SSE RIGA

Bachelor Thesis

# The Efficiency of Public Healthcare Spending in Latvia

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**List of Abbreviations**

DEA – Data Envelopment Analysis

DMU – Decision Making Unit

EU – European Union

FDH – Free Disposal Hull

GDP – Gross Domestic Product

OECD – The Organization for Economic Co-operation and Development

SFA – Stochastic Frontier Analysis

WHO – World Health Organization

**Abstract**

This paper assesses the efficiency of public spending in healthcare in Latvia compared to other OECD countries using the Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA) methods. While Latvia achieves relatively high intermediate outputs (hospital beds/doctors/nurses per capita) with rather low spending, these intermediate outputs do not automatically translate into longer life expectancy, suggesting low system efficiency. The findings also imply that higher healthcare spending efficiency is consistently associated with greater government accountability and lower corruption; moreover, life expectancy is negatively related to alcohol and sugar consumption. Overall, Latvia could increase life expectancy by almost six years, by raising healthcare system efficiency and achieving healthier lifestyles.

## 1. Introduction

The role of the government is to ensure economic growth and social welfare given the continuous pressure on the budget balance. Moreover, non-discretionary factors, such as globalization and ageing population, might pose additional challenge from both revenue and spending side (Deroose & Kastrop, 2008). As a result, one of the government's main objectives is to maximize the efficiency of the public spending, which is generating more economic activity and social welfare with the same level of expenditure or achieving the same standard of living with lower spending. By dividing the total public spending into separate categories and assessing their efficiency individually, it would be significantly easier to identify and implement the relevant reforms in order to maximize the efficiency. Social, educational, healthcare expenditures are among the most important categories to consider. First, these spending categories represent considerable shares of GDP. Consequently, by managing them efficiently, the government will improve the budget sustainability. Second, these categories are especially relevant for creating social welfare and improving the standard of living. However, higher spending does not always translate into more welfare. To make appropriate reforms, the government should rely on efficiency evaluation. This paper focuses on the case of Latvian healthcare system. It aims at identifying the relative position of the country as compared to other OECD members when it comes to maximizing the health status of the society without wasteful spending.

Recent OECD (2017) reports characterize the Latvian health system and health outcomes as significantly improving over the last decade. Although with a positive outlook, Latvia still lags behind other EU members. According to OECD, the healthcare system is extremely underfunded. In 2015, Latvia recorded the second lowest level of healthcare spending in the EU (after Romania), in terms of both expenditure per capita and spending as a share of GDP (OECD, 2017). On the other hand, health outcomes are also lagging behind. Latvia has recorded to have the third lowest life expectancy among all the EU members, with 74.8 years compared to the EU average of 80.6 years. Additionally, Latvia has the highest rate of amenable mortality for men, and second highest for women, when compared to other EU countries (OECD, 2017). The amenable mortality rate is the rate of deaths that could be prevented given appropriate health care. Consequently, it is imperative to assess the efficiency of the Latvian public expenditure in healthcare to identify the right direction of reform.

During the last fifteen years, economists have evaluated the efficiency of public spending in different countries by constructing an efficient frontier (e.g., Afonso & Kazemi, 2016; Grigoli, 2012; Jafarov & Gunnarsson, 2008). Afterwards, they position each country on the graph and assess its distance relative to the efficient frontier. Being on the frontier means that the country has managed to maximize its efficiency of public spending. Any position below the frontier signals that the country could decrease its expenditures in the sector and still achieve the same outcomes, or it could improve the outcomes without increased spending.

Besides finding out whether the country is efficient in managing its resources, it is also important to highlight which factors are associated with a more efficient healthcare spending. As countries become wealthier, the demand for public services tends to go up (also known as Wagner’s law). To avoid a significant increase in the tax burden, it is imperative that the country continuously improves its spending efficiency (Hauner & Kyobe, 2008). Knowing the factors that have an impact on the efficiency level will help policymakers to find the right instruments in order to ensure the improvement of spending efficiency.

Generally, there are two categories of methods that are widely used to estimate the frontier, non-parametric and parametric (Lovell, Schmidt, & Fried, 2007). The non-parametric methods are easier to implement since they do not require many assumptions and strict functional form; however, they also have the disadvantage of considering the whole residual as inefficiency. They are used for relative efficiency analysis. Countries that are the most efficient are assumed to be maximizing their efficiency, and as a result they form the frontier. In the case of parametric methods, the residual is split in two parts, inefficiency and an error term related to random events. The frontier is estimated based on the functional form assumed. In both cases, countries are then benchmarked against the frontier: the larger the distance, the more inefficient the country is considered.

In the literature, the most popular non-parametric method to evaluate the efficiency of a country’s public expenditure is Data Envelopment Analysis (DEA) (e.g., Afonso, Schuknecht, & Tanzi, 2008; Hauner & Kyobe, 2008; de Cos & Moral-Benito, 2014). Recently, the parametric Stochastic Frontier Analysis (SFA) has gained popularity among the researchers (e.g., Wranik, 2012; Afonso & St. Aubyn, 2010). Given a well-defined functional form, SFA might be superior to DEA, because it does not assume that a country that is the most efficient among other countries cannot improve its level of efficiency.

This paper addresses the following two research questions:

**1) How efficient is the Latvian healthcare system?**

**2) What factors could improve healthcare spending efficiency?**

The efficiency analysis employs both Data Envelopment Analysis and Stochastic Frontier Analysis. It aims to identify by how much it could improve the current outcomes without spending more. It also evaluates the factors that could have an impact on the countries' efficiency scores.

The study covers all OECD member countries over the period from 2007 to 2016. The efficiency of healthcare spending is measured using the following variables: public healthcare spending as input variable; the number of hospital beds per 1000 population, the number of doctors per 1000 population, the number of nurses per 1000 population as output variables; and life expectancy at birth as an outcome variable. The inefficiency is then explained by government accountability, control of corruption, the population density, the supply of sugar and the consumption of alcohol, and the climate in the country.

The paper is structured in the following way. Section II introduces the main concepts and the theoretical framework. It also discusses some of the common practices in the literature. Section III describes the employed methodology. Section IV provides more detailed information on the variables used in the analysis. Section V depicts the results. Section VI is a discussion based on the obtained results and Section VII concludes.

## 2. Literature review

### *2.1 Theoretical framework*

The study of efficiency and effectiveness relates to the interdependence between inputs, outputs, and outcomes. Although the research area became extremely popular in the last decade, the analysis of efficiency and effectiveness dates back to the mid of the 20th century, when Farrell (1957) attempted to capture the efficiency of an industry. He argued that for better planning and policy making, it is essential to understand the capacity of the industry to increase its output without attracting additional resources, i.e. by improving its efficiency.

Figure 1 illustrates the framework proposed by Mandl, Dierx, and Ilzkovitz (2008) in order to address the concepts of efficiency and effectiveness.

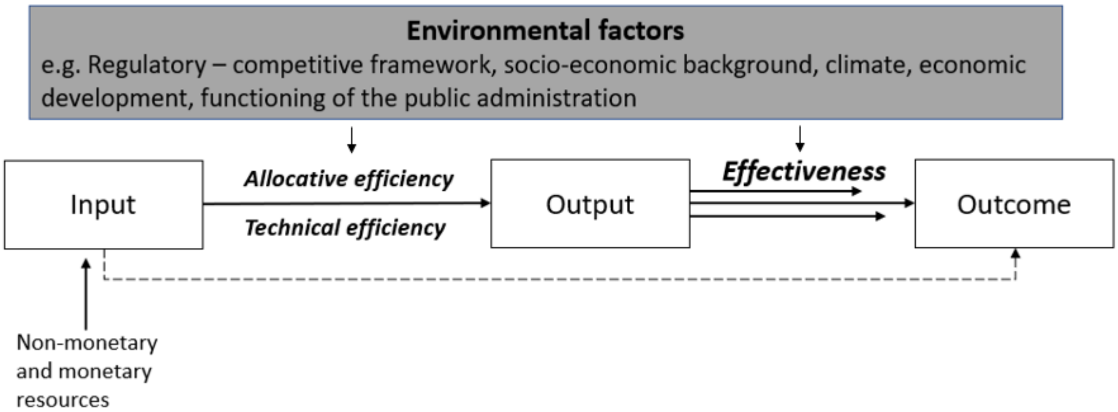


*Figure 1. Efficiency framework. Mandl, Dierx, & Ilzkovitz (2008)*

The employed resources (i.e. the inputs) generate outputs. For example, the **public healthcare spending** (input) affects the **number of doctors** that activate in a country (output). The input-output relationship is usually examined for efficiency assessment, which allows to determine by how much the inputs could be decreased with no change in the output level, and/or by how much the output could be increased with no additional inputs. Generally, the are two types of efficiency to consider: *technical efficiency* and *allocative efficiency* (Mandl, Dierx, & Ilzkovitz, 2008). The former relies on the concept of a "best-practice" efficiency frontier. It benchmarks each decision-making unit (DMU) (e.g., a country) against the frontier to identify whether there is room for improvement in each DMU's efficiency level, either from the input (capital or labor) or the output side. The allocative efficiency focuses on the optimal combination of inputs so as to generate the highest level of output. It is considered that allocative efficiency is reached when the welfare of the whole society is maximized (Drummond, 1989). To measure the allocative efficiency, thorough understanding of the underlying processes and complexities is required (Mandl, Dierx, & Ilzkovitz, 2008). As a result, most of the available studies focused on capturing and explaining the technical efficiency (e.g., Afonso & Kazemi, 2016; Afonso & St. Aubyn, 2005; Grigoli, 2012; Verhoeven, Gunnarsson, & Carcillo, 2007).

