

T.R.
GEBZE TECHNICAL UNIVERSITY
INSTITUTE OF SOCIAL SCIENCES

**EFFICIENCY EVALUATION OF OPERATIONS STRATEGY
MATRIX IN HEALTHCARE SYSTEMS OF OECD COUNTRIES**

Aydın ÖZDEMİR
DOCTORAL DISSERTATION
DEPARTMENT OF BUSINESS ADMINISTRATION

GEBZE
2022

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GEBZE
2022



DOKTORA JÜRİ ONAY FORMU

GTÜ Sosyal Bilimler Enstitüsü Yönetim Kurulu'nun 23/11/2022 tarih ve 2022/41-01 sayılı kararıyla oluşturulan jüri tarafından **05/12/2022** tarihinde tez savunma sınavı yapılan **Aydın ÖZDEMİR**'in tez çalışması İşletme Anabilim Dalında **DOKTORA** tezi olarak kabul edilmiştir.

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ÖZET

Bu tezin üç amacı vardır; (i) Veri Zarflama Analizi (VZA) kullanarak OECD (38) ülkelerinin sağlık sistemlerindeki Operasyon Stratejisi Matrisi'nin etkinliğini değerlendirmek, (ii) Yapay Sinir Ağları (YSA) ve Veri Zarflama Analizi entegrasyonunu (VZA-YSA Modeli) kullanarak OECD (38) ülkelerinin sağlık sistemlerindeki Operasyon Stratejisi Matrisi'nin etkinliğini değerlendirmek, (iii) OECD (38) ülkelerini Veri Zarflama Analizi Matrisine (VZAM) göre Süper Yıldızlar, Potansiyel Yıldızlar, Soru İşaretleri ve Etkin Yönetilecek olmak üzere dört gruba ayırmak. Bu tez beş bölümden oluşmaktadır; Bölüm 1, Tezin Araştırma Soruları ve Amaçları, Tezin Önemi, Tezin Ontolojik Çerçevesi, Tezin Epistemolojik Çerçevesi ve Tezin Anahattı bölümlerini içermektedir. Bölüm 2, ilgili literatürün ayrıntılı bir incelemesini sunar ve Operasyon Stratejisi, Sağlık Sistemleri, OECD Ülkelerinin Sağlık Sistemlerine Genel Bakış, VZA, YSA ve Veri Zarflama Analizi Matrisi (VZAM) bölümlerini içerir. Bölüm 3, tezin metodolojisi hakkında ayrıntılı bilgi sağlar ve Örneklem, Girdiler, Çıktılar ve Veriler ile Analiz Tasarımı bölümlerini içerir. Bölüm 4, analiz sonuçlarını sunar ve Veri Zarflama Analizi (VZA) Aşamasının Sonuçları, VZA-YSA Aşamasının Sonuçları ve Veri Zarflama Analizi Matrisi (VZAM) Aşamasının Sonuçları bölümlerini içerir. Bölüm 5, tezin araştırma soruları bağlamında bir tartışma yapar ve Tartışmalar ve Yorumlar, Teorik Çıkarımlar, Yönetimsel Çıkarımlar, Tezin Sınırlılıkları ve Gelecekteki Araştırma Yönleri ve Sonuç bölümlerini içerir. Analiz prosedürü üç aşamadan oluşur; Veri Zarflama Analizi (VZA) Aşaması, VZA-YSA Modeli Aşaması ve Veri Zarflama Analizi Matrisi (VZAM) aşaması. Tezin sonunda OECD ülkelerinin sağlık yöneticileri için, bu tezin bulgularına dayanan çeşitli yönetimsel çıkarımlar sunulmaktadır.

Anahtar Kelimeler: Operasyon Stratejisi, Sağlık Sistemleri, Operasyon Stratejisi Matrisi, Veri Zarflama Analizi, Yapay Sinir Ağları, Veri Zarflama Analizi Matrisi.

SUMMARY

This dissertation has three objectives; (i) to evaluate the efficiency of the Operations Strategy Matrix in healthcare systems of OECD (38) countries using Data Envelopment Analysis (DEA), (ii) to evaluate the efficiency of the Operations Strategy Matrix in healthcare systems of OECD (38) countries using the integration of Artificial Neural Network (ANN) and Data Envelopment Analysis (DEA-ANN Model), (iii) to classify OECD (38) countries divided into four groups Super Stars, Potential Stars, Question Marks and To Be Governed Effectively based on Data Envelopment Analysis Matrix (DEAM). This dissertation is composed of five chapters; Chapter 1 includes The Research Questions and Objectives of the Dissertation, The Significance of the Dissertation, The Ontological Framework of the Dissertation, The Epistemological Framework of the Dissertation and The Outline of the Dissertation sections. Chapter 2 provides a review of relevant literature in detail and includes Operations Strategy, Healthcare Systems, Overview of Healthcare Systems of OECD Countries, DEA, ANN, and Data Envelopment Analysis Matrix (DEAM) sections. Chapter 3 provides detailed information on the methodology of the dissertation and includes the Sample, Inputs, Outputs and Data, and Analysis Design sections. Chapter 4 presents the analysis results and includes the Results of the Data Envelopment Analysis (DEA) Stage, the Results of the DEA-ANN Stage, and the Results of the Data Envelopment Analysis Matrix (DEAM) Stage sections. Chapter 5 makes a discussion in the context of the research questions of the dissertation and includes the Discussions and Comments, Theoretical Implications, Managerial Implications, Limitations of the Dissertation and Future Research Directions, and Conclusion sections. The analysis procedure consists of three stages; the Data Envelopment Analysis (DEA) Stage, DEA-ANN Model Stage and the Data Envelopment Analysis Matrix (DEAM) Stage. At the end of the dissertation, several managerial implications based on the findings of this dissertation are presented for healthcare managers of OECD countries.

Keywords: Operations Strategy, Healthcare Systems, Operations Strategy Matrix, Data Envelopment Analysis, Artificial Neural Network, Data Envelopment Analysis Matrix

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“Who dares to teach, must never cease to learn.” said John Cotton Dana.

This dissertation is the result of my never ceasing to learn. Even though I have put all my passion and effort to this dissertation, its completion would not have been possible without the participation of a few valuable contributors.

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Finally, I dedicate this dissertation to my dear late mother Nezahat ÖZDEMİR, who passed away on 28.05.2022 when she was only 58 years old, so that she is proud of me as she watches me from her garden of heaven.

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LIST OF ABBREVIATIONS

<u>Abbreviations</u>	<u>Description</u>
ANN	: Artificial Neural Network
AUST	: Australia
AUT	: Austria
BEL	: Belgium
BPNN	: Back Propagation Neural Network
CAN	: Canada
CHL	: Chile
COL	: Colombia
CRI	: Costa Rica
CZE	: Czech Republic
DEA	: Data Envelopment Analysis
DEA-ANN	: The Integration of DEA and ANN
DEAM	: Data Envelopment Analysis Matrix
DMU	: Decision Making Unit
DNK	: Denmark
EST	: Estonia
FIN	: Finland
FRA	: France
DEU	: Germany
GRC	: Greece
HUN	: Hungary
ISL	: Iceland
IRL	: Ireland
ISR	: Israel
ITA	: Italy
JPN	: Japan
KOR	: Korea
LM	: Levenberg–Marquardt
LVA	: Latvia

Abbreviations**Description**

LTU	: Lithuania
LUX	: Luxembourg
MEX	: Mexico
MLP	: Multi-Layer Perceptron
MSE	: Mean Square Error
NLD	: Netherlands
NZL	: New Zealand
NOR	: Norway
OECD	: The Organisation for Economic Co-operation and Development
OM	: Operations Management
OR	: Operations Research
OS	: Operations Strategy
POL	: Poland
PRT	: Portugal
SVK	: Slovak Republic
SVN	: Slovenia
ESP	: Spain
SWE	: Sweden
CHE	: Switzerland
TUR	: Türkiye
GBR	: United Kingdom
USA	: United States

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1. INTRODUCTION

The Research Questions and Objectives of the Dissertation section, The Significance of the Dissertation section, The Ontological Framework of the Dissertation section, The Epistemological Framework of the Dissertation section, and The Outline of the Dissertation section are presented as follows.

1.1. The Research Questions and Objectives of the Dissertation

Healthcare systems have transformed towards a value-based, patient-centred healthcare delivery model in developed countries such as OECD countries (Shahid et al., 2019). These new approaches related to healthcare delivery cause new complexities regarding how healthcare systems need to be structured, managed and measured (Kuziemy, 2016).

Since countries can learn from each other, none have a monopoly on what is a sound healthcare system (Anderson, 1963); determining and measuring efficiency is an essential strategy in healthcare decision-making (Shirvani & Azizi, 2022).

There are some notable works on healthcare systems of OECD countries in the relevant literature, such as (de Bienassis et al., 2022; Lorenzoni, Marino, et al., 2019; Lorenzoni, Pinto, et al., 2019; Marino et al., 2017; Morgan & James, 2022).

In this context, this dissertation has three research questions;

- (i) Are OECD (38) countries efficient in the healthcare system in terms of the Operations Strategy Matrix using Data Envelopment Analysis (DEA)?
- (ii) Are OECD (38) countries efficient in the healthcare system in terms of the Operations Strategy Matrix using the integration of Artificial Neural Network (ANN) and Data Envelopment Analysis (DEA-ANN Model)?
- (iii) How are OECD (38) countries classified according to their DEA and DEA-ANN Model scores based on Data Envelopment Analysis Matrix?

There are some notable works that Data Envelopment Analysis applied to healthcare at the level of countries/states/regions in the relevant literature, such as

(Abolghasem et al., 2019; Ekiz Bozdemir et al., 2021; El Husseiny, 2022; Gavurova et al., 2021; Gómez-Gallego et al., 2021; Y. Gong, 2013; Ibrahim & Daneshvar, 2018; İlğün & Şahin, 2022; Jordi et al., 2020; Kang et al., 2021; Klumpp et al., 2022; Kočiřová et al., 2020; Mourad et al., 2021; Olejnik et al., 2021; Önen & Sayın, 2018; Özdemir et al., 2021; Pereira et al., 2022; Ramalho et al., 2022; Shen et al., 2020; Top et al., 2020).

In this context, the first objective of this dissertation is to evaluate the efficiency of the operations strategy matrix in healthcare systems of OECD (38) countries using Data Envelopment Analysis (DEA).

There are some notable works that DEA-ANN Model applied to the healthcare area in the relevant literature, such as (Misiunas et al., 2016; Revuelta et al., 2021; Taherinezhad & Alinezhad, 2022; Tosun, 2012; Zarrin et al., 2022).

In this context, the second objective of this dissertation is to evaluate the efficiency of the operations strategy matrix in healthcare systems of OECD (38) countries using the integration of Artificial Neural Network (ANN) and Data Envelopment Analysis (DEA-ANN Model).

There are some notable works of the Data Envelopment Analysis Matrix applied to healthcare in the relevant literature, such as (Osman et al., 2011; Vafaei Najar et al., 2018).

In this context, the third objective of this dissertation is to classify OECD (38) countries divided into four groups Super Stars, Potential Stars, Question Marks and To Be Governed Effectively based on Data Envelopment Analysis Matrix (DEAM).

1.2. The Significance of the Dissertation

Performance evaluation is an essential continuous improvement tool for organisations to stay competitive and plays a vital role in the global market, where intense competition grows more each day (J. Zhu, 2014).

The measurement of performance aims to find out either how far an organization could be expected to raise its output with the present amount of input or how much input could be saved while producing the present level of output by simply raising its efficiency, and so make sure an organization's control (Kao, 2017; Thanassoulis, 2001).

Many researchers and practitioners have been working to develop a suitable way and tool to objectively measure the performance of an organization that uses multiple inputs to produce multiple outputs (Kao, 2017). Efficiency, as one of the significant components of the version, means using the minimum amount of inputs for a given amount of outputs (Ozcan, 2014).

Since healthcare services are subject to budget limitations and it is gradually becoming more challenging to provide improved healthcare services without increasing delivery costs, performance evaluation of healthcare facilities is relevant in all countries (Wanke & Aktas, 2018). According to (Stevenson, 2021); operations strategy can significantly influence an organisation's competitiveness. If it is well structured and well executed, there is a good chance the organization will be successful; if it is not well designed or completed, it is far less likely to be successful.

In this context, the below considerations demonstrate the significance of the dissertation;

- ✓ Using Operations Strategy Matrix, a novel and objective evaluation tool,
- ✓ Conducting a trilogy hybrid methodology; (i) Data Envelopment Analysis (DEA) with both desirable and undesirable output, (ii) the integration of Artificial Neural Network (ANN) and Data Envelopment Analysis (DEA-ANN Model), and (iii) Data Envelopment Analysis Matrix (DEAM).

1.3. The Ontological Framework of the Dissertation

According to (Bryman & Bell, 2011), questions of social ontology are concerned with the nature of social entities, and ontological orientation in quantitative research refers to objectivism, which is an ontological position that implies that social phenomena confront us as external facts that are beyond our reach or influence. In other words, ontological perspectives are conceptualisations of reality or truth (Howell, 2013).

According to (Barney & Clark, 2007), strategic management is organized about a central research question; *“why do some firms persistently outperform others?”*

According to (Barney & Arikan, 2017), this question does not assume that there will always be consistent performance differences between firms. Instead, it thinks that consistent performance differences will appear between firms in some cases and that traditional economic theories of firm performance cannot explain those differences.

Strategic management scholars also discuss these differences in firm performance (Barney, 2001). Resource-Based Theory (RBT) has emerged as one of several essential explanations for persistent organisational performance differences in strategic management (Barney & Arikan, 2017).

(Hitt et al., 2016) have explored the complementarity of Resource-Based Theory (RBT) and the four major Operations Management (OM) foci identified from Operations Management (OM) research; Operations Strategy, Performance Management, Supply Chain Management, and Product/Service Innovation.

In this dissertation, while Operations Strategy and Performance Management are the main research areas, Supply Chain Management and Product/Service Innovation are sub-research areas.

These considerations demonstrate the ontological perspectives of this dissertation.

1.4. The Epistemological Framework of the Dissertation

According to (Bryman & Bell, 2011), an epistemological subject concerns the question of what is (or should be) regarded as adequate knowledge in a discipline and epistemological orientation in quantitative research refers to positivism, which is an epistemological status that defends the implementation of the methods of the natural sciences to the work of social reality and beyond.

In other words, epistemological perspectives are the relationship between the observer and the observed (Howell, 2013).

Healthcare Operations Management is a discipline that integrates scientific management principles to identify the most efficient and optimal methods to support healthcare delivery (Langabeer & Helton, 2021).

In this dissertation, Operations Strategy, a field of Operations Management, was investigated through;

- (i) Data Envelopment Analysis (DEA), a method of Operations Research,
- (ii) Data Envelopment Analysis (DEA) and Artificial Neural Network (ANN) (DEA-ANN Model), an integrated approach to Operations Research and Management Information Systems,
- (iii) Data Envelopment Analysis Matrix (DEAM), an integrated method of Operations Research and Strategic Management,

in the healthcare area as a part of the Healthcare Operations Management discipline.

These considerations demonstrate the epistemological perspectives of this dissertation.

1.5. The Outline of the Dissertation

This dissertation is composed of five chapters;

Chapter 2 provides a review of relevant literature in detail and includes Operations Strategy, Healthcare Systems, Overview of Healthcare Systems of OECD Countries, Data Envelopment Analysis (DEA), Artificial Neural Network (ANN), and Data Envelopment Analysis Matrix (DEAM) sections.

Chapter 3 provides detailed information on the thesis methodology and includes the Sample, Inputs, Outputs and Data, and Analysis Design sections.

Chapter 4 presents the analysis results and includes the Results of the Data Envelopment Analysis (DEA) Stage, DEA-ANN Stage, and Data Envelopment Analysis Matrix (DEAM) sections.

Chapter 5 makes a discussion in the context of the dissertation's research questions and includes the Discussions and Comments section, Theoretical Implications section, Managerial Implications section, Limitations of the Dissertation and Future Research Directions section, and Conclusion section.

2. LITERATURE REVIEW

The Operations Strategy section, Overview of Healthcare Systems of OECD Countries section, Data Envelopment Analysis (DEA) section, Artificial Neural Network (ANN) section, and Data Envelopment Analysis Matrix (DEAM) section are presented as follows.

2.1. Operations Strategy

The fundamentals of the Operations Strategy section, Strategic Decision Areas section, Competitive Priorities/Performance Objectives section, Operations Strategy Matrix section and Related Works section are presented.

2.1.1. Fundamentals of Operations Strategy

Operations management (OM) is the collection of activities that create value in goods and services by transforming inputs into outputs (Heizer et al., 2020). Operations management provides the foundation for an organization's competitive strategy (Greasley, 2020) and is about how an organisation produce goods and services (Slack & Brandon-Jones, 2021). It is also concerned with designing and operating systems for manufacture, transport, supply or service (Roy, 2005).

Operations management uses resources (*i.e., experience, people, machines, knowledge, partner, etc.*) to appropriately (*i.e., effectively, efficiently, creatively, etc.*) create (*i.e. produce, change, sell, assemble, move, cure, shape, etc.*) outputs (*i.e. ideas, products, services, etc.*) that fulfil (*i.e. match, satisfy, exceed, delight, etc.*) defined (*i.e. potential, perceived, current, emerging, real, etc.*) market (*i.e. citizens', client, customer, society, etc.*) requirements (*i.e. dreams, demands, needs, concerns, etc.*) (Slack et al., 2011).

While operations management is responsible for making strategic (long-term) decisions that affect the entire organization and have to support the mission and the overall strategy of the organization (Kamauff, 2010), operations strategy aims to interpret the overall strategy of the organization (Greasley, 2020). However, there is no commonly accepted definition of operations strategy (Lewis, 2020). It can be

defined as the pattern of strategic decisions and actions that set the operation's role, objectives and activities (Slack et al., 2016; Slack & Lewis, 2017).

Since strategy is usually regarded as the opposite of those day-to-day routine activities (Slack et al., 2011), the very idea of an *operations strategy* is a contradiction in terms of many organizations (Slack & Brandon-Jones, 2021). But *operations* is not the same as *operational*; it does have a strategic role (Slack et al., 2016).

It is also necessary to distinguish between the “content” and “process” of the operational strategy (Slack et al., 2011). While the content of operations strategy is the specific decisions and actions that set the operations role, objectives and activities (Slack et al., 2016), the process of operations strategy is the technique used to make the specific *content* decisions (Slack et al., 2011).

Although at a superficial level, the difference between operations strategy and operations management is assumed as a strategic perspective on how operations resources and processes are managed, the differences are depicted in Table 2.1. (Slack & Lewis, 2017).

Table 2. 1: The Differences Between Operations Management and Operations Strategy

Operations Management (OM)	Operations Strategy (OS)
OM is primarily concerned with short to medium-time scales	OS is longer-term
OM is primarily concerned with managing resources within and between smaller operations	OS is concerned with a higher level of analysis
OM is concerned with the details of how products and services are produced	OS involves a greater level of aggregation
OM is mainly concerned with what is immediately recognisable and tangible	OS uses a higher level of abstraction

Source: (Slack & Lewis, 2017)

The role of operations strategy is to provide a long-term plan for using the organization’s resources to produce the organization’s essential goods and services (R. D. Reid & Sanders, 2013).

An operations strategy must include at least the following (Brown et al., 2005);

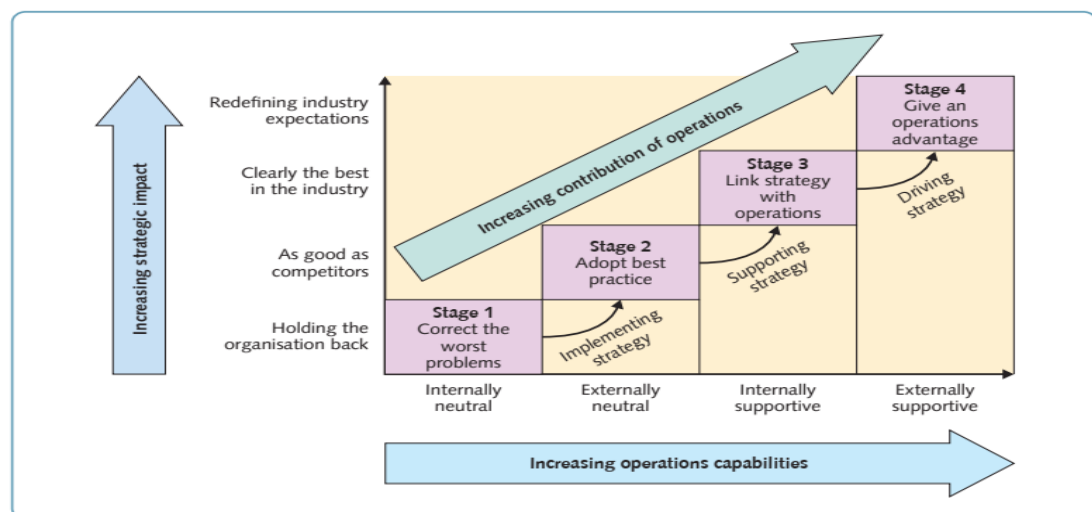
- ✓ Amounts of capacity
- ✓ The range and locations of facilities
- ✓ Technology investment
- ✓ Formation of the strategic buyer
- ✓ The rate of new product or service introduction
- ✓ Organizational structure

Operations strategy should articulate a vision for the contribution of operations function to the overall organization strategy (Slack & Brandon-Jones, 2021). The assistance can be evaluated by considering the organizational aims or aspirations of the operations function (Slack et al., 2011).

Professors Hayes and Wheelwright of Harvard University developed a four-stage model which can be used to evaluate mentioned contribution and role of the operations function (Hayes & Wheelwright, 1984; Slack et al., 2016).

The model traces the progression of the operations function from the largely negative and reactive role of Stage-1 Operations to its becoming the central and proactive element of competitive strategy in excellent Stage-4 Operations (Greasley, 2020; Slack et al., 2011).

The four stages are presented in Figure 2.1.



Source: (Slack & Brandon-Jones, 2021)

Figure 2. 1: Hayes and Wheelwright's Four-Stage Model

According to Figure 2.1. the four stages are summarized below;

✓ *Stage 1 (Internally Neutrality)*

This is the very poorest contribution level by the operations function and is attempted to improve by avoiding making mistakes in this stage (Slack et al., 2011). The principle of this stage is “*correct the worst problems*” (Slack & Lewis, 2017).

✓ *Stage 2 (Externally Neutrality)*

The first step of breaking out of stage 1 is for the operations function to begin comparing itself with similar companies or organizations in the outside market (*being “externally neutral”*) (Slack et al., 2016). The principle of this stage is “*adopt best practices*” (Slack & Lewis, 2017).

✓ *Stage 3 (Internally Supportive)*

These operations have probably reached the “first division” in their market and are trying to be ‘internally supportive’ by providing a credible operations strategy (Slack & Brandon-Jones, 2021). The principle of this stage is “*link strategy with operations*” (Slack & Lewis, 2017).

✓ *Stage 4 (Externally Supportive)*

These operations are innovative, creative and proactive and drive the organization’s strategy by being ‘one step ahead’ of competitors – what Hayes and Wheelwright call “*being externally supportive*” (Slack et al., 2011). The principle of this stage is “*give an operations advantage*” (Slack & Lewis, 2017).

Although there are some slightly different views and definitions of operations strategy (Slack et al., 2011), as mentioned above, there is no commonly accepted definition of it (Lewis, 2020).

However, four “perspectives” emerge between these views and definitions, as depicted in Figure 2.2. (Slack et al., 2016).



Source: (Slack & Lewis, 2017)

Figure 2. 2: Four Perspectives on Operations Strategy Matrix

According to Figure 2.2., the four perspectives are summarized below;

- ✓ Operations strategy is a *top-down* reflection of what the organization wants to do (Slack et al., 2011).
- ✓ Operations strategy is a *bottom-up* activity where operations improvements cumulatively build the strategy (Slack et al., 2016).
- ✓ Operations strategy involves translating *market requirements* into operations decisions (also known as the *outside-in* perspective) (Slack & Brandon-Jones, 2021; Slack & Lewis, 2017).
- ✓ Operations strategy involves exploiting the capabilities of *operations resources* in chosen markets (also known as the *inside-out* perspective) (Slack et al., 2011; Slack & Brandon-Jones, 2021).

A top-down perspective often defines three related levels of strategy: corporate, business and functional (Slack & Brandon-Jones, 2021). The corporate strategy consists of decisions about what types of business the group wants to be in, what parts of the world it wants to operate in, how to allocate its resources between its various organizations and so on (Slack et al., 2011).

Within the corporate group, each business unit will also need to put together its business strategy, which regulates its mission and objectives and defines how it

aims to compete in its markets (Slack & Lewis, 2017). Besides, within the business, functional strategies need to consider what part each function should make in contributing to the business's strategic objectives (Slack et al., 2016).

Operations strategy should reflect the bottom-up experience of operational reality (Slack & Brandon-Jones, 2021). Organizations reviewing their strategies should consult the individual functions within the organization about their constraints and capabilities (Slack et al., 2016). The principle of the bottom-up perspective is to shape the objectives and activities of an operation by the knowledge it gains from its operational (day-to-day) activities (Slack & Lewis, 2017). Therefore, an alternative to the top-down perspective is that many strategic ideas emerge over time from operational (day-to-day) experience (Slack et al., 2011).

Operations strategy should reflect the requirements of the organization's markets (Slack et al., 2016). This perspective on operations strategy is sometimes called the "*outside-in*" perspective (Slack & Lewis, 2017). Operations seek to satisfy customers by developing their five performance objectives, also known as competitive priorities/factors, which define the customers' requirements (Slack et al., 2011). These performance objectives/ competitive priorities are explained in *Section 2.2.3*.

The long-term objective of the operations strategy is to build operations-based capabilities (Slack & Brandon-Jones, 2021). The operations resources perspective, also known as the inside-out perspective, is based on a particularly influential theory of business strategy – the Resource-Based Theory (RBT) of an organization (Slack et al., 2011).

Resource-Based Theory (RBT) is a model of a firm performance that focuses on the resources and capabilities controlled by a firm as a source of competitive advantage (Barney & Hesterly, 2012). RBT is mainly concerned with the nature of strategic capabilities and resources (Sanders & Wong, 2020). The basis of a firm's competitive advantage can be explained and predicted through the RBT framework (Kozlenkova et al., 2014).

Resource-Based Theory (RBT) explains that the sustainable competitive advantage of an organization arises out of firm resources that are valuable, rare, imperfectly imitable, and hard to substitute (Bromiley & Rau, 2016). Firms with

superior resources can deliver more significant benefits to their customers for a given cost (Peteraf & Barney, 2003).

There are some critical terms in Resource-Based Theory (RBT). The first of these terms is *resources*; it means anything which could be thought of as a strength or weakness of a firm (Wernerfelt, 1984) and can be described as the tangible and intangible assets which are tied semi-permanently to the firm (Nothnagel, 2008; Wernerfelt, 1984). The firm uses resources to conceive of, choose and implement its strategies (Barney & Arian, 2017; Nothnagel, 2008). While a firm's factories and products are tangible assets, its reputation among customers and teamwork among its managers are considered intangible assets (Barney & Hesterly, 2012).

Resource-Based Theory holds that organizations with an “*above-average*” strategic performance are likely to have a sustainable competitive advantage because of their core competencies or capabilities (Slack et al., 2016). An organisation's resources are closely linked to its ability to outperform competitors and can be classified as strategic if they exhibit the properties (Slack & Lewis, 2017). This circumstance refers to the VRIO Framework, which can be applied in analysing the potential of a broad range of firm resources to be sources of sustained competitive advantage (Barney & Clark, 2007). It is the primary tool for accomplishing internal analysis and stands for four questions one has to ask about a resource or capability to determine its competitive potential (Barney & Hesterly, 2012).

The VRIO Framework is presented as follows:

- ✓ The question of Value (**V**): Do a firm's resources and capabilities enable the firm to respond to environmental threats or opportunities (Barney & Clark, 2007)?
- ✓ The question of Rarity (**R**): Is a resource currently controlled by only a small number of competing firms (Barney & Hesterly, 2012)?
- ✓ The question of Imitability (**I**): Do firms without a resource face a cost disadvantage in obtaining or developing it (Barney & Clark, 2007)?
- ✓ The question of Organization (**O**): Are a firm's other policies and procedures organized to support the exploitation of its valuable, rare, and costly-to-imitate resources (Barney & Hesterly, 2012)?

Four perspectives of operations strategy are not alternative views of what operations strategy is; on the contrary, operations managers should hold all four views simultaneously (Slack & Lewis, 2017). Because they are reasonably compatible with its operations strategy fitting together from whichever perspective is chosen, in other words, In other words, each perspective is *reconciled* with the others (Slack & Brandon-Jones, 2021).

An operations strategy should be comprehensive and coherent, provide correspondence, prioritize the most critical issues (Slack et al., 2011), can provide the basis for improvement by achieving a fit between an operation's market requirements, i.e. outside-in perspective and its operations resources and capabilities, i.e. inside-out perspective (Slack et al., 2016).

On the other hand, while the content of the operations strategy reconciles the market requirements and operations resource perspectives, the process of operations strategy reconciles the top-down and bottom-up perspectives (Slack & Lewis, 2017).

The reconciliation of market requirements and operations resources is depicted in Figure 2.3.



Source: (Slack & Lewis, 2017)

Figure 2. 3: The Reconciliation of Market Requirements and Operations Resources

In Figure 2.3., the market requirements perspective on operations strategy is summarised in terms of five generic performance objectives (quality, speed, dependability, flexibility and cost) that purpose is to articulate market requirements in a way that will be useful to operations (Slack & Lewis, 2017).

While Strategic Decision Areas depicted in Figure 2.3. are explained in *Section 2.1.2.*, Performance Objectives shown in Figure 2.3. are presented in *Section 2.1.3.*

2.1.2. Strategic Decision Areas

Strategic Decision Areas are the collections of decisions needed to manage the operation's resources (Slack & Lewis, 2017). These consist of Capacity Strategy, Supply Network Strategy, Process Technology Strategy, and Development and Organization Strategy.

2.1.2.1. Capacity Strategy

Capacity is the maximum level of value-added activity over time that the operation can achieve under normal conditions (Slack et al., 2011). Besides, capacity is the throughput or number of units a facility can hold, receive, store, or produce in a period (Heizer et al., 2020).

Capacity management is coping with mismatches between an operation's demand and its ability to supply (Slack & Brandon-Jones, 2021). This circumstance means deciding how the operation should react to fluctuations in demand (Slack et al., 2011). The capacity planning and control activity should measure demand and capacity and reconcile capacity and demand (Greasley, 2020). Any measure of capacity should reflect the ability of an operation or process to supply demand (Slack & Brandon-Jones, 2021).

The capacity strategy includes capacity levels; the number of sites; the size of sites; when to change capacity; how much to change capacity; and location decisions (Slack & Lewis, 2017). Capacity decisions have to be integrated into the organization's mission and strategy, and there are four special considerations for an excellent capacity decision as follows (Heizer et al., 2020);

- ✓ Forecast demand accurately,
- ✓ Match technology increments and sales volume,

- ✓ Find the optimum operating size (volume),
- ✓ Build for change.

The capacity strategy of an operation defines its overall scale, the number and size of different sites between which its capacity is distributed, the specific activities allocated to each site and the location of each site (Slack & Lewis, 2017). Capacity appears in many different types, such as storage space, availability of employee skills, equipment numbers and transportation facilities (Greasley, 2020).

There are three levels of capacity decision; the first of these is strategic capacity decisions level with a years-moth time scale, the second of these is medium-term capacity decisions level with a months-week time scale, the third of these is short-term capacity decisions level with a weeks-hours-minutes time scale (Slack & Lewis, 2017).

2.1.2.2. Supply Network Strategy

A supply network perspective means setting an operation in the context of all the customers and suppliers interacting with it (Slack et al., 2011). Materials, parts, information, ideas and sometimes people all flow through the network of customer-supplier relationships formed by all these operations (Slack & Brandon-Jones, 2021). While on its supply side, an operation has its suppliers of parts, information, or services, on the demand side, the operation has customers (Slack et al., 2016). The suppliers and customers directly contacting an operation are named its immediate supply network (Slack & Brandon-Jones, 2021).

Supply networks strategy is defined as a set of interconnected organisations whose different processes and activities together produce value and includes decisions about questions as follows (Slack & Lewis, 2017);

- ✓ What is purchasing and supply strategy?
- ✓ What should we do, and what should we buy?
- ✓ How do we buy; what is the role of contracts and relationships?
- ✓ How do we manage supply dynamics?
- ✓ How do we manage suppliers over time?
- ✓ How do we manage supply chain risks?

There are several important reasons for taking a supply network perspective as follows (Slack et al., 2011);

- ✓ It helps an understanding of competitiveness,
- ✓ It helps identify significant links in the network,
- ✓ It helps focus on long-term issues,
- ✓ It helps focus on the cost.

Since supply networks are interrelationships of independent operations, each operation relