	0.90641	37	2
Spain	1.00000	1	0.90129	38	-37
Latvia	0.94692	66	0.89981	39	27

Table 3 Continued

Country	VRS Efficiency$_n$	Rank	HDI-IGOV$_n$	Rank	Change in Rank
United Kingdom	0.99111	38	0.89973	40	-2
Bulgaria	0.94112	70	0.89374	41	29
Hungary	0.97991	49	0.89105	42	7
Croatia	0.96661	53	0.89093	43	10
Cameroon	0.96345	57	0.88001	44	13
New Zealand	1.00000	1	0.87393	45	-44
Austria	0.99973	28	0.87046	46	-18
Morocco	0.95236	64	0.86992	47	17
Canada	0.99425	34	0.86928	48	-14
Bolivia	0.91442	78	0.86857	49	29
Estonia	0.99155	36	0.86364	50	-14
Turkey	0.97297	51	0.86207	51	0
Greece	0.99652	30	0.85717	52	-22
India	0.87548	82	0.85605	53	29
Switzerland	1.00000	1	0.85446	54	-53
Kenya	0.95675	60	0.84980	55	5
United States	1.00000	1	0.84648	56	-55
Malaysia	0.99572	32	0.84464	57	-25
Ireland	0.98191	46	0.84218	58	-12
Japan	1.00000	1	0.84189	59	-58
Netherlands	0.97797	50	0.84090	60	-10
France	0.98738	42	0.83742	61	-19
Denmark	0.99597	31	0.83276	62	-31
Sweden	0.99313	35	0.82966	63	-28
Finland	0.99448	33	0.81674	64	-31
Tunisia	0.93242	74	0.79321	65	9
Iran	0.93292	73	0.78845	66	7
Singapore	1.00000	1	0.74358	67	-66
China	0.94446	67	0.73705	68	-1
Hong Kong	1.00000	1	0.72699	69	-68
Norway	0.98467	44	0.72529	70	-26
Oman	1.00000	1	0.67024	71	-70
Kuwait	1.00000	1	0.61899	72	-71
Angola	0.89511	80	0.61491	73	7
Iraq	0.94121	69	0.53704	74	-5
Congo, Democratic Republic of the	1.00000	1	0.50399	75	-74
Yemen	1.00000	1	0.50399	76	-75
United Arab Emirates	1.00000	1	0.50399	77	-76
Saudi Arabia	1.00000	1	0.50399	78	-77
Jordan	0.98251	45	0.49517	79	-34
Ghana	0.93785	71	0.47266	80	-9
Algeria	0.91484	77	0.46107	81	-4
Sudan	0.90769	79	0.45746	82	-3
South Africa	0.84112	83	0.42392	83	0
Côte d'Ivoire	0.77382	84	0.38999	84	0

Source: Author.

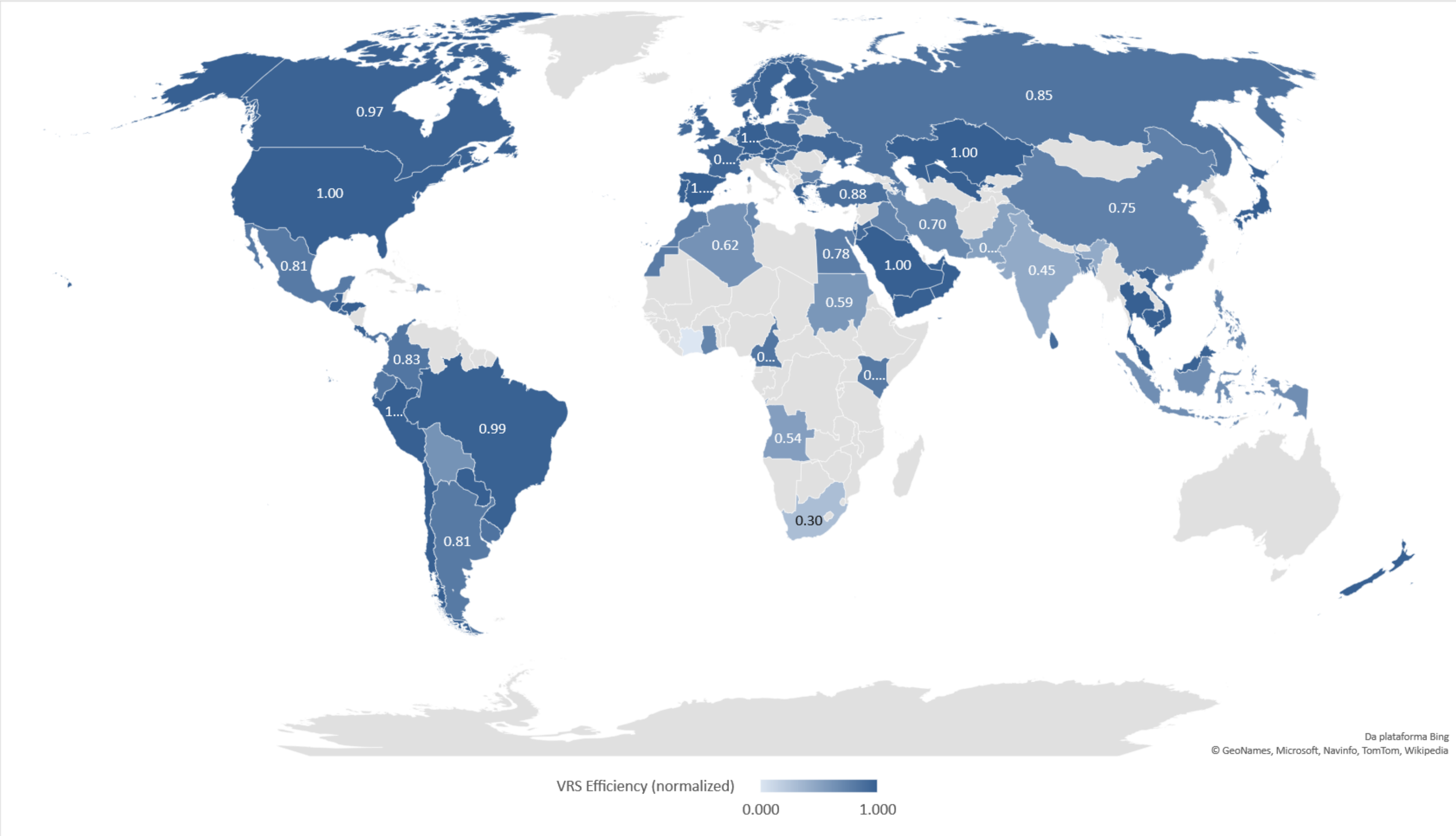
By the standard frontier of the VRS model, 27 countries were considered efficient in converting public investment in human development, namely Cambodia, Chile, the Democratic Republic of the Congo, Costa Rica, Germany, Guatemala, Honduras, Hong Kong, Israel, Japan, Kazakhstan, Kuwait, New Zealand, Oman, Paraguay, Peru, Portugal, Saudi Arabia, Singapore, Spain, Switzerland, Thailand, United Arab Emirates, United States, Uzbekistan, Vietnam and Yemen.

It can be observed in Table 7 from subchapter 4.5 that the efficient countries mentioned above share some common characteristics, such as (a) a high GDP per capita to promote human development, which is the case of Germany, Hong Kong, Japan, Kuwait, New Zealand, Oman, Saudi Arabia, Singapore, Switzerland, United Arab Emirates, and the United States; (b) a socialist past, which is the case of Cambodia, Kazakhstan, Uzbekistan, and Vietnam; and (c) a very low level of public investment per capita (inputs) that lead to high efficiency (lower than 400 of constant 2011 international dollars), which is the case of Cambodia, the Democratic Republic of the Congo, Guatemala, Honduras, Paraguay, Peru, Uzbekistan and Yemen. Chile, Costa Rica, Israel, Portugal, Spain, and Thailand were the countries that did not seem to fit any of the previous groups of countries.

When the inverted frontier analysis was applied to obtain the HDI-IGOV, countries with high levels of investment per capita achieved poor results and thus lost many positions in the HDI-IGOV ranking. This was the case of Singapore (from 1^{st} to 67^{th}), Hong Kong (from 1^{st} to 69^{th}), Oman (from 1^{st} to 71^{st}), Kuwait (from 1^{st} to 72^{nd}), United Arab Emirates (from 1^{st} to 77^{th}), and Saudi Arabia (from 1^{st} to 78^{th}). On the other hand, low and middle-income countries mostly maintained their position at the top, except for the Democratic Republic of the Congo (from 1^{st} to 75^{th}) and Yemen (from 1^{st} to 76^{th}), which had been benefited from the set of weights and its meager investment. Philippines and Indonesia were the countries that improved the most from the VRS efficiency ranking to the HDI-IGOV ranking.

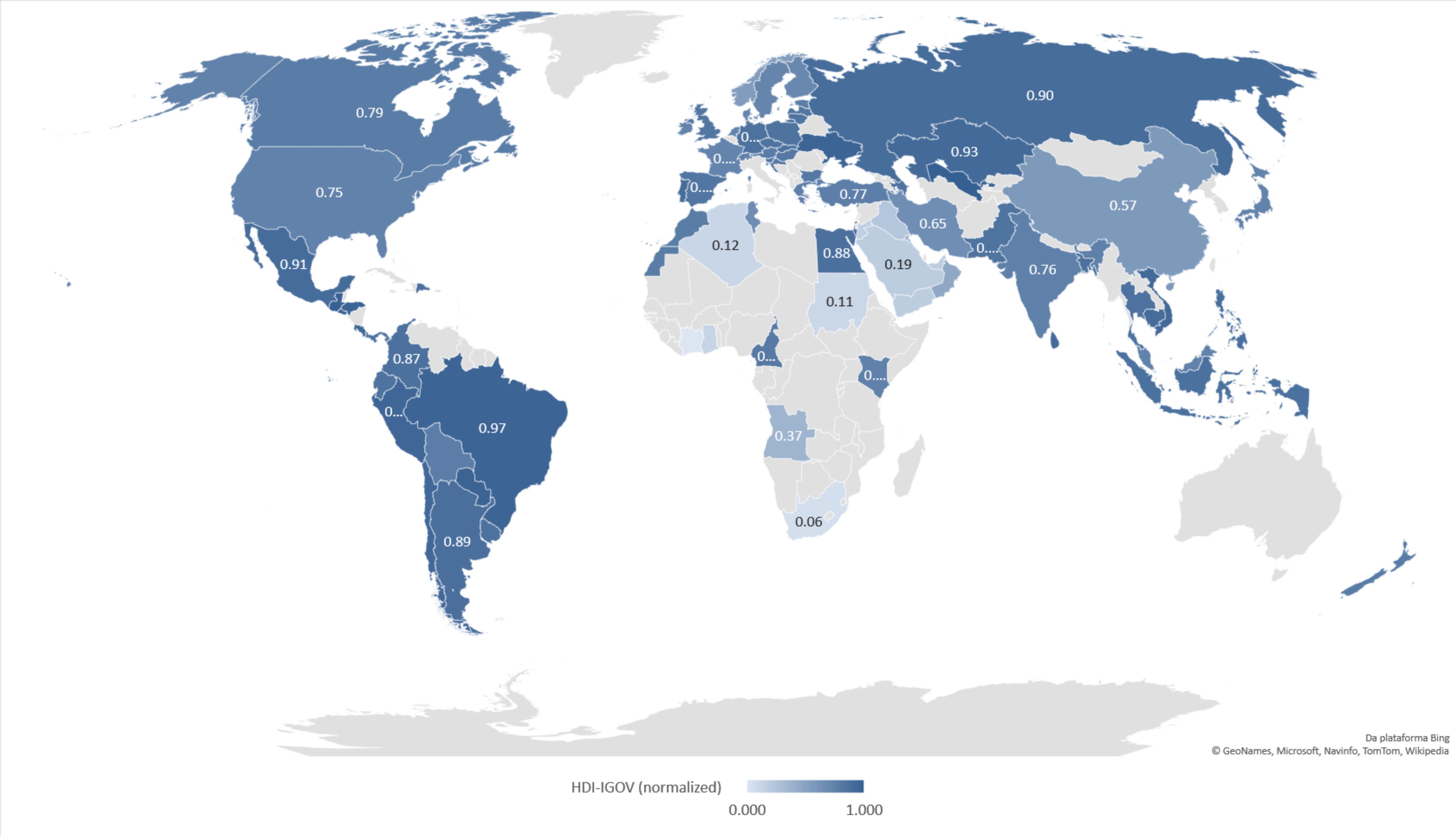
Figure 4 shows a map of social efficiency worldwide with public investment as an input variable of the VRS model (standard frontier). Figure 5 shows a social efficiency map measured by the HDI-IGOV composite index (standard and inverted frontier). For a better comparison between the two maps, a min-max normalization was applied for both indicators.

Figure 4 World's social efficiency for public investment (VRS model)



Source: Author.

Figure 5 World's HDI-IGOV composite index performance (standard and inverted frontier)



Source: Author.

4.3 Private Investment Efficiency Analysis in 2017

This subchapter presents the efficiency analysis for private investment. DEA results are shown in Table 4. The VRS efficiency and the HDI-IPRIV were normalized by the min-max technique and presented as VRS Efficiency$_n$ and HDI-IPRIV$_n$.

Table 4 DEA results for the social efficiency of private investment

Country	VRS Efficiency$_n$	Rank	HDI-IPRIV$_n$	Rank	Change in Rank
Bolivia	1.00000	1	1.00000	1	0
Uzbekistan	1.00000	1	0.99660	2	-1
Ukraine	1.00000	1	0.99078	3	-2
Azerbaijan	0.99011	48	0.97805	4	44
Vietnam	1.00000	1	0.97502	5	-4
Honduras	1.00000	1	0.97322	6	-5
El Salvador	0.98497	54	0.96736	7	47
Cambodia	1.00000	1	0.96525	8	-7
Kenya	1.00000	1	0.96522	9	-8
Paraguay	0.98757	49	0.96478	10	39
Pakistan	0.96575	67	0.96431	11	56
Ecuador	0.99951	32	0.96392	12	20
Peru	1.00000	1	0.95888	13	-12
Argentina	0.99287	43	0.95303	14	29
Guatemala	0.97706	61	0.94701	15	46
Sri Lanka	0.99053	47	0.94117	16	31
Bangladesh	0.96172	69	0.93517	17	52
Egypt	0.97244	64	0.93423	18	46
Costa Rica	1.00000	1	0.93151	19	-18
Bulgaria	0.98746	50	0.92455	20	30
Colombia	0.98282	56	0.92447	21	35
Poland	1.00000	1	0.91632	22	-21
Uruguay	0.98518	53	0.91005	23	30
Philippines	0.92837	77	0.90909	24	53
Kazakhstan	1.00000	1	0.90191	25	-24
Russia	0.97789	59	0.89183	26	33
Thailand	1.00000	1	0.89032	27	-26
Chile	1.00000	1	0.88736	28	-27
Iran	0.99422	41	0.87732	29	12
Brazil	0.94820	73	0.87710	30	43
Lithuania	1.00000	1	0.87083	31	-30
New Zealand	1.00000	1	0.87066	32	-31
Slovenia	0.99589	36	0.86797	33	3
Latvia	0.99158	44	0.86599	34	10
Mexico	0.94391	74	0.86560	35	39
Cameroon	0.97086	65	0.86556	36	29
India	0.89667	79	0.86389	37	42
Malaysia	0.99572	37	0.86135	38	-1
Slovak Republic	0.98633	52	0.85851	39	13

Table 4 Continued

Country	VRS Efficiency$_n$	Rank	HDI-IPRIV$_n$	Rank	Change in Rank
Tunisia	0.98151	57	0.85825	40	17
Hungary	0.97991	58	0.85593	41	17
Dominican Republic	0.93395	76	0.85556	42	34
Israel	1.00000	1	0.85123	43	-42
Estonia	0.99493	38	0.84397	44	-6
Iraq	0.94966	72	0.84369	45	27
United Kingdom	0.99111	46	0.83555	46	0
Japan	1.00000	1	0.82739	47	-46
Greece	1.00000	1	0.82601	48	-47
Portugal	0.99792	33	0.82270	49	-16
Czech Republic	0.99134	45	0.81982	50	-5
Morocco	0.96402	68	0.81977	51	17
Oman	1.00000	1	0.80576	52	-51
China	0.95928	70	0.80045	53	17
Indonesia	0.90762	78	0.80009	54	24
Canada	0.99636	34	0.79954	55	-21
Germany	1.00000	1	0.79495	56	-55
Croatia	0.96745	66	0.79173	57	9
Panama	0.95155	71	0.78077	58	13
Saudi Arabia	1.00000	1	0.78026	59	-58
Hong Kong SAR	1.00000	1	0.77167	60	-59
Sweden	0.99314	42	0.75701	61	-19
Finland	0.99448	39	0.75403	62	-23
Netherlands	0.97783	60	0.75301	63	-3
Austria	0.99973	30	0.74550	64	-34
Denmark	0.99597	35	0.73048	65	-30
United States	1.00000	1	0.71896	66	-65
Turkey	0.97297	63	0.71159	67	-4
France	0.98721	51	0.70985	68	-17
Spain	0.99954	31	0.68229	69	-38
Norway	0.98467	55	0.67096	70	-15
United Arab Emirates	1.00000	1	0.65283	71	-70
Switzerland	1.00000	1	0.64785	72	-71
Algeria	0.94316	75	0.58686	73	2
Angola	0.89129	80	0.53174	74	6
Kuwait	1.00000	1	0.53090	75	-74
Congo, Democratic Republic of the	1.00000	1	0.51072	76	-75
Singapore	1.00000	1	0.51072	77	-76
Yemen	1.00000	1	0.51072	78	-77
Jordan	0.99442	40	0.50787	79	-39
Ireland	0.97690	62	0.49893	80	-18
Ghana	0.86687	81	0.44273	81	0
South Africa	0.85129	82	0.43477	82	0
Sudan	0.84219	83	0.43013	83	0
Côte d'Ivoire	0.81641	84	0.41696	84	0

Source: Author.

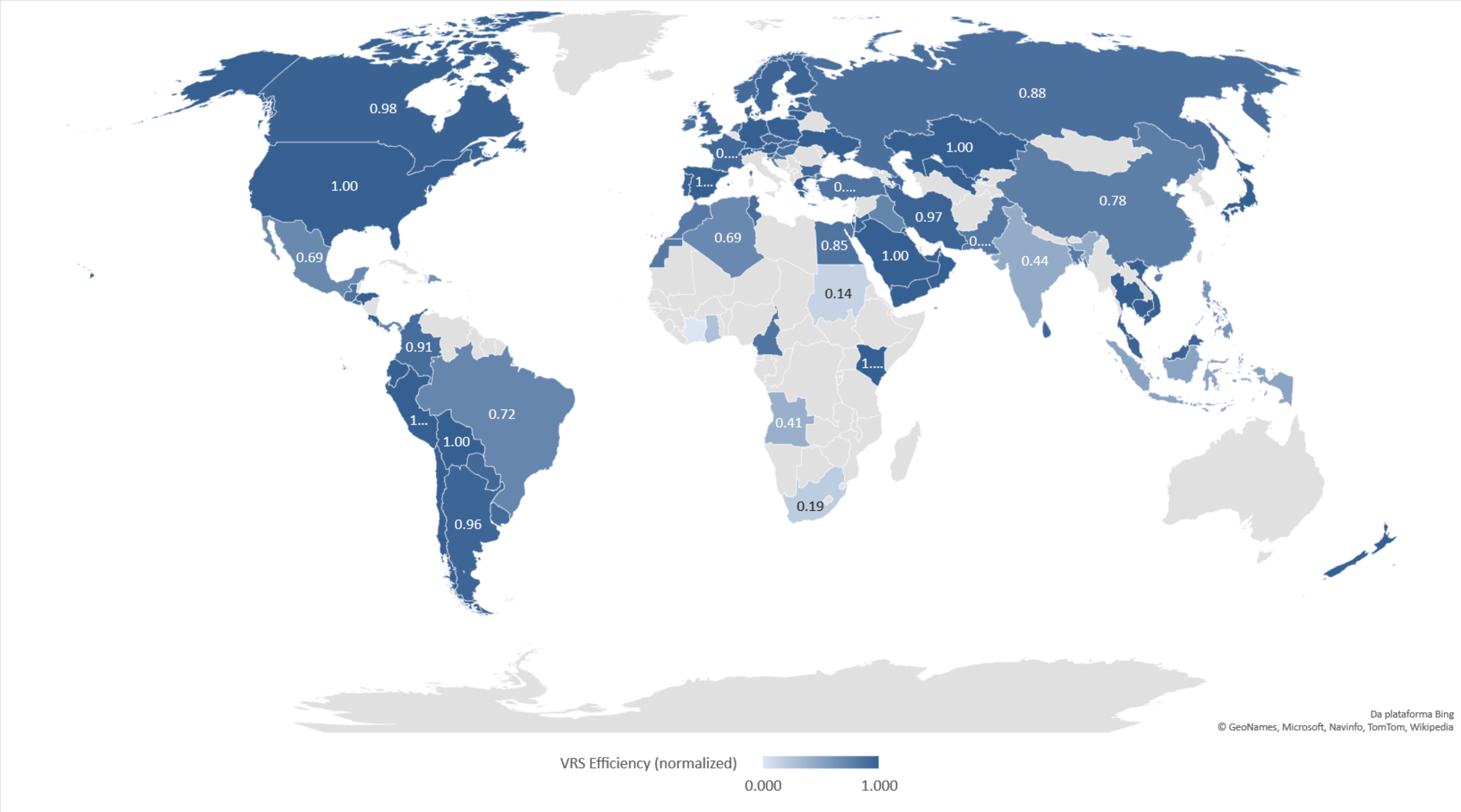
By the standard frontier of the VRS model, 29 countries were considered efficient in converting public investment in human development, namely Bolivia, Cambodia, Chile, the Democratic Republic of the Congo, Costa Rica, Germany, Greece, Honduras, Hong Kong, Israel, Japan, Kazakhstan, Kenya, Kuwait, Lithuania, New Zealand, Oman, Peru, Poland, Saudi Arabia, Singapore, Switzerland, Thailand, Ukraine, United Arab Emirates, United States, Uzbekistan, Vietnam and Yemen.

First, from Table 7 from subchapter 4.5, it can be observed that many countries that had been considered efficient in converting public investment into human development were also efficient for private investment. Bolivia, Greece, Kenya, Lithuania, Poland, and Ukraine were the countries that were among the efficient ones for the first time. Second, the same common characteristics from the previous subchapter can be identified among the 29 efficient countries: (a) a high GDP per capita to promote human development, which is the case of Germany, Hong Kong, Japan, Kuwait, New Zealand, Oman, Saudi Arabia, Singapore, Switzerland, United Arab Emirates, and the United States; (b) a socialist past, which is the case of Cambodia, Kazakhstan, Lithuania, Ukraine, Uzbekistan, and Vietnam; and (c) a very low level of private investment per capita (inputs) that lead to high efficiency (lower than 1,200 of constant 2011 international dollars), which is the case of Bolivia, Cambodia, the Democratic Republic of the Congo, Honduras, Kenya, Ukraine, Uzbekistan, Vietnam, and Yemen. Additionally, Chile, Costa Rica, Greece, Israel, Peru, Poland, and Thailand were the only countries that did not fit any previous groups.

When the inverted frontier analysis was applied to obtain the HDI-IPRIV, again, countries with high investment per capita levels achieved poor results and thus lost many positions in the HDI-IPRIV ranking. This was the case of United Arab Emirates (from 1st to 71st), Switzerland (from 1st to 72nd), Kuwait (from 1st to 75th), and Singapore (from 1st to 77th). On the other hand, low and middle-income countries mostly maintained their position in the top, except for the Democratic Republic of the Congo (from 1st to 76th) and Yemen (from 1st to 77th), which had been benefited from the set of weights and its meager investment. Pakistan and Philippines were the countries that improved the most from the VRS efficiency ranking to the HDI-IPRIV ranking.

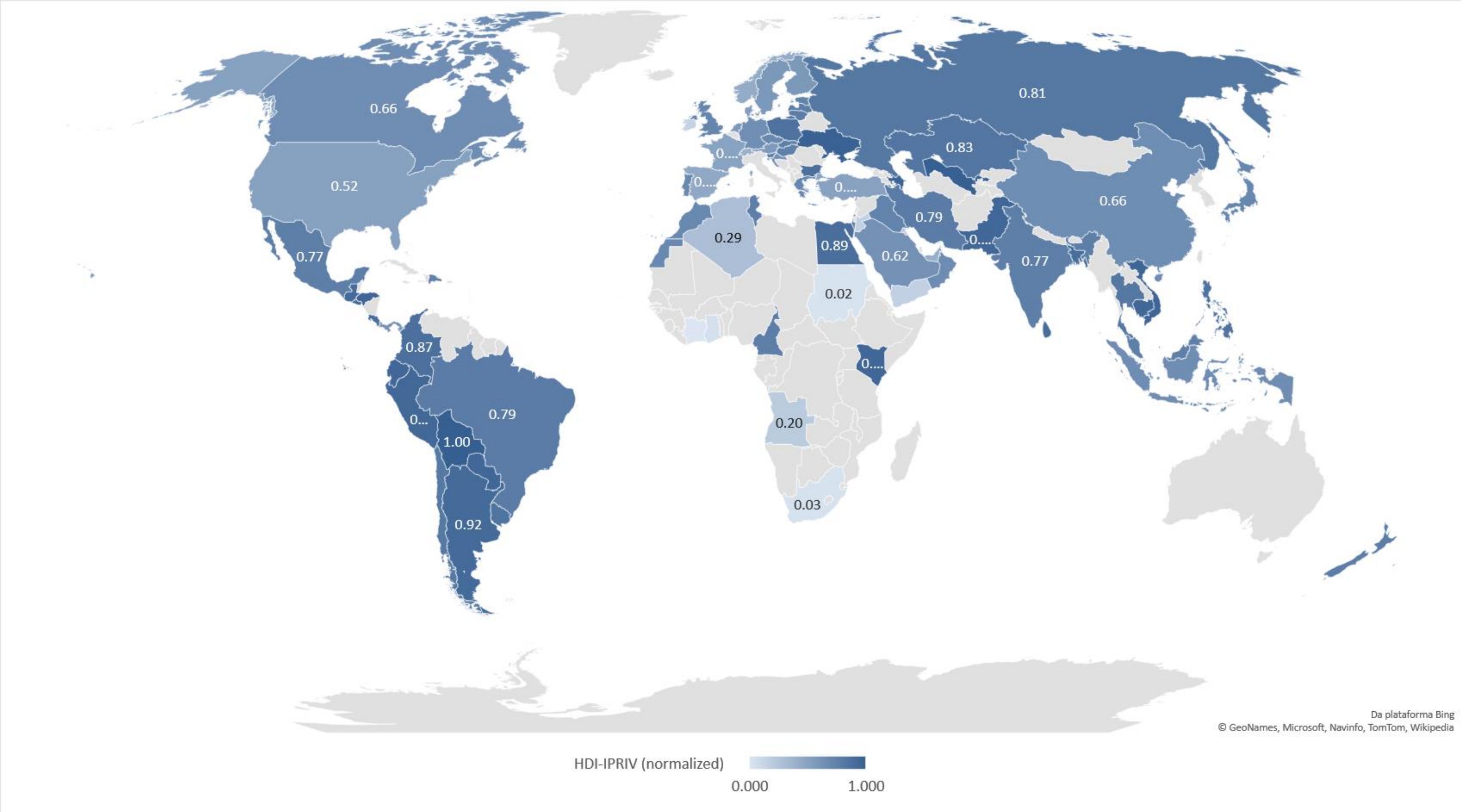
Figure 7 shows a social efficiency map measured by the HDI-IPRIV composite index (standard and inverted frontier). For a better comparison between the two maps, a min-max normalization was applied for both indicators.

Figure 6 World's social efficiency for private investment (VRS model)



Source: Author.

Figure 7 World's HDI-IPRIV composite index performance (standard and inverted frontier)



Source: Author.

4.4 Total Investment Efficiency Analysis in 2017

This subchapter presents the efficiency analysis for both public and private investment. DEA results are shown in Table 5. The VRS efficiency and the HDI-ITOT were normalized by the min-max technique and presented as VRS Efficiency$_n$ and HDI-ITOT$_n$.

Table 5 DEA results for the social efficiency of total investment

Country	VRS Efficiency$_n$	Rank	HDI-ITOT$_n$	Rank	Change in Rank
Uzbekistan	1.00000	1	1.00000	1	0
Ukraine	1.00000	1	0.98717	2	-1
Honduras	1.00000	1	0.97705	3	-2
Paraguay	1.00000	1	0.97335	4	-3
El Salvador	0.98829	52	0.97310	5	47
Vietnam	1.00000	1	0.96765	6	-5
Guatemala	1.00000	1	0.96273	7	-6
Pakistan	0.97176	66	0.96152	8	58
Peru	1.00000	1	0.95444	9	-8
Cambodia	1.00000	1	0.95385	10	-9
Azerbaijan	0.99011	51	0.95346	11	40
Ecuador	0.99951	35	0.94489	12	23
Argentina	0.99287	46	0.93627	13	33
Costa Rica	1.00000	1	0.93269	14	-13
Sri Lanka	0.99183	47	0.92968	15	32
Bolivia	1.00000	1	0.92775	16	-15
Bangladesh	0.96172	71	0.92124	17	54
Colombia	0.98282	58	0.91742	18	40
Egypt	0.97244	65	0.91306	19	46
Philippines	0.93297	78	0.90648	20	58
Brazil	0.99701	36	0.90580	21	15
Uruguay	0.98518	56	0.90427	22	34
Kazakhstan	1.00000	1	0.89682	23	-22
Bulgaria	0.98746	53	0.89480	24	29
Chile	1.00000	1	0.89107	25	-24
Poland	1.00000	1	0.88771	26	-25
Russia	0.97843	62	0.88752	27	35
Thailand	1.00000	1	0.88746	28	-27
Kenya	1.00000	1	0.88694	29	-28
Mexico	0.95669	73	0.87513	30	43
Dominican Republic	0.93698	77	0.85944	31	46
Lithuania	1.00000	1	0.85410	32	-31
Cameroon	0.97144	67	0.85120	33	34
Latvia	0.99158	48	0.84751	34	14
Israel	1.00000	1	0.84321	35	-34
Slovak Republic	0.98633	55	0.84227	36	19
India	0.89667	81	0.83766	37	44
Slovenia	0.99603	38	0.83549	38	0
New Zealand	1.00000	1	0.83152	39	-38

Table 5 Continued

Country	VRS Efficiency$_n$	Rank	HDI-ITOT$_n$	Rank	Change in Rank
Portugal	1.00000	1	0.82720	40	-39
Hungary	0.97991	61	0.82069	41	20
United Kingdom	0.99111	50	0.81217	42	8
Iran	0.99422	44	0.81085	43	1
Indonesia	0.92236	79	0.80996	44	35
Malaysia	0.99572	40	0.80804	45	-5
Czech Republic	0.99134	49	0.80731	46	3
Estonia	0.99493	41	0.80350	47	-6
Morocco	0.96402	69	0.79331	48	21
Greece	1.00000	1	0.79243	49	-48
Panama	0.96401	70	0.78961	50	20
Tunisia	0.98151	60	0.78912	51	9
Germany	1.00000	1	0.78681	52	-51
Croatia	0.97004	68	0.77608	53	15
Canada	0.99636	37	0.76451	54	-17
Japan	1.00000	1	0.75429	55	-54
China	0.95928	72	0.73604	56	16
Netherlands	0.97807	63	0.71505	57	6
Austria	0.99973	34	0.70820	58	-24
Sweden	0.99314	45	0.69791	59	-14
United States	1.00000	1	0.68846	60	-59
Turkey	0.97297	64	0.68578	61	3
Oman	1.00000	1	0.68203	62	-61
Spain	1.00000	1	0.68078	63	-62
Finland	0.99448	42	0.67974	64	-22
Denmark	0.99597	39	0.67899	65	-26
France	0.98738	54	0.66455	66	-12
Hong Kong SAR	1.00000	1	0.64034	67	-66
Switzerland	1.00000	1	0.63793	68	-67
Norway	0.98467	57	0.56551	69	-12
Iraq	0.94966	74	0.55083	70	4
Congo, Democratic Republic of the	1.00000	1	0.51286	71	-70
Kuwait	1.00000	1	0.51286	72	-71
Yemen	1.00000	1	0.51286	73	-72
Singapore	1.00000	1	0.51286	74	-73
United Arab Emirates	1.00000	1	0.51286	75	-74
Saudi Arabia	1.00000	1	0.51286	76	-75
Jordan	0.99442	43	0.50999	77	-34
Ireland	0.98191	59	0.50358	78	-19
Angola	0.89511	82	0.49764	79	3
Algeria	0.94316	75	0.48371	80	-5
Ghana	0.93785	76	0.48098	81	-5
Sudan	0.90769	80	0.46551	82	-2
South Africa	0.85403	83	0.43800	83	0
Côte d'Ivoire	0.82250	84	0.42182	84	0

Source: Author.

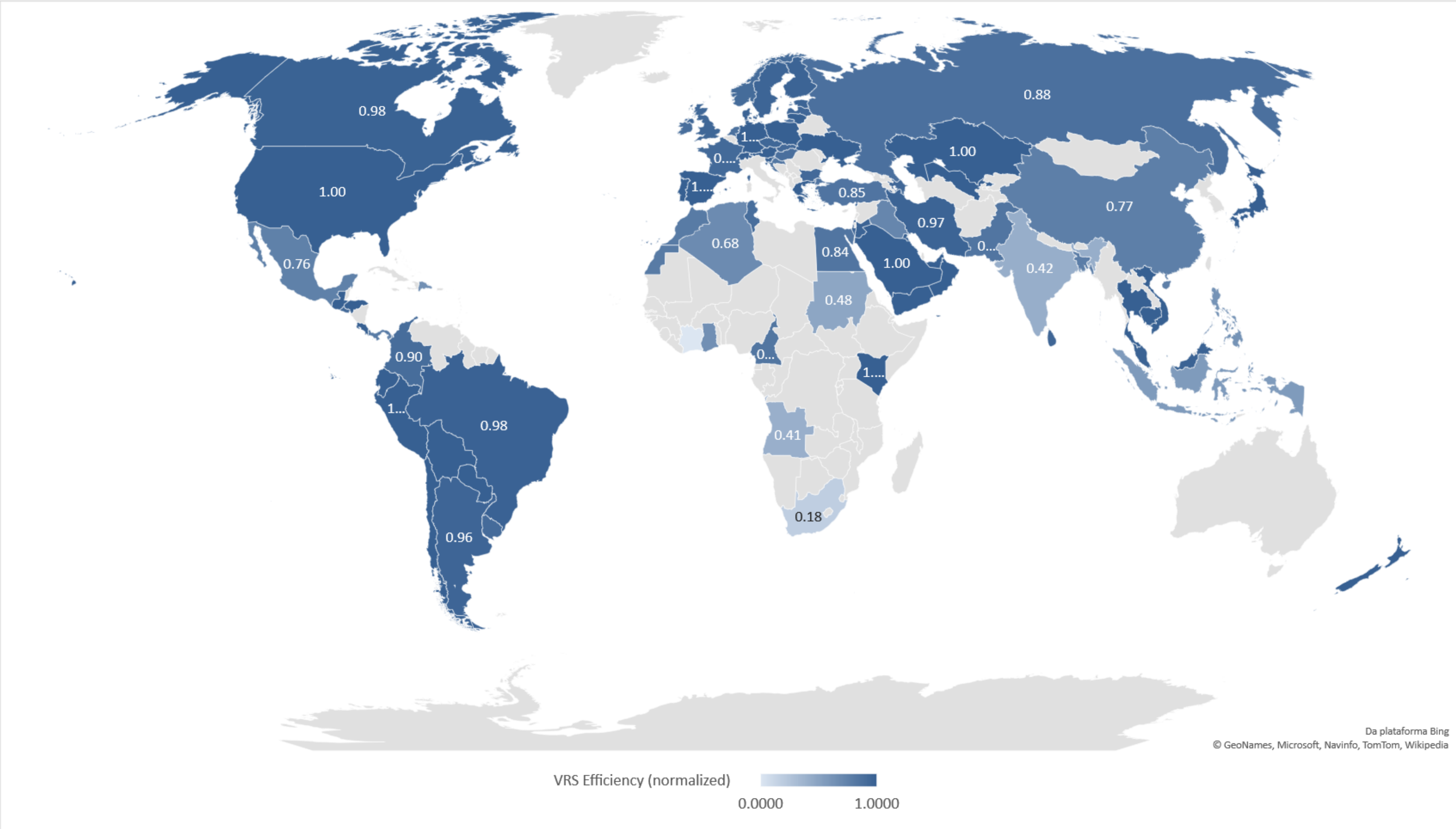
By the standard frontier of the VRS model, 33 countries were considered efficient in converting public and private investment in human development, namely Bolivia, Cambodia, Chile, the Democratic Republic of the Congo, Costa Rica, Germany, Greece, Guatemala, Honduras, Hong Kong, Israel, Japan, Kazakhstan, Kenya, Kuwait, Lithuania, New Zealand, Oman, Paraguay, Peru, Poland, Portugal, Saudi Arabia, Singapore, Spain, Switzerland, Thailand, Ukraine, United Arab Emirates, United States, Uzbekistan, Vietnam and Yemen.

As expected, the countries that had been considered efficient in converting private and public investment into human development stood out once more in the analysis of this subchapter. Moreover, the same common characteristics from the previous subchapters could be used to separate the countries in the following way: (a) Germany, Hong Kong, Japan, Kuwait, New Zealand, Oman, Saudi Arabia, Singapore, Switzerland, United Arab Emirates, and the United States with a high GDP per capita to promote human development; (b) Cambodia, Kazakhstan, Lithuania, Ukraine, Uzbekistan, and Vietnam with a socialist past; and (c) Bolivia, Cambodia, the Democratic Republic of the Congo, Guatemala, Honduras, Kenya, Paraguay, Ukraine, Uzbekistan, Vietnam, and Yemen with an extremely low level of total investment per capita (inputs) that lead to high efficiency (lower than 1,600 of constant 2011 international dollars). Lastly, Chile, Costa Rica, Greece, Israel, Peru, Poland, Portugal, Spain, and Thailand were the countries that did not seem to fit any of the previous groups.

Once more, when the inverted frontier analysis was applied to obtain the HDI-IPRIV, countries with high levels of investment achieved poor results and thus lost many positions in the HDI-ITOT ranking. This was the case of Hong Kong (from 1^{st} to 67^{th}), Switzerland (from 1^{st} to 68^{th}), Kuwait (from 1^{st} to 72^{nd}), Singapore (from 1^{st} to 74^{th}), United Arab Emirates (from 1^{st} to 75^{th}), and Saudi Arabia (from 1^{st} to 76^{th}). On the other hand, low and middle-income countries mostly maintained their position at the top, except for the Democratic Republic of the Congo (from 1^{st} to 71^{st}) and Yemen (from 1^{st} to 73^{rd}), which had been benefited from the set of weights and its meager investment. Bangladesh and Philippines were the countries that improved the most from the VRS efficiency ranking to the HDI-ITOT ranking.

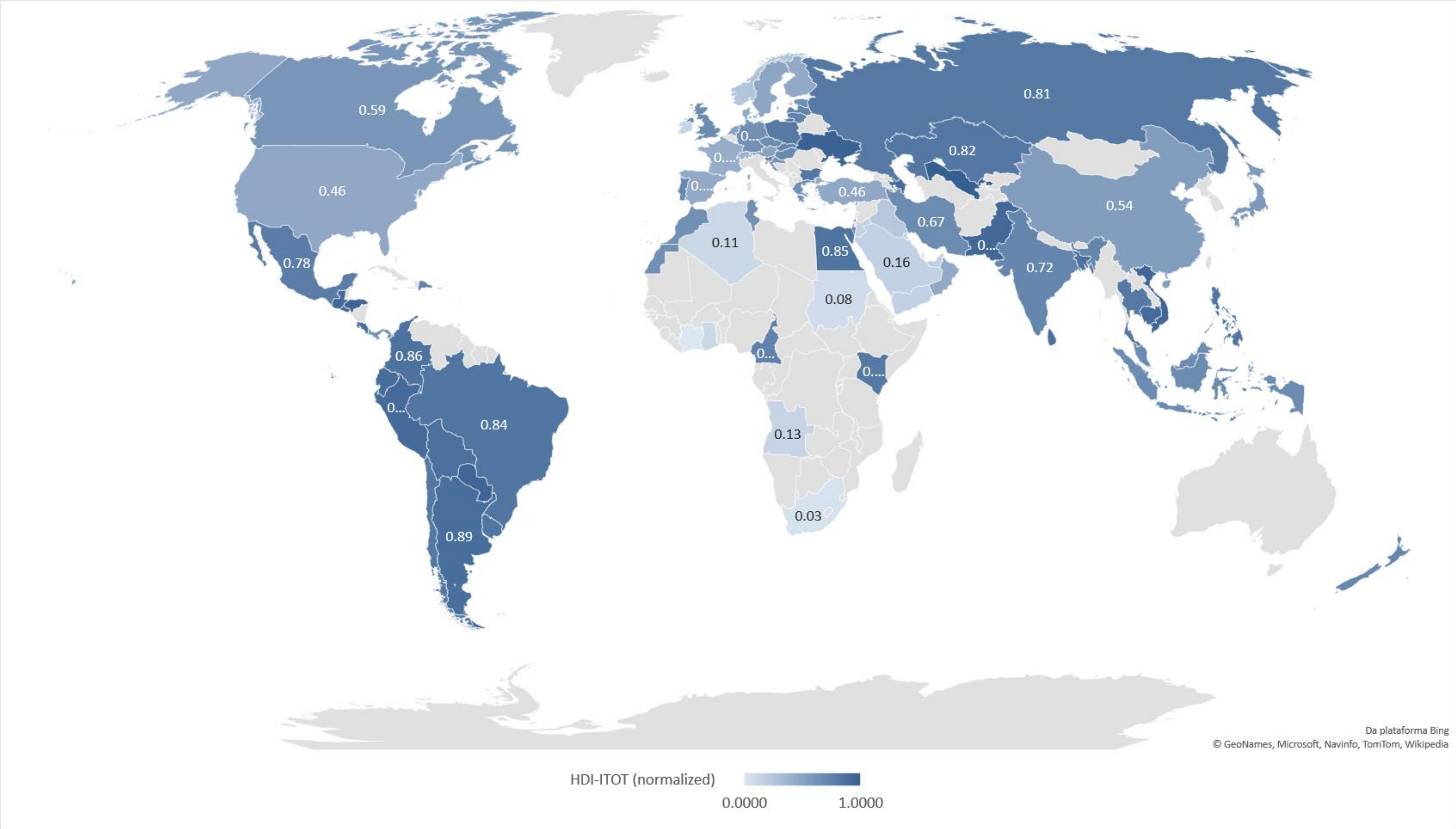
Figure 8 shows a map of social efficiency worldwide with public and private investment as input variables for the VRS model (standard frontier). Figure 9 shows a social efficiency map measured by the HDI-ITOT composite index (standard and inverted frontier). For a better comparison between the two maps, a min-max normalization was applied for both indicators.

Figure 8 World's social efficiency for total investment (VRS model)



Source: Author.

Figure 9 World's HDI-ITOT composite index performance (standard and inverted frontier)



Source: Author.

4.5 Concluding Remarks

This chapter intended to evaluate the efficiency of countries to convert public and private investment into human development. The results obtained by the VRS model of DEA has shown that many countries that had been considered efficient in previous studies about social efficiency also stood out in this analysis as shown in Table 6 (DESPOTIS, 2005a, 2005b; MARIANO; REBELATTO, 2014; RAAB; KOTAMRAJU; HAAG, 2000). Countries that appeared for the first time in the standard frontier were Bolivia, Cambodia, the Democratic Republic of the Congo, Guatemala, Honduras, Israel, Kazakhstan, Kenya, Kuwait, Lithuania, Oman, Paraguay, Peru, Poland, Portugal, Saudi Arabia, Singapore, Switzerland, Thailand, United Arab Emirates, and United States. This might have occurred because of the deficient level of investment per capita, which is the case of Bolivia, Cambodia, the Democratic Republic of the Congo, Guatemala, Honduras, Kenya, and Paraguay, or because those countries were outside the scope of their research or also because the indicators and methods differed. Nonetheless, countries such as Kuwait and the United Arab Emirates were mentioned in the literature as more efficient than others in using their economic wealth to improve social indicators (DRÈZE; SEN, 2003).

Table 6 Efficiency results of previous studies

Author	Scope of analysis	Social information	Efficient countries
Raab et al. (2000)	Underdeveloped countries (38 countries)	Seven child quality of life indicators	Costa Rica, Chile, Jamaica, and Uruguay
Despotis (2005a)	Asia and Pacific (27 countries)	HDI indicators	Fiji, Hong Kong, Mongolia, Myanmar, Nepal, Philippines, Solomon Islands, South Korea, Sri Lanka, and Vietnam
Despotis (2005b)	World (174 countries)	HDI indicators	Armenia, Azerbaijan, Canada, Cuba, Estonia, Georgia, Greece, Jamaica, Japan, Malawi, New Zealand, Sierra Leone, Solomon Islands, Spain, Sweden, Tajikistan, Tanzania, Ukraine, The United Kingdom, and Yemen
Mariano and Rebelatto (2014)	World (101 countries)	10 indicators	Albania, Armenia, Australia, Bangladesh, Belarus, The Czech Republic, Estonia, Georgia, Germany, Hungary, Japan, Kyrgyzstan, Malta, Moldova, Montenegro, Mozambique, Norway, South Korea, Sweden, Tajikistan, Ukraine, Uzbekistan, and Vietnam

Source: Author.

The inverted frontier method had the same effects in this study as the ones observed in Mariano and Rebelatto (2014), where developed countries with high GDP per capita were penalized while low and middle-income countries maintained or even improved their results. This might indicate that those developed countries could achieve an even better performance despite having good social indicators. However, it must be taken into account that this study considered only four outputs variables that represent basic capabilities. According to UNDP (2019), inequalities in basic capabilities are shrinking, whereas inequalities are increasing in enhanced capabilities, which reflect aspects of life that will be more empowering and likely become more critical in the future. Thus, a further analysis considering enhanced capabilities as output variables is suggested for future research.

Regarding the composite indicators HDI-IGOV, HDI-IPRIV, and HDI-ITOT, one should note the concentration of former Soviet republics and past socialist countries in the highest ranks, the same result observed in previous studies. Nonetheless, Uzbekistan, Honduras, Ukraine, El Salvador, and Paraguay were the countries that achieved the best performance for all three indicators. This result might have occurred due to their low level of investment per capita compared to other countries. On the other hand, countries such as Ghana, Sudan, South Africa, and Côte d'Ivoire ranked last even with low investment per capita levels. Furthermore, Yemen and the Democratic Republic of the Congo, which had been considered efficient by the standard frontier for all input variables, were significantly penalized because of their poor performance in more than one social indicator. Moreover, it is noteworthy that while most countries achieved similar results for public and private investment, some have shown disparities between their efficiencies, which was the case of Bolivia (49^{th} for HDI-IGOV and 1^{st} for HDI-IPRIV), Kenya (55^{th} for HDI-IGOV and 9^{th} for HDI-IPRIV), Iran (66^{th} for HDI-IGOV and 29^{th} for HDI-IPRIV), Portugal (14^{th} for HDI-IGOV to 49^{th} for HDI-IPRIV) and Indonesia (22^{nd} for HDI-IGOV to 54^{th} for HDI-IPRIV). This result is important because it might help policymakers understand which investment should be prioritized or focused on improvements.

Table 7 Summary of efficient countries (standard frontier)

Country	HDI-ITOT Rank	HDI-IGOV Rank	HDI-IPRIV Rank	IGOV (US$ Billions)	IPRIV (US$ Billions)	GDP per Capita (US$)	SR (%)	ER (%)	LEB (Years)	MYS (Years)	Efficient for (Input of VRS Model)
Uzbekistan	1.0	1.0	2.0	74.7	531.3	9,475.0	100.0	61.2	71.4	11.5	IGOV, IPRIV, ITOT
Ukraine	2.0	7.0	3.0	151.9	576.1	8,858.4	96.2	49.3	71.8	11.3	IPRIV, ITOT
Honduras	3.0	3.0	6.0	158.3	709.4	4,441.0	81.3	63.3	74.9	6.6	IGOV, IPRIV, ITOT
Paraguay	4.0	5.0	10.0	251.8	1,045.7	8,874.9	89.8	67.3	74.0	8.4	IGOV, ITOT
Vietnam	6.0	11.0	5.0	502.3	969.8	6,431.0	83.5	76.2	75.2	8.2	IGOV, IPRIV, ITOT
Guatemala	7.0	2.0	15.0	85.5	884.8	7,623.9	65.1	60.7	73.8	6.5	IGOV, ITOT
Peru	9.0	8.0	13.0	397.5	1,520.6	12,078.8	74.3	74.3	76.3	9.2	IGOV, IPRIV, ITOT
Cambodia	10.0	15.0	8.0	209.4	409.5	3,441.1	59.2	81.7	69.3	4.8	IGOV, IPRIV, ITOT
Costa Rica	14.0	10.0	19.0	423.4	2,073.5	14,580.5	97.8	55.3	79.9	8.7	IGOV, IPRIV, ITOT
Bolivia	16.0	49.0	1.0	755.1	411.4	6,468.6	60.7	66.5	70.9	9.0	IPRIV, ITOT
Kazakhstan	23.0	12.0	25.0	586.3	2,824.2	24,585.6	97.9	65.9	73.0	11.8	IGOV, IPRIV, ITOT
Chile	25.0	9.0	28.0	477.9	3,942.9	21,624.7	100.0	58.0	79.9	10.4	IGOV, IPRIV, ITOT
Poland	26.0	31.0	22.0	857.3	3,066.2	27,050.3	98.8	54.3	77.8	12.3	IPRIV, ITOT
Thailand	28.0	30.0	27.0	875.6	2,511.1	15,844.6	98.8	66.7	76.7	7.7	IGOV, IPRIV, ITOT
Kenya	29.0	55.0	9.0	189.0	252.1	3,057.5	29.1	72.8	65.9	6.5	IPRIV, ITOT
Lithuania	32.0	35.0	31.0	788.7	4,064.0	27,115.2	93.4	56.6	75.5	13.0	IPRIV, ITOT
Israel	35.0	20.0	43.0	920.2	6,273.6	31,138.6	100.0	61.4	82.6	13.0	IGOV, IPRIV, ITOT
New Zealand	39.0	45.0	32.0	1,750.0	5,449.7	35,524.7	100.0	66.8	81.7	12.7	IGOV, IPRIV, ITOT
Portugal	40.0	14.0	49.0	604.5	4,873.0	27,815.1	99.6	53.8	81.4	9.2	IGOV, ITOT
Greece	49.0	52.0	48.0	667.6	2,486.8	25,315.3	99.0	41.0	81.3	10.5	IPRIV, ITOT
Germany	52.0	29.0	56.0	979.3	7,969.0	46,085.6	99.2	58.2	81.0	14.1	IGOV, IPRIV, ITOT
Japan	55.0	59.0	47.0	1,864.9	7,152.1	39,072.5	99.9	59.2	84.1	12.8	IGOV, IPRIV, ITOT
United States	60.0	56.0	66.0	1,829.3	9,576.5	54,497.9	100.0	59.6	78.5	13.4	IGOV, IPRIV, ITOT
Oman	62.0	71.0	52.0	4,415.8	5,677.3	38,584.0	100.0	69.4	77.4	9.7	IGOV, IPRIV, ITOT
Spain	63.0	38.0	69.0	810.8	7,606.1	34,712.9	99.9	48.0	83.3	9.8	IGOV, ITOT

Table 7 Continued

Country	HDI-ITOT Rank	HDI-IGOV Rank	HDI-IPRIV Rank	IGOV (US$ Billions)	IPRIV (US$ Billions)	GDP per Capita (US$)	SR (%)	ER (%)	LEB (Years)	MYS (Years)	Efficient for (Input of VRS Model)
Hong Kong	67.0	69.0	60.0	3,028.5	8,782.4	50,088.4	96.4	58.7	84.7	12.0	IGOV, IPRIV, ITOT
Switzerland	68.0	54.0	72.0	1,942.8	13,769.6	56,316.3	99.9	65.1	83.6	13.4	IGOV, IPRIV, ITOT
Congo, Democratic Republic of the	71.0	75.0	76.0	26.5	114.9	788.3	20.5	61.1	60.0	6.8	IGOV, IPRIV, ITOT
Kuwait	72.0	72.0	75.0	3,454.5	8,602.0	66,781.5	100.0	71.9	75.3	7.3	IGOV, IPRIV, ITOT
Yemen	73.0	76.0	78.0	3.8	90.1	1,878.8	59.1	32.8	66.1	3.0	IGOV, IPRIV, ITOT
Singapore	74.0	67.0	77.0	3,530.7	17,615.4	70,340.5	100.0	68.0	83.1	11.5	IGOV, IPRIV, ITOT
United Arab Emirates	75.0	77.0	71.0	8,219.9	10,928.5	76,639.9	98.6	80.3	77.6	10.9	IGOV, IPRIV, ITOT
Saudi Arabia	76.0	78.0	59.0	4,868.0	5,751.3	51,365.6	100.0	52.7	74.9	9.7	IGOV, IPRIV, ITOT

Source: Author; UNDP; World Bank.

5 CONCLUSION

This research aimed to analyze the efficiency of countries in converting public and private investment into human development. To this end, the association between those variables was first validated prior to the DEA's efficiency analysis. Thus, this study sought to contribute to the social efficiency discussion by analyzing the impact of the public and private sectors separately. As a result, the assumption of the causal relationship between the investment of both sectors and the social indicators was confirmed by econometry.

Regarding the social indicators, it should be mentioned that their selection was based on the literature, and this study did not intend to establish a set of indicators for human development, which is still a promising field of research. Moreover, one could notice that only the most traditional human development dimensions were used in this research. This simplification was necessary to achieve the highest number of countries in the analysis without dealing with missing data. Therefore, future work can also focus on a broader set of social indicators to analyze public and private investment efficiency.

Although the tiebreaker method of the inverted frontier was applied in this study, other methods such as the cross-evaluation could be used in future research for comparison. Furthermore, additional tools and models of the DEA could be explored, particularly those for time analysis, such as the Malmquist index or the Window Analysis, where the impact of investment over time could also be assessed. Finally, weight restrictions and the use of a temporal lag between the inputs and outputs are other tools that were applied in previous analyses and could be used in future work to assess the efficiency of investment.

Additionally, the three composite indices developed in this study to assess the social efficiency of public and private investment among nations can also be applied by policy makers and international organizations. The OECD, for example, may use those indicators to evaluate which inefficient countries requires policy reforms to improve the quality of their investments more urgently. Multilateral development banks, on the other hand, might be interested in which countries could seize their resources to improve human development more efficiently

As for the results, one can observe that the countries regarded as efficient by the VRS model of this study were mostly mentioned in previous analyses. As discussed by Mariano and Rebelatto (2014), many of those countries had a socialist past. However, regarding the composite indices obtained in this study (HDI-IGOV, HDI-IPRIV, and HDI-ITOT), it should be noted that countries with the lowest levels of investment per capita were intensively benefited. This confirms Ferraz (2019) remarks that the interpretation of those indicators should be made with caution, requiring further analysis, particularly of the countries at the top of the ranking and in the economic development process.

Lastly, future research can complement the results found in this study by further investigating the investment strategies and policies adopted in the countries regarded as efficient. This is particularly important in the context of nations where private investment participation is becoming more relevant over time, especially in sectors that are closely related to the quality of life, such as public infrastructure.

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