The second part of the framework proposed by Mandl, Dierx, and Ilzkovitz (2008) – *effectiveness* – covers the relationship between inputs/outputs and outcomes. Verhoeven, Gunnarsson, and Lugaresi (2007) use the concept of *system efficiency* to describe the same relationship. To illustrate the link using the previous example, the level of **public health care spending** (input) and the **number of doctors per 1000 population** (output) could have an impact on the **healthy life expectancy** or the **infant mortality rate** in a country (outcomes).

The concepts of output and outcome are often used interchangeably (Afonso, Schuknecht, & Tanzi, 2005). The main concern of any government is how to maximize the outcomes given the budget constraint. But the outcome is usually difficult to capture in one indicator, which poses pressure on researchers to study the output level instead (Pereira & Moreira, 2007). Other limitations that should be acknowledged is that certain policies/outputs could have a lagged effect on outcome, and/or there could be external factors that influence the outcome (Mandl, Dierx, & Ilzkovitz, 2008).

Mandl et al (2008) names these external forces – environmental factors (also known as non-discretionary or exogenous inputs). They encompass all the determinants of the output/outcome that cannot be easily controlled by the policy makers. They might include the geographical position, climate, historical socio-economic development, corruption, etc. Usually, the classical methods to measure technical efficiency cannot account for these factors, which requires employing more complex models, such as two-stage or even three-stage models (Afonso, Schuknecht, & Tanzi, 2008).

### *2.2 Input/Output/Outcome measures*

The studies of technical efficiency in healthcare usually rely on public expenditure as the input variable. Afonso and Kazemi (2016), Hauner and Kyobe (2008), and Grigoli (2012) use the public expenditure in healthcare to GDP ratio as the only input variable. In contrast, Evans, Tandon, Murray, and Lauer (2001) use the public healthcare expenditure per capita as the only input variable. Others (Jafarov &

Gunnarsson, 2008; Verhoeven, Gunnarsson, & Lugaresi, 2007) studied the efficiency level of the total healthcare system. Therefore, they use the total spending in healthcare (both public and private) as an input variable.

Besides studying the efficiency of inputs in generating outputs/outcomes, some papers aim to analyze the efficiency of outputs in generating outcomes. In this framework, outputs become input variables. For example, Jafarov and Gunnarsson (2008) augment the analysis by including the following output variables: the density of physicians, pharmacists, and healthcare workers; the number of hospital beds; the number of immunization vaccines; the average length of stay in a hospital; the average duration of doctors' consultation; and the bed occupancy rate. The density of doctors, the number of beds, and the immunization rate are by far the most popular variables to measure the intermediate output. They have been included in the study of efficiency in healthcare by Verhoeven, Gunnarsson, and Carcillo (2007); Hauner and Kyobe (2008); Grigoli (2012); Asandului, Roman, and Fatulescu (2014); Hadad, Hadad, and Simon-Tuval (2013); and de Cos and Moral-Benito (2014). The latter two studies considered other socio-economic and lifestyle factors as input variables (e.g. fruit/tobacco/alcohol consumption). Usually these factors are used as determinants of the obtained efficiency scores, not as input variables. (e.g. Jafarov & Gunnarsson, 2008; Retzlaff-Roberts, Chang, & Rubin, 2004; Verhoeven, Gunnarsson, & Carcillo, 2007).

As defined by Jafarov and Gunnarsson (2008), *outcomes* relate to the fundamental objectives of the policy makers. The health status of the population reflects the standard of living in a country. Although it is difficult to find one measure that would perfectly indicate the health condition of the population, the literature distinguishes between two closely related categories of outcome measures in healthcare: mortality rates and life expectancy.

The crude mortality rate is the share of the population that died during a particular period (Canada's Univesity, n.d.). For more accurate international comparison, researchers often rely on standardized mortality rates (Verhoeven, Gunnarsson, & Carcillo, 2007; Jafarov & Gunnarsson, 2008). This way, they account for differences in demographics across countries. For example, a more prominent aging population phenomenon would not necessarily translate into a higher mortality rate, making the comparison more accurate. Other studies focus on specific mortality rates – based on a particular group inside the population. The infant mortality is one of the most popular measures of health development in a country. Afonso and Kazemi (2016), Grigoli (2012), Afonso, Schuknecht, and Tanzi (2008), Asandului, Roman, and Fatulescu (2014), Retzlaff-Roberts, Chang, and Rubin (2004) considered the infant mortality rate as an outcome in the efficiency analysis of the healthcare spending. Verhoeven, Gunnarsson, and Carcillo (2007) and Jafarov and Gunnarsson (2008) included in their efficiency analysis another two specific mortality rates: child mortality and maternal mortality. Although widely used in the literature, mortality rates have also been scrutinized: can a high mortality rate be explained by an inefficient and ineffective healthcare system, or is it also due to other fundamental factors, such as high poverty rates that cannot be easily controlled.

Smedby and Andersen (2010) pointed out that the objective of the healthcare system should not be limited by the quantity of life – it should be concerned by the quality of life as well. Hernandez de Cos and Moral-Benito (2014) accounted for this aspect by including the *amenable mortality rate* as an output variable in their study of the determinants of an efficient healthcare system. The amenable mortality rate shows the percentage of deaths that could be prevented if adequate and timely health care would have been provided.

The quality over quantity principle is valid also for life expectancy as a measure of healthcare outcome. In efficiency analysis researchers often replace the simple life expectancy by healthy life expectancy (Verhoeven, Gunnarsson, & Carcillo, 2007; Asandului, Roman, & Fatulescu, 2014) and/or disability-adjusted life expectancy (de Cos & Moral-Benito, 2014). Another famous replacement for simple life expectancy as a healthcare outcome is *life expectancy at birth* (Afonso & Kazemi, 2016; Wranik, 2012;Grigoli, 2012; Asandului, Roman, & Fatulescu, 2014). It is derived from the standardized (age-specific) death rates and indicates “the average number of years that a newborn is expected to live if the current mortality rates continue to apply” (World Health Organization, 2006). Wranik (2012) argues that life expectancy at birth is the best indicator of outcome in the estimation of an efficiency frontier using the stochastic frontier approach since the measure is based on fewer assumptions. He believes that the other popular measures, such as infant mortality rate or potential years of life lost, are negative consequences of a flawed healthcare system.

Other outcome measures in the healthcare spending efficiency analysis include premature mortality from all causes below age 70 (Retzlaff-Roberts, Chang, & Rubin, 2004), incidence of tuberculosis (Jafarov & Gunnarsson, 2008), and others. The choice of the outcome measures is usually explained by data availability and by the common practice in the existing literature (Verhoeven, Gunnarsson, & Carcillo, 2007). Because each outcome measure has its advantages and disadvantages, the existing studies usually rely on at least two indicators (de Cos & Moral-Benito, 2014).

Depending on the sample of countries, period, variables used, and estimation method, previous efficiency analyses of healthcare spending offer different classifications of countries based on their efficiency level. Because the most popular method for efficiency assessment is Data Envelopment Analysis, which is based on the relative efficiency of the decision-making units, the sample of countries plays a vital role in the outcome of the analysis.

### *2.3 Determinants of efficiency scores*

In order to maximize the efficiency of public spending in healthcare, it is imperative for the policymakers to focus on what factors explain the inefficiency level of a country. This way they will be able to concentrate on more targeted reforms that would minimize the wasteful spending. Hauner and Kyobe (2008) studied the efficiency of spending in education and healthcare sectors and proposed a comprehensive classification of factors that could potentially explain the efficiency scores of each country. They distinguish between *economic*, *institutional*, and *demographic and geographic* determinants. The authors introduce an extensive list of economic factors that can influence the healthcare public spending efficiency: *healthcare spending to GDP ratio*; *income per capita*; *inflation*; *trade liberalization, openness of the economy*, as well as two dummy variables for *developing countries* and *commodity exports*.

According to Hauner and Kyobe (2008), the paramount finding of their study is the negative relationship between the spending to GDP ratio and efficiency. Their conclusion is supported by Hauner (2008), which studied the spending efficiency among the regions of Russia. In contrast, La Porta, Lopez-de-Silanes, Shleifer, and Vishny (1999) argue that larger governments tend to spend more efficiently. Additionally, Hauner and Kyobe (2008) indicate that there is high probability of endogeneity in case of healthcare spending. Inefficiency could also drive the spending up. Although they support the idea that "throwing money at the problem, does not solve the problem", it may be difficult to argue that countries that are severely underfunded, such as Latvia (OECD, 2017), would become less efficient by spending more. It depends on the healthcare system efficiency of the country, as per Verhoeven, Gunnarsson, and Lugaresi (2007).

Spending to GDP ratio is one of the few determinants of efficiency that can be directly influenced by policymakers. Most of the other determinants are exogenous factors that can be influenced only through structural changes. One example of exogenous determinants is income per capita. Hauner and Kyobe (2008) also includes it under the economic factors' category. They argue that the impact of income per capita on healthcare spending efficiency is unclear and depends on specific characteristics of the analysis. On the one hand, higher income per capita might decrease the efficiency through increasing the relative cost of public services (Baumol, 1967). On the other hand, the empirical evidence suggests that richer countries usually achieve better health and education outcomes (Afonso & St. Aubyn, 2005) and vice-versa – poorer countries achieve worse outcomes (La Porta, Lopez-de-Silanes, Shleifer, & Vishny, 1999). Based on their study, Hauner and Kyobe (2008) support the second hypothesis – higher income per capita positively affects the healthcare spending efficiency. In contrast, Verhoeven, Gunnarsson, and Carcillo (2007) support the first hypothesis, arguing that GDP per capita has a strong negative impact on public spending efficiency. Their claim is supported by two arguments. The first one is the above-mentioned Baumol effect – richer countries have to deal with a larger cost of public services (e.g., through higher salaries to public sector workers). And second, the wealthier the population, the higher probability that they will consume more services, including healthcare services that they do not need or that do not impact the main indicators of health status, such as life expectancy or mortality rates (Verhoeven, Gunnarsson, & Carcillo, 2007). To account for possible non-linearity related to the income variable, Hauner and Kyobe (2008) include in their analysis two dummy variables, *developing country* and *commodity exporter* (since the income level of countries that heavily rely on commodity exports usually overstates the actual level of development in the country, including the performance/efficiency of public spending). However, the authors do not find any statistically significant effect related to either of the dummy variables.

Another economic factor proposed by Hauner and Kyobe (2008) is the inflation rate. The authors expected that higher inflation would make the budgeting process less accurate, thus increasing the inefficiency of spending. However, to their surprise, they observe a positive relationship between inflation and the efficiency of public spending in healthcare. According to the authors, a possible explanation for this might be the fact that given unexpected inflation and no additional resources to cover the planned expenditure, the healthcare spending to GDP ratio is going to decrease. In line with their previous finding, a lower spending to GDP ratio is associated with an increase in efficiency (Hauner & Kyobe, 2008).

Other economic factors used by Hauner and Kyobe (2008) to explain the healthcare spending efficiency scores are trade liberalization (measured by the average tariff rates) and openness of the economy (measured by the total imports and exports). Both factors are meant to reflect the effect of the international relationships of the country on its public spending efficiency. A more open economy with lower trading barriers is expected to be more efficient at spending public resources. This could be due to exchange of skills and technology. In addition, the superior performance might be driven by the competitive forces in the market. However, Hauner and Kyobe (2008) do not find any statistically significant relationship between any of the two variables and the efficiency of public healthcare spending.

Among the *institutional factors* that could explain the efficiency of public spending in healthcare, Hauner and Kyobe (2008) list the following variables: *government accountability, corruption control*, *democracy, durable political regime, social infrastructure,* and *education*. The authors argue that well-functioning institutions are not only a precondition to steady economic growth but also an important determinant of government efficiency. As a measure of government accountability and corruption control, Hauner and Kyobe (2008) took the respective World Bank indices, which range from zero to 100 and the higher the value the better the country performs. Although their results show that indeed, governments that are more accountable tend to spend more efficiently in education, they find an opposite (but not robust) effect in case of public healthcare spending. Corruption is usually associated with waste; therefore, countries with stronger corruption control are expected to be more efficient at spending public resources.

Democracy is expected to have a positive impact on government accountability. A durable political regime (measured as the number of years from the last change of the political regime) is expected to facilitate the budgeting process and thus minimizing the inefficiency of public spending. The social infrastructure and the level of education are expected to positively influence the efficiency of spending in healthcare through a more closely monitored government (Hauner & Kyobe, 2008).

Retzlaff-Roberts, Chang, and Rubin (2004) find a strong statistically significant effect of education on healthcare outcomes. They argue that people that are more educated tend to have a better standard of living, which translates into better housing condition, healthier lifestyle, and better access to healthcare services – all through the effect of higher income. Evans, Tandon, Murray, and Lauer (2001), also find a positive association between educational attainment and health status. He argues that people that are more educated find it easier to convert the information and the healthcare services into actual health outcomes. Moreover, Evans, Tandon, Murray, and Lauer (2001) argue that due to the strong interdependence between income and education, the income per capita variable should not be taken into account in the analysis. They believe that income affects the health outcomes only through other factors, such as education, consumption habits, and lifestyle. Verhoeven, Gunnarsson, and Lugaresi (2007) also find a negative correlation between the average years of schooling and the main mortality rates in the country, which is in line with the previous findings.

Finally, the *demographic and geographic* determinants proposed by Hauner and Kyobe (2008) comprise *the share of population over 65-year-old, the share of population under 14-year-old, population density*, *language fractionalization*, and *climate*. An aging population poses pressure on the budget balance – lower revenue collected from elder people and higher costs associated with their social insurance and healthcare services required. In the same time, a larger share of population over 65-year-old can be directly reflected in the outcome measures (e.g., longer life expectancy). Therefore, Hauner and Kyobe (2008) avoid including the healthy life expectancy as an outcome measure in their analysis. Even so, their findings suggest that a larger share of an aging population is associated with higher efficiency of healthcare spending. It could be explained by the fact that the government has be efficient at managing its resources; otherwise, it will not be able to stand the pressure on the budget. In contrast, Verhoeven, Gunnarsson, and Carcillo (2007) do not find any significant proof that the population age structure affects the link between healthcare spending and health outcomes.

Hauner and Kyobe (2008) studied the spending efficiency in both, healthcare and education sectors. The share of population under 14-year-old as a determinant of spending efficiency scores is more appropriate in case of education expenditure. Indeed, the authors show that the factor does not have any impact on the healthcare spending efficiency. They also find that the population density positively influences the efficiency scores. This outcome is in line with their expectation that a denser population decreases the cost of public services through economies of scale and this way enhance the efficiency of the government expenditure. In the same time, Hauner and Kyobe (2008) do not find any statistically significant effects from language fractionalization and differences in climate. The initial expectation was that language fractionalization would increase the cost of public services provision, decreasing the efficiency of public spending in the same time. The index of malaria stability and the distance from the equator (used as proxies for climate) were expected to increase the required government expenditure (e.g., heating costs) and negatively affect the efficiency scores.

Another popular category of factors that influence the efficiency scores in healthcare spending relates to the lifestyle chosen by the population. It includes the alcohol consumption (Jafarov & Gunnarsson, 2008), tobacco (Retzlaff-Roberts, Chang, & Rubin, 2004), and diet – assessed by the consumed number of calories per day (Verhoeven, Gunnarsson, & Carcillo, 2007). In their study of healthcare spending efficiency, Retzloff, Chang, and Rubin (2004) also account for *income inequality* by including the Gini coefficient in the analysis. They argue that the social environment determines the previously discussed lifestyle choices and this way affect the health status of the population. Verhoeven, Gunnarsson, and Lugaresi (2007) also consider the Gini index as an exogenous variable that affect the health outcomes of a country.

Although the external factors that can affect the efficiency scores of public healthcare spending are numerous and diverse, the framework proposed by Hauner and Kyobe (2008) makes the analysis more structured by grouping these factors into three major categories: economic, institutional, and demographic and geographic determinants. A fourth category could encompass all the social and behavioral determinants. Some of the factors in the latter category could be easier to influence by the policymakers (e.g., by introducing larger excise taxes or alcohol prohibition); however, this could also lead to the development of the grey economy. Therefore, for steady improvements in the health status of the population, the policymakers have to focus on campaigns that would determine the people to change their lifestyle choices.

## 3. Methodology

The technical efficiency of the public spending can be measured using different methods, which are generally classified into non-parametric and parametric models (Lovell, Schmidt, & Fried, 2007). The first category relies on linear programming to determine an efficient frontier against which each DMU is evaluated. The most prominent examples of non-parametric methods include the Data Envelopment Analysis (DEA) and the Free Disposal Hull (FDH). The second category of models relies on econometric theory to estimate an efficient frontier that accounts for two different error terms: one that is responsible for the inefficiency, and the other caused by random noise. The most popular parametric method is the Stochastic Frontier Analysis (SFA).

The Full Disposal Hull model was first proposed by Deprins, Simar, and Tulkens (1984). Although, the FDH method is one of the first models used to assess the efficiency, it is rarely used nowadays. Studies that relied on FDH to assess the public spending efficiency include: Afonso, Schuknecht, and Tanzi (2005); Afonso and St. Aubyn (2005); Herrera and Pang (2005). The Data Envelopment Analysis augmented the model by allowing for convexity. As a result, DEA gradually replaced FDH since it provides more accurate estimates (Afonso & Kazemi, 2016). Examples of studies that use DEA to assess the efficiency of public spending include: Verhoeven, Gunnarsson, and Carcillo (2007); Afonso, Schuknecht, and Tanzi (2008); Jafarov and Gunnarsson (2008).

Data Envelopment Analysis is a non-parametric tool that uses linear programming methods to estimate the efficient frontier, subject to the convexity constraint. The term “envelopment” comes from the fact that the frontier envelops all the sample countries. The relative efficiency is then determined by comparing each country with the “best-practice” frontier. For assessing the efficiency of healthcare expenditure, DEA encompasses a set of input variables (e.g. healthcare expenditure as a share of GDP), intermediate output variables (e.g. number of beds in hospitals, number of consultation hours per doctor), and outcome variables (e.g. life expectancy, amenable mortality rate).

Generally, there are two types of technical efficiency: input-based and output-based. The input-based efficiency scores are limited by the interval from zero to one and reflect the share of spending that could be cut without diminishing the current level of output (Jafarov & Gunnarsson, 2008). In other words, it measures the cost reduction that could be achieved through improvements in efficiency. The output-based efficiency scores also take values from zero to one. A score equal to one indicates that the country is relatively efficient, and it is located on the frontier. The output-based efficiency measures by how much the outputs could be improved for the same level of expenditure given improvements in efficiency (Jafarov & Gunnarsson, 2008). In case of constant returns to scale, both input- and output-oriented efficiency scores are equal.

Assume $a$ inputs and *z* outputs for *n* countries. For each *i*-th country, $y_i$ is the column vector of the inputs and $x_i$ is the column vector of the outputs. Suppose also X is the $(a \times n)$ input matrix and Y is the $(z \times n)$ output matrix. The analytical specifications underpinning the output-oriented Data Envelopment Analysis, assuming variable returns to scale, are described below (Afonso & St. Aubyn, 2010).

For each $i$-th country:

$$
\begin{aligned}
& Max_{\lambda_i \delta_i} \delta_i \\
& \text{subject to } \delta_i y_i \leq Y\lambda \\
& x_i \geq X\lambda \\
& n1'\lambda = 1 \\
& \lambda \geq 0
\end{aligned}
\tag{1}
$$

where $\delta_i$ is a scalar satisfying $\delta_i \leq 1$. It measures the output-oriented efficiency score of the *i*-th country, reflecting the difference to the efficient frontier. If a country's score is below one, it is situated under the frontier, being considered inefficient.

The vector λ is a $(n \times 1)$ vector of constants. It reflects the weights used to determine the position of an inefficient country if it were to become efficient. This is done through a linear combination of other countries that are considered as fully efficient (Afonso & St. Aubyn, 2005). The constraint $n1'\lambda = 1$ reflects the convexity assumption.

DEA has a major advantage of not requiring a functional form. However, it still has some drawbacks to consider (Jafarov & Gunnarsson, 2008). First, the selected sample and any measurement errors can have a significant impact on the results since DEA rely on relative efficiency and it implicitly assumes that the units on the frontier are fully efficient. Second, the total distance to the frontier is considered to come from inefficiency, not allowing for any random effects. And third, non-discretionary factors can influence the relative efficiency scores.

Generally, DEA models account only for discretionary input variables – those that can be directly influenced by governments. However, there are also factors that influence the general health stance of the country but cannot be directly regulated by government authorities. Examples of such variables include the level of corruption, government accountability, and the predominant lifestyle of the population. In order to incorporate the effect of environmental variables, a two-stage model is usually employed (Afonso & Kazemi, 2016).

Let $\omega_i$ be a $(1 \times r)$ vector of environmental variables. For a two-stage model, the following regression is estimated

$$\widehat{\delta_i} = \omega_i \beta_i + \varepsilon_i \tag{2}$$

where $\widehat{\delta_i}$ are the efficiency scores calculated by Equation (1) and $\beta_i$ is a $(r \times 1)$ vector of coefficients corresponding to each environmental variable. The equation is estimated by maximum likelihood assuming a truncated regression.

For robust conclusions, this paper also employs the Stochastic Frontier Analysis. This method relies on parametric econometric techniques to estimate a continuous, regular function that underlines the efficient frontier (Grigoli, 2012). Its main advantage lies on the fact that it does not consider countries with relatively highest efficiency to be fully efficient. This way the effect of the sample selection bias is decreased.

A cross-sectional production function can be described by

$$Y_i = f(X_i; \beta) \cdot TE_i \tag{3}$$

where $X_i$ represents the vector of inputs of each decision-making unit (DMU) $i$; $Y_i$ reflects the respective output; and $f(.)$ is the production frontier that depends on inputs and on the technological factor $\beta$. The term $TE_i$ captures the output-oriented efficiency of each DMU $i$ and is determined by dividing the actual output to the maximum possible output,

$$TE_i = \frac{Y_i}{f(X_i; \beta)} \tag{4}$$

Farrell (1957) proposed a slightly different interpretation for Equation (3):

$$Y_i = f(X_i; \beta) \cdot \exp(-u_i) \qquad u_i \geq 0 \tag{5}$$

where $u_i$ reflects the technical inefficiency (i.e. the gap between the actual output and the frontier). The imposed restriction ensures that $TE_i \leq 1$, which is in line with Equation (4). This equation is described as a deterministic frontier function (Murillo- Zamorano, 2004). If we assume a linear function, the Equation (5) becomes

$$Y_i = \beta_0 + \sum_{n=1}^{N} \beta_n X_{ni} - u_i \tag{6}$$

Finally, when the function is parametrized, different econometric techniques (deterministic or stochastic) can be used to estimate the value of $u_i$ and so of $TE_i$ (Murillo- Zamorano, 2004).

The Stochastic Frontier Approach was independently introduced by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977). The general single-output form of SFA is given by

$$Y_i = \beta_0 + \sum_{n=1}^{N} \beta_n X_{ni} + v_i - u_i \tag{7}$$

where the most important novelty compared to a traditional function is the split of the error term into two different components. The $u_i$ term represents the individual technical inefficiency of each DMU and the $v_i$ term reflects the general statistical noise, i.e. the effect of all the factors that cannot be directly controlled by the DMU (Parmeter & Kumbhakar, 2014). In comparison, DEA method ignores the $v_i$ term, assuming that the total residual is due to inefficiency.

The residual that accounts for the general noise is assumed to be identical independent and identically distributed (Murillo- Zamorano, 2004). Regarding the second error term, which captures the technical inefficiency, there is no uncontested distribution assumption in the literature. Among the most popular are the half-normal distribution (Aigner, Lovell, & Schmidt, 1977), the exponential distribution (Meeusen & van Den Broeck, 1977), the truncated normal distribution (Stevenson, 1980), and the gamma distribution (Greene, 1980). None of them is perfect – although they are unbiased estimates, they are not consistent because $plim\ E(u_i |\ v_i - u_i) - u_i$ is not zero (Murillo- Zamorano, 2004). Nevertheless, it is possible to obtain confidence intervals for any of the above-mentioned distributional assumptions. As Murillo-Zamorano (2004) pointed out, although the latter models were designed to fix the imperfections of the first two models, usually the advantage is eclipsed by the complexity associated with the model. As a result, the normal-half normal distribution has proven to be the most preferred alternative among the researchers (Battese & Coelli, 1992).

Assuming a half-normal distribution, Jondrow, Lovell, Materov, and Schmidt (1982) prove that the expected value of the inefficiency error conditional on the total residual is

$$E[u_i|\varepsilon_i] = \frac{\sigma\lambda}{(1+\lambda^2)}\left[\frac{\phi(\varepsilon_i\lambda/\sigma}{\Phi(-\varepsilon_i\lambda/\sigma} - \frac{\varepsilon_i\lambda}{\sigma}\right] \quad (8)$$

where $\phi(.)$ is the density of a standard normal distribution, $\Phi(.)$ is the cumulative density function, as well as $\lambda = \sigma_u/\sigma_v$, $\varepsilon_i = v_i - u_i$, and $\sigma = (\sigma_u^2 + \sigma_v^2)^{1/2}$ (Murillo- Zamorano, 2004).

After determining the conditional estimates of the inefficiency error, Jondrow, Lovell, Materov, and Schmidt (1982) gauge the inefficiency level of each DMU as

$$TE_i = 1 - E[u_i|\varepsilon_i] \quad (9)$$

Next, Hjalmarsson, Kumbhakar and Heshmati (1996) came up with confidence intervals for the efficiency estimator introduced by Jondrow, Lovell, Materov, and Schmidt (1982).

## 4. Data

This paper aims to evaluate the efficiency of public healthcare spending in Latvia by comparing its performance to other OECD members. The analysis covers the period from 2007 to 2016, mainly due to data availability constraints. The study relies on a cross-section framework, taking the 10-year average for all the variables that are employed in the model. This would minimize any potential effects from the business cycle.

Based on the literature reviewed, in order to assess the level of efficiency in healthcare spending, the following variables are considered:

- input variables: public healthcare expenditure per capita and as a share of GDP;
- intermediate output variables: number of hospital beds per 1000 population, number of doctors per 1000 population, number of nurses per 1000 population;
- outcome variable: life expectancy at birth.

The variables are extracted from the OECD Healthcare database.

Table 1 depicts a summary statistic of all the relevant variables employed in the models.

To explain the efficiency of public spending in healthcare, one of the most relevant categories of variables are considered the institutional factors, proposed by

Hauner and Kyobe (2008). They include the government accountability and the corruption control. Both indices come from the Worldwide Government Indicators project of the World Bank. More accountable governments are expected be more responsible at planning and spending public resources. Similarly, corruption is associated with waste (i.e. inefficient spending); therefore, a tighter control of corruption is expected to contribute to a more efficient use of public resources. The performance of both indices is assessed on a scale from -2.5 (weak) to +2.5 (strong).

*Table 1. Summary statistic*

| Variables | Observations | $\bar{x}$ | $\sigma$ | *Min* | *Max* |
|---|---|---|---|---|---|
| Public Healthcare spending as % of GDP | 36 | 8.63 | 2.14 | 4.75 | 16.24 |
| Public Healthcare spending per capita | 36 | 2398.44 | 1239.06 | 458.45 | 4910.35 |
| Number of hospital beds | 36 | 4.92 | 2.43 | 1.59 | 13.43 |
| Number of doctors | 31 | 3.19 | 0.69 | 2.05 | 4.86 |
| Number of nurses | 29 | 8.94 | 3.83 | 2.54 | 16.13 |
| Life expectancy at birth | 36 | 79.71 | 2.77 | 73.37 | 83.22 |
| Government accountability | 36 | 1.13 | 0.40 | -0.22 | 1.64 |
| Corruption control | 36 | 1.24 | 0.81 | -0.48 | 2.35 |
| Density of population | 36 | 136.41 | 135.66 | 2.94 | 514.32 |
| Alcohol consumption | 36 | 9.26 | 2.69 | 1.30 | 13.97 |
| Sugar supply | 36 | 42.06 | 9.86 | 25.54 | 62.39 |
| Climate (latitude) | 36 | 46.70 | 9.61 | 19.20 | 64.10 |

The population density is a demographic factor that could influence the efficiency scores. A denser population is associated with economies of scale and more efficient public spending (less money is spent on hospital administration and other similar expenses). Geographical factors, such as climate, may have an impact on the health of the population, and thus affect indirectly the efficiency of the public spending in healthcare sector.

The behavioral factors include the consumption of alcohol and diet (sugar supply). Unhealthy lifestyles are reflected in shaky health outcomes at the national level. In the same time, the government has to put more effort in ensuring an efficient use of the limited public resources. Other similar factors, such as the consumption of tobacco and the fruit/vegetables intake, could not be included in the analysis due to missing data for some of the countries.

All the determinants are extracted from the OECD Healthcare database or the World Bank Statistics. The main concerns regarding the variables used relate to the endogeneity and homogeneousness of the data. The Data Envelopment Analysis is more susceptible to these risks, that might create biased results. In case of larger expected measurement errors, the Stochastic Frontier Approach is considered more appropriate. As a robustness check, this paper employs both methods.

## 5. Results

The Data Envelopment Analysis was employed as a first method to estimate the public healthcare spending efficiency among the OECD countries. The approach relies on relative efficiency, and as a result, the most efficient countries in the sample form the efficiency frontier.

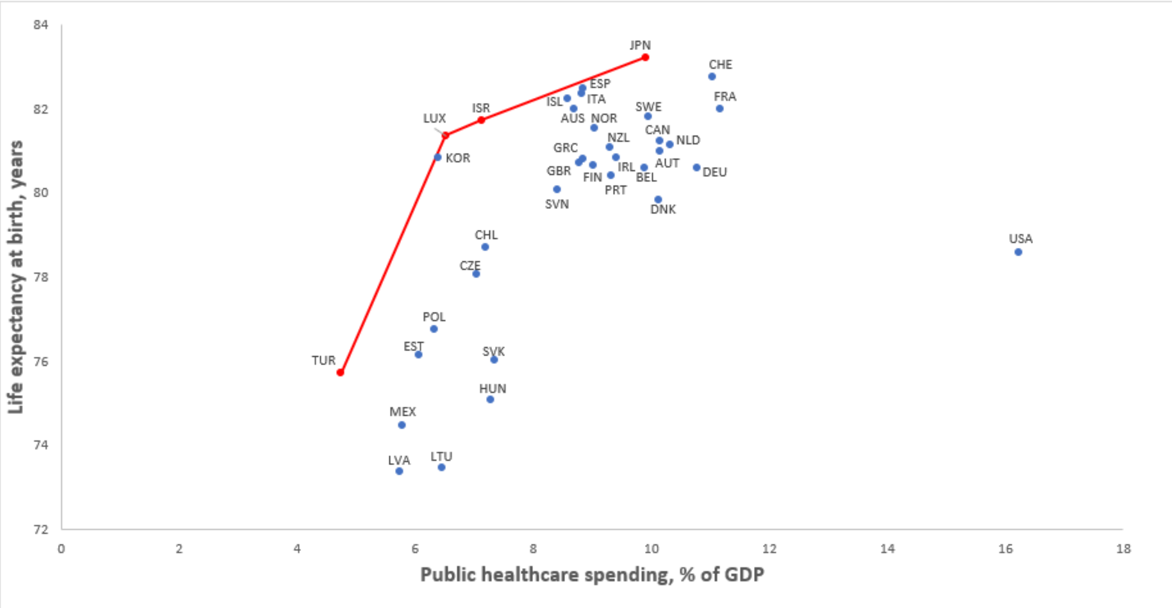


*Figure 2. DEA Efficiency frontier (Input: Public healthcare spending, percentage of GDP). Appendix D for abbreviations*

Figure 2 exhibits the frontier based on the input-outcome relationship, i.e. how effective are governments at translating the public healthcare spending into actual health outcomes. The findings suggest that Japan, Israel, Luxembourg, and Turkey are among the leading OECD countries at efficient healthcare spending. Figure 2 also illustrates the relative inefficiency of the Latvian healthcare system. First, it is important to note how underfunded the system is. Among all the OECD members, Latvia has the second lowest public healthcare spending as a share of GDP. Although Turkey spends on average by 1p.p. less, it manages to obtain a higher life expectancy at birth. The rationale of DEA is that all the countries that spend more but achieve less than any country on the frontier are less efficient. The findings suggest that Latvia could improve the average life expectancy at birth by approximately five years (or 6.93 percent) without increasing the level of spending (Appendix A). In the same time, Latvia ranks 33rd among the 36 OECD members at efficient spending in healthcare.

United States is a clear outlier among the other countries. This is because the American government spends more than 16 percent of its GDP on healthcare programs. In contrast, the average percentage spent by all the other OECD members is 8.42. For comparison, the Latvian public healthcare spending constitutes on average only 5.23% of the Gross Domestic Product. Although U.S.A is an outlier, the country was not excluded from the Data Envelopment Analysis. Since it does not lie on the frontier, it does not influence the result of the other countries. The position of each DMU is assessed only relative to the countries with "the best-practice".

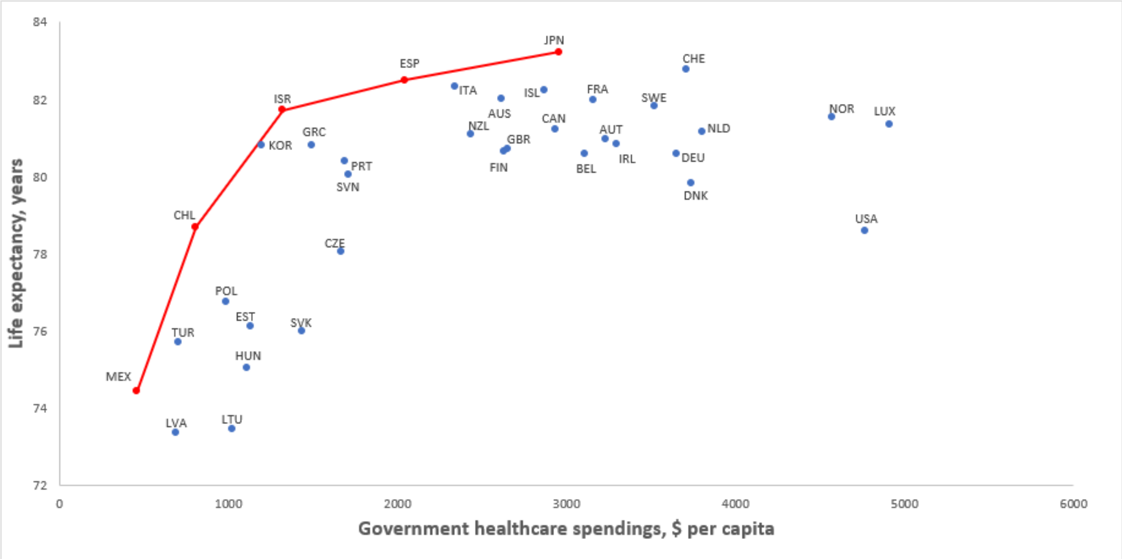


*Figure 3. DEA Efficiency frontier (Input: Public healthcare spending, per capita). Appendix D for abbreviations*

Figure 3 depicts a similar DEA result based on input-outcome relationship, but now it considers the public healthcare spending per capita (as opposed to percentage of GDP) as the main input variable in the healthcare system. The findings suggest that Mexico, Chile, Israel, Spain, and Japan are the most efficient countries at transforming public healthcare expenditure into health outcomes. Similar to the previous case, Latvia is spending significantly less than the other countries. The inefficiency of the Latvian public healthcare spending is reflected in the fact that Mexico is spending even less per capita but manages to obtain better health outcomes. So, Mexico is spending its resources relatively more efficiently.

Latvia ranks 31st among the other 36 countries at translating the public resources (when measured per capita) into health outcomes (Appendix A).

The first two figures are based on total efficiency (from public spending to life expectancy). Further, the total efficiency was divided into two relationships (public spending – intermediate outputs, and intermediate outputs – life expectancy). In the first case, the objective is to determine how efficient is the government at ensuring the intermediate outputs (number of beds/doctors/nurses). Whether the input is measured by public healthcare spending as a percentage of GDP or per capita, Latvia is among the leading countries in both cases. As for the second relationship, the objective is to assess the efficiency of the intermediate outputs at ensuring a positive health stance in the country. In this case, Latvia ranked 27$^{th}$ out of 28 countries, the least efficient being Lithuania (Appendix B). According to DEA estimates, Latvia could increase the average life expectancy by about 7.5 years, given an improvement in the efficiency of the intermediate outputs.

The total efficiency scores obtained through Data Envelopment Analysis were then regressed on a set of environmental variables. Table 2 depicts the results of the first truncated regression. The efficiency scores calculated in the first DEA model (input: public healthcare spending to GDP; outcome: life expectancy at birth) were explained by a set of non-discretionary factors, including: an index of government accountability, the density of the population, the average sugar supply per capita, and the consumption of alcohol. The truncated regression eliminates from the analysis all the countries that form the "best-practice" frontier. This is because these countries are relatively more efficient but not necessarily 100% efficient.

*Table 2. Truncated regression based on the efficiency scores estimated by DEA Model 1*

| Probability > chi - square = 0.0000 | | | | | Number of observations = 32 | |
|---|---|---|---|---|---|---|
| Variable name | Beta | Standard error | Z-score | P > \|z-score\| | 95% confidence interval | |
| Constant | 1.03788 | 0.0254 | 40.88 | 0.000 | 0.9881 | 1.0876 |
| Government accountability | 0.07531 | 0.0128 | 5.87 | 0.000 | 0.0502 | 0.1004 |
| Density of population | 0.00006 | 0.0000 | 2.01 | 0.045 | 0.0000 | 0.0001 |
| Sugar supply | -0.00129 | 0.0004 | -3.46 | 0.001 | -0.0020 | -0.0006 |
| Alcohol consumption | -0.00563 | 0.0019 | -3.03 | 0.002 | -0.0093 | -0.0020 |
| Climate | -0.00107 | 0.0005 | -2.37 | 0.018 | -0.0020 | -0.0002 |

Government accountability has a statistically significant (at 1%) positive effect on the efficiency of public healthcare spending. It is expected that an increase of 1 unit in the index of government accountability, would improve the efficiency score by 0.075. For Latvia, that would imply an expected increase in the average life expectancy at birth by approximately five and a half years.

The density of the population is also expected to have a positive impact on the efficiency of public expenditure in healthcare (statistically significant at 5%). One hundred more people on the square km would generate an improvement in the efficiency score by 0.006. Another endogenous factor that affects the general health status of the country and thus can influence indirectly the efficiency of public resources in the healthcare sector is the climate in the country. The results show that the farther is the country from the equator, the less efficient is the spending or rather the general health status of the population is negatively affected by a harsh climate.

The sugar supply and the consumption of alcohol reflect the lifestyle choices of the population. They directly affect the health status of the country. In Latvia, one more kg of sugar per year (per capita) is expected to decrease the average life expectancy by more than one month. The effect of alcohol consumption is more prominent. An additional liter consumed per year (per capita) is expected to decrease the average life expectancy of Latvians by about five months. The effects of the supply of sugar and alcohol consumption are both statistically significant at 1%.

*Table 3. Truncated regression based on the efficiency scores estimated by DEA Model 2*

| Probability > chi -square = 0.0000 | | | | | Number of observations = 31 | |
|---|---|---|---|---|---|---|
| Variable name | Beta | Standard error | Z-score | P > \|z-score\| | 95% confidence interval | |
| Constant | 1.07417 | 0.0248 | 43.31 | 0.000 | 1.0256 | 1.1228 |
| Corruption control | 0.02056 | 0.0042 | 4.89 | 0.000 | 0.0123 | 0.0288 |
| Density of population | 0.00004 | 0.0000 | 1.76 | 0.078 | 0.0000 | 0.0001 |
| Sugar supply | -0.00112 | 0.0003 | -3.33 | 0.001 | -0.0018 | -0.0005 |
| Alcohol consumption | -0.00313 | 0.0013 | -2.49 | 0.013 | -0.0056 | -0.0007 |
| Climate | -0.00115 | 0.0004 | -2.89 | 0.004 | -0.0019 | -0.0004 |

Table 3 depicts the results of the second truncated regression, which attempts to explain the efficiency scores estimated by the second Data Envelopment model by a set of non-discretionary variables, similar to those used in the first truncated regression. The main difference lies in the measurement of the input variable used in the DEA model. The second DEA output is based on public healthcare spending per capita as the input variable. Both truncated regressions result in similar findings.

When the efficiency scores rely on public healthcare spending per capita (as opposed to percentage of GDP), the index of corruption control becomes more important for the total efficiency level in healthcare than the index of government accountability. An increase of one unit in the corruption control index is expected to improve the efficiency score by 0.0206. This would translate in an expected increase of more than a year in the average life expectancy of Latvians. The effect of corruption control is significant at 1%.

The positive effect of the density of population is similar in both truncated regressions. Also, the effect of the climate is consistent in both cases. The influence of the lifestyle choices is also quite similar to the results depicted in Table 2.

The Stochastic Frontier Analysis was employed as an alternative method to study the efficiency of public healthcare spending. Table 4 depicts the results of the first SFA regression. As the stochastic frontier approach does not assume that those countries that are relatively more efficient are fully efficient, all 36 countries were included in the analysis.

*Table 4. Stochastic frontier normal/half-normal Model 1*

| Probability > chi-square = 0.1099 | | | | | Number of observations = 36 | |
|---|---|---|---|---|---|---|
| Variable name | Beta | Standard error | Z-score \|Z\| | P > \|Z\| | 95% confidence interval | |
| *Life expectancy at birth* | | | | | | |
| Constant | 79.5908 | 1.4059 | 56.61 | 0.000 | 76.8353 | 82.3462 |
| Public healthcare spending, % of GDP | 0.2329 | 0.1457 | 1.60 | 0.110 | -0.0526 | 0.5185 |
| *St. dev. of random error* | | | | | | |
| Constant | -0.6100 | 0.3948 | -1.55 | 0.122 | -1.3837 | 0.1637 |
| *St. dev of inefficiency* | | | | | | |
| Constant | -4.7720 | 3.6061 | -1.32 | 0.186 | -11.840 | 2.2957 |
| Government accountability | -7.5993 | 2.1064 | -3.61 | 0.000 | -11.728 | -3.4708 |
| Density of population | -0.0074 | 0.0046 | -1.60 | 0.109 | -0.0165 | 0.0016 |
| Sugar supply | 0.1334 | 0.0595 | 2.24 | 0.025 | 0.0167 | 0.2500 |
| Alcohol consumption | 0.6412 | 0.2723 | 2.35 | 0.019 | 0.1075 | 1.1748 |
| Climate | 0.0577 | 0.0522 | 1.11 | 0.269 | -0.0445 | 0.1600 |

When observing the relationship between public healthcare spending (as percentage of GDP) and the life expectancy at birth, the findings do not suggest a statistically significant effect (at 1%, 5%, or 10%). Even so, the coefficient associated with healthcare spending is positive and would have been significant at 15%.

SFA does not assume that all the residual is inefficiency. As a result, Table 4 depicts a clear separation between the random error and inefficiency. The same variables that were used in the truncated regression were included in the SFA model in order to explain the variability of the inefficiency. All the variables preserved their statistically significant effect. However, it is important to note that while the truncated regressions attempted to explain the level of efficiency, the SFA model studies the factors that affect the inefficiency level. Consequently, for the same effect – the truncated regression and SFA display different signs.

The government accountability affects negatively the inefficiency level. In other words, an increase of one unit in the index of government accountability results on average in almost eight years added to the life expectancy at birth. The effect is statistically significant at 1%.

The density of the population is also expected to have a negative impact on the inefficiency. One more person per square km would improve the efficiency of public healthcare spending, adding to the average life expectancy approximately one month (0.008 of a year). The effect, however, is at the limit of acceptable statistical significance. Although climate is expected to increase the inefficiency (as in the case of truncated regressions), the effect becomes statistically insignificant.

The lifestyle variables are expected to increase the inefficiency. One additional kg of sugar per capita per year is associated with a decrease of one and a half months in the average life expectancy. In the same time, an additional liter of alcohol consumed per capita per year is associated with an average decrease in life expectancy by seven and a half months.

Note that the first SFA regression includes all 36 countries. If we exclude United States because of its abnormal healthcare spending to GDP ratio, the results will not change much (Appendix C). The most important difference is that the effect of public healthcare spending becomes statistically significant at 10%. The numerical value of the coefficients did not change considerably.

*Table 5. Stochastic frontier normal/half-normal Model 2*

| Probability > chi-square = 0.1300 | | | | | Number of observations = 36 | |
|---|---|---|---|---|---|---|
| Variable name | Beta | Standard error | Z-score \|Z\| | P > \|Z\| | 95% confidence interval | |
| *Life expectancy at birth* | | | | | | |
| Constant | 80.622 | 0.8210 | 98.20 | 0.000 | 79.013 | 82.231 |
| Public healthcare spending, per capita | 0.0004 | 0.0002 | 1.51 | 0.130 | -0.0001 | 0.0008 |
| *St. dev. of random error* | | | | | | |
| Constant | -0.4674 | 0.3802 | -1.23 | 0.219 | -1.2125 | 0.2777 |
| *St. dev. of inefficiency* | | | | | | |
| Constant | -7.2070 | 6.0887 | -1.18 | 0.237 | -19.141 | 4.7267 |
| Government accountability | -8.4912 | 2.9111 | -2.92 | 0.004 | -14.197 | -2.7855 |
| Density of population | -0.0060 | 0.0048 | -1.24 | 0.215 | -0.0155 | 0.0035 |
| Sugar supply | 0.1588 | 0.0852 | 1.86 | 0.062 | 0.0083 | 0.3258 |
| Alcohol consumption | 0.6700 | 0.3101 | 2.16 | 0.031 | 0.0622 | 1.2778 |
| Climate | 0.0904 | 0.0730 | 1.24 | 0.216 | -0.0527 | 0.2336 |

Table 5 depicts the output of the second SFA regression. In this case, the public healthcare spending is measured on per capita basis. Similar to the previous regression, public healthcare spending does not have a statistically significant effect on the average life expectancy. The coefficient however is positive, meaning that increasing spending would rather improve the health outcomes.

The same factors were used to explain the inefficiency of spending in healthcare. The index of government accountability is expected to affect positively the level of efficiency. An improvement of one in the index is associated with an additional eight years to the average life expectancy. The density of the population is also associated with improvements in efficiency; however, the effect is statistically insignificant. The influence of climate on efficiency remains negative and statistically insignificant.

The lifestyle variables are again negatively affecting the efficiency of public healthcare spending. One more kg of sugar supplied per year per capita translates into a decrease of life expectancy at birth by approximately two months. An additional liter of alcohol consumed per year per capita has an even more dramatic effect – a decrease of eight months in the average life expectancy.

Overall, the results are consistent across the models. Government accountability affects positively the efficiency of public healthcare spending. Hauner and Kyobe (2008) showed that government accountability has a statistically significant positive effect on the efficiency of public spending in education. They were not able to find a similar result in case of healthcare. Also, their findings suggest that the density of population positively affects the efficiency of public healthcare, which is in line with the findings of this paper. In all the models, sugar supply and alcohol consumption were found to negatively influence the efficiency of public healthcare spending. This coincides with the findings of Verhoeven, Gunnarsson and Carcillo (2007) and Jafarov and Gunnarsson (2008), respectively.

Several other variables were employed in order to explain the efficiency of public healthcare expenditure. They include: the share of total healthcare spending that is covered by out-of-pocket money of the population, income per capita, the rate of inflation, and mean years of schooling. The respective variables were found to have a statistically insignificant effect on the level of efficiency. Given a small number of observations, these variables were taken out of the model, so that the effect from other factors would not be distorted.

## 6. Discussion of results

The first objective of this paper is to find out **how efficient is the Latvian healthcare system**. The output of Data Envelopment Analysis (Figure 2 and Figure 3) clearly depicts the relative position of Latvia compared to the other OECD members. The resources allocated to healthcare programs as a share of the GDP of the country are significantly lower than the average among the other countries. This leads us back to the idea that the Latvian healthcare system is underfunded. In the same time, the average life expectancy at birth is also among the lowest in the sample. Consequently, there is no surprise that the country obtained one of the lowest ranks in terms of efficiency of public spending in healthcare. The Data Envelopment Analysis results estimated that Latvia could improve the average life expectancy by about six years if the question of efficient spending is addressed. The healthcare system requires a careful and thorough examination in order to ensure an improvement in the health status and therefore in the standard of living of the population.

Further investigation of the total efficiency level by dividing the input-outcome relationship into two parts (input to intermediate outputs and intermediate outputs to outcomes) brings us to an interesting conclusion. Latvia is among the leaders in translating monetary resources into intermediate outputs (hospital beds/doctors/nurses per capita). Although this is a good point, it could be explained by the fact that Latvia has one of the lowest levels of healthcare expenditure. Spending significantly less and achieving comparable results (in terms of intermediate outputs) indicates that the country is cost efficient. The problems arise when the intermediate outputs need to be translated into actual health outcomes (also known as system efficiency). As the Appendix B suggests, Latvia is among the worst performing countries. As a conclusion, the Latvian healthcare system is indeed inefficient, and the main cause for that is the system inefficiency rather than any cost inefficiencies.

The second objective of the paper is to determine **what factors could improve the efficiency of public healthcare spending** and therefore through which mechanisms the government authorities could intervene. Both methods (Data Envelopment Analysis and Stochastic Frontier Analysis) yielded similar conclusions. The SFA results illustrate that although more public healthcare spending would have a positive effect on the average life expectancy, it is not enough to explain its variability (the effect is slightly insignificant).

First and among the most significant factors that affect the efficiency of public healthcare spending is the government accountability. It reflects how diligent the government authorities are at doing their job properly. A responsible government would not waste the scarce public resources on projects that do not add much value to the population. Instead, it would prioritize the needs of the society and would allocate more resources on programs of major importance. An accountable government would spend less on administrative expenses and free up these resources for healthcare, education, or social programs, contributing to a better standard of living for the average person. On a scale from -2.5 to +2.5, Latvia has a ten-year average of 0.81 as the government accountability index. This suggests that the government is not particularly diligent at performing its responsibilities and this might be a major reason why system inefficiencies appear. How can a country improve its government accountability index? It could limit or thoroughly examine the administrative expenses of the government. It could create an agency that would have the task to follow the government actions (but there are already plenty of such agencies). And finally, it could post online a detailed transcript on how the public resources are employed. More informed and aware citizens would incentivize the government to be more responsible. Even though the main conclusion is that government accountability positively affects the efficiency of public spending in healthcare, I believe the same effect should hold for the efficiency of total public spending.

The index of corruption control is another variable that characterize the government performance. Usually government accountability goes hand in hand with a tighter control of corruption. As a result, the institutional indices exhibit a high correlation. This paper focused primarily on government accountability as it is a broader indicator of performance. However, in some cases, corruption control proved to have a more significant influence. This happens when the public healthcare spending is measured on per capita basis.

Another factor that explains the efficiency of public healthcare spending in healthcare is the density of the population. A country with a less dense population would need to spend on hospitals and human resources that would serve less people than their full capacity. In addition, more hospitals translate into more administrative expenses, which are wasteful and do not contribute to a healthier society. In contrast, a denser population means that the intermediate outputs would not be wasted.

In Latvia, there are 33 people per square km and the average among the OECD countries is 136 people per square km. This could be a possible explanation why the intermediate outputs are less efficient in Latvia. Resources are wasted on maintenance expenses of regional hospitals operate at under-capacity. The effect of density of the population on the efficiency of public healthcare spending is positive but extremely small and its statistical significance is unstable. Although the government could work on programs that would minimize the emigration of the population, there are better strategies for improving the efficiency of public resources in healthcare.

An important variable in the efficiency of public healthcare expenditure is the predominant lifestyle of the population. A healthy or unhealthy lifestyle will directly translate into life expectancy. From the public expenditure perspective – this matters a lot. If people on average do not care about their health and adopt a set of habits that in the long run deteriorates their wellbeing, the government needs to spend much more to maintain a certain life expectancy level. More hospitals/doctors/nurses are needed, more subsidies for medicines are granted, more resources are needed to cover the treatment expenses for everyone so there are no inequality issues – a government operating under such conditions would find it much more difficult to be efficient at spending.

In this paper, two variables were employed as a proxy for the lifestyle choices of the population: sugar supply and alcohol consumption. Both have a negative and statistically significant effect on efficiency. According to the findings however, alcohol consumption is more damaging for the average life expectancy and efficiency of public spending. Latvians consume slightly more alcohol than the average among the OECD countries, and supply slightly less sugar compared to the average. It is important to note that countries that form the efficient DEA frontiers (deemed “the most efficient”) consume significantly below the average in both cases, alcohol and sugar. How can the government influence the lifestyle choices of the population? It could invest more in campaigns that promote a healthy lifestyle, educate the pupils so they grow up with a “healthy-lifestyle” mindset, limit the supply of unhealthy products (e.g., sugar, alcohol, tobacco). This would considerably facilitate the task of optimizing the use of the public resources in healthcare.

## 7. Conclusion

The purpose of this research was to assess the efficiency of the Latvian public resources allocated to the healthcare sector and to identify the mechanisms that could improve this efficiency. The first observation of the study is that the Latvian healthcare system does not function properly. The main performance indicator – the average life expectancy – is among the lowest in the OECD countries. Since the Latvian healthcare system is severely underfunded, a part of the problem could be explained by the lack of monetary resources to ensure a healthy society. But additional spending is often limited by a tight budget constraint. As a result, maximizing the efficiency of the available resources is essential for improving the overall health of the population.

In the same time, the findings suggest that spending alone is not enough to ensure superior health outcomes. Additional mechanisms contribute to an efficient use of public resources in healthcare. First and foremost, the government accountability – is the public authorities doing their job responsibly. Planning and spending wisely is a key driver of efficient expenditure. Also related to the activity of public institutions is the control of corruption. By minimizing corruption, the public resources are not wasted on unproductive purposes. Another driver of efficient healthcare expenditure is the choice of the population to avoid health-destructive habits, such as alcohol consumption or a sugar-rich diet.

In conclusion, the research paper points out that the Latvian public resources are not used efficiently. Being aware of this problem is the first step in solving it. Further, the study identifies several mechanisms that, if addressed correctly, could improve the efficiency of the public healthcare expenditure and contribute to a better standard of living for Latvians.

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## 9. Appendices

### *Appendix A. DEA output – Total efficiency scores*

| Country | Model 1 | | Model 2 | |
|---|---|---|---|---|
| | Efficiency score | Rank | Efficiency score | Rank |
| Australia | 0.9931 | 10 | 0.9886 | 10 |
| Austria | 0.9731 | 21 | 0.9731 | 22 |
| Belgium | 0.9686 | 24 | 0.9685 | 26 |
| Canada | 0.9761 | 17 | 0.9763 | 19 |
| Chile | 0.9626 | 26 | 1 | 1 |
| Czech Republic | 0.9558 | 28 | 0.9510 | 30 |
| Denmark | 0.9594 | 27 | 0.9594 | 29 |
| Estonia | 0.9526 | 29 | 0.9446 | 32 |
| Finland | 0.9749 | 19 | 0.9723 | 24 |
| France | 0.9851 | 12 | 0.9851 | 12 |
| Germany | 0.9683 | 25 | 0.9683 | 27 |
| Greece | 0.9777 | 15 | 0.9867 | 11 |
| Hungary | 0.9175 | 35 | 0.9327 | 34 |
| Iceland | 0.9966 | 7 | 0.9888 | 9 |
| Ireland | 0.9745 | 20 | 0.9714 | 25 |
| Israel | 1 | 3 | 1 | 1 |
| Italy | 0.9963 | 8 | 0.9954 | 7 |
| Japan | 1 | 4 | 1 | 1 |
| Korea | 0.9980 | 6 | 0.9977 | 6 |
| ***Latvia*** | ***0.9307*** | ***33*** | ***0.9492*** | ***31*** |
| Lithuania | 0.9055 | 36 | 0.9187 | 36 |
| Luxembourg | 1 | 1 | 0.9775 | 18 |
| Mexico | 0.9422 | 32 | 1 | 1 |
| Netherlands | 0.9751 | 18 | 0.9751 | 20 |
| New Zealand | 0.9780 | 14 | 0.9792 | 15 |
| Norway | 0.9854 | 11 | 0.9798 | 14 |
| Poland | 0.9509 | 30 | 0.9624 | 28 |
| Portugal | 0.9697 | 23 | 0.9790 | 16 |
| Slovak Republic | 0.9288 | 34 | 0.9288 | 35 |
| Slovenia | 0.9714 | 22 | 0.9748 | 21 |
| Spain | 0.9981 | 5 | 1 | 1 |
| Sweden | 0.9832 | 13 | 0.9832 | 13 |
| Switzerland | 0.9945 | 9 | 0.9945 | 8 |
| Turkey | 1 | 1 | 0.9776 | 17 |
| United Kingdom | 0.9770 | 16 | 0.9728 | 23 |
| United States | 0.9442 | 31 | 0.9442 | 33 |

OECD countries
Model 1: Data Envelopment Analysis (Input - Public healthcare spending to GDP ratio; Outcome - Life expectancy at birth)
Model 2: Data Envelopment Analysis (Input - Public healthcare spending per capita; Outcome - Life expectancy at birth
An efficiency score of 1 indicates the countries that are relatively more efficient at public healthcare spending. The rest of the efficiency scores indicate the position of each country relative to the "best-practice" frontier. The difference reflects the potential improvement in

the health status of the population (in percentage terms) given the same level of spending but enhanced efficiency.

***Appendix B. DEA output – Intermediate efficiency scores***

| **Country** | **Model 3** | | **Model 4** | | **Model 5** | |
|---|---|---|---|---|---|---|
| | **Efficiency score** | **Rank** | **Efficiency score** | **Rank** | **Efficiency score** | **Rank** |
| Australia | 0.7739 | 21 | 0.8425 | 18 | 0.9971 | 11 |
| Austria | 1 | 7 | 1 | 1 | 0.9778 | 21 |
| Belgium | 0.7860 | 20 | 0.8085 | 21 | 0.9784 | 20 |
| Canada | 0.5969 | 27 | 0.6512 | 28 | 1 | 4 |
| Czech Republic | 0.9197 | 12 | 0.9119 | 12 | 0.9431 | 24 |
| Denmark | 0.9855 | 8 | 1 | 1 | 0.9693 | 22 |
| Estonia | 0.8581 | 15 | 0.8007 | 22 | 0.9234 | 25 |
| Finland | 0.9302 | 11 | 1 | 1 | 0.9806 | 18 |
| France | 0.8609 | 14 | 0.8971 | 14 | 0.9928 | 13 |
| Hungary | 0.8237 | 17 | 0.8943 | 15 | 0.9120 | 26 |
| Iceland | 0.9746 | 10 | 1 | 1 | 0.9969 | 12 |
| Israel | 0.7456 | 23 | 0.7518 | 26 | 1 | 1 |
| Italy | 0.8372 | 16 | 0.8441 | 17 | 0.9999 | 9 |
| Japan | 1 | 1 | 1 | 1 | 1 | 8 |
| Korea | 1 | 1 | 1 | 1 | 1 | 6 |
| ***Latvia*** | ***1*** | ***5*** | ***1*** | ***1*** | ***0.8966*** | ***27*** |
| Lithuania | 1 | 1 | 1 | 1 | 0.8875 | 28 |
| Luxembourg | 1 | 1 | 0.7930 | 23 | 0.9911 | 14 |
| Mexico | 0.5707 | 28 | 1 | 11 | 1 | 1 |
| Netherlands | 0.7716 | 22 | 0.7796 | 24 | 0.9836 | 17 |
| New Zealand | 0.6357 | 25 | 0.7559 | 25 | 0.9971 | 10 |
| Norway | 1 | 6 | 1 | 1 | 0.9865 | 16 |
| Poland | 0.8026 | 19 | 0.8573 | 16 | 0.9602 | 23 |
| Slovenia | 0.6741 | 24 | 0.8143 | 20 | 0.9799 | 19 |
| Spain | 0.8121 | 18 | 0.8369 | 19 | 1 | 1 |
| Sweden | 0.8827 | 13 | 0.9066 | 13 | 1 | 5 |
| Switzerland | 0.9762 | 9 | 1 | 1 | 1 | 7 |
| United Kingdom | 0.6200 | 26 | 0.6659 | 27 | 0.9905 | 15 |

OECD countries
Chile, Germany, Greece, Ireland, Portugal, Slovak Republic, Turkey, and United States excluded due to missing data
Model 3: Data Envelopment Analysis (Input - Public healthcare spending to GDP ratio; Intermediate outputs - Number of hospital beds/doctors/nurses per 1000 population)
Model 4: Data Envelopment Analysis (Input - Public healthcare spending per capita; Intermediate outputs - Number of hospital beds/doctors/nurses per 1000 population)
Model 5: Data Envelopment Analysis (Inputs - Number of hospital beds/doctors/nurses per 1000 population; Outcome - Life expectancy at birth)
An efficiency score of 1 indicates the countries that are relatively more efficient at public healthcare spending or at employing the intermediate outputs so as to generate superior results in terms of health status. The rest of the efficiency scores indicate the position of each country

relative to the "best-practice" frontier. The difference reflects the potential improvement (in percentage terms) given the same level of spending but enhanced efficiency.

### *Appendix C. Stochastic frontier normal/half-normal Model 1a*

| Probability > chi-square = 0.0690 | | | | | Number of observations = 35 | |
|---|---|---|---|---|---|---|
| Variable name | Beta | Standard error | Z-score \|Z\| | P > \|Z\| | 95% confidence interval | |
| Life expectancy at birth | | | | | | |
| Constant | 79.179 | 1.4858 | 53.29 | 0.000 | 76.267 | 82.091 |
| Public healthcare spending, % of GDP | 0.2786 | 0.1532 | 1.82 | 0.069 | -0.0217 | 0.5790 |
| *St. dev. of random error* | | | | | | |
| Constant | -0.5831 | 0.4128 | -1.41 | 0.158 | -1.3922 | 0.2259 |
| *St. dev. of inefficiency* | | | | | | |
| Constant | -4.7338 | 3.7061 | -1.28 | 0.201 | -11.998 | 2.5301 |
| Government accountability | -7.4104 | 2.1289 | -3.48 | 0.000 | -11.583 | -3.2379 |
| Density of population | -0.0070 | 0.0047 | -1.49 | 0.136 | -0.0162 | 0.0022 |
| Sugar supply | 0.1248 | 0.0638 | 1.96 | 0.050 | 0.0002 | 0.2498 |
| Alcohol consumption | 0.6237 | 0.2723 | 2.29 | 0.022 | 0.0900 | 1.1574 |
| Climate | 0.0623 | 0.0528 | 1.18 | 0.238 | -0.0411 | 0.1657 |

Model 1a has the same input variables as Model 1. The only difference is the number of observations. Model 1a does not include United States since its abnormal healthcare spending to GDP ratio might distort the coefficients associated to each variable.

### *Appendix D. List of country abbreviations used in Figure 2 and Figure 3*

| **Country** | **Abbreviation** |
|---|---|
| Australia | AUS |
| Austria | AUT |
| Belgium | BEL |
| Canada | CAN |
| Chile | CHL |
| Czech Republic | CZE |
| Denmark | DNK |
| Estonia | EST |
| Finland | FIN |
| France | FRA |
| Germany | DEU |
| Greece | GRC |
| Hungary | HUN |
| Iceland | ISL |
| Ireland | IRL |
| Israel | ISR |
| Italy | ITA |
| Japan | JPN |

| | |
|---|---|
| Korea | KOR |
| Latvia | LVA |
| Lithuania | LTU |
| Luxembourg | LUX |
| Mexico | MEX |
| Netherlands | NLD |
| New Zealand | NZL |
| Norway | NOR |
| Poland | POL |
| Portugal | PRT |
| Slovak Republic | SVK |
| Slovenia | SVN |
| Spain | ESP |
| Sweden | SWE |
| Switzerland | CHE |
| Turkey | TUR |
| United Kingdom | GBR |
| United States | USA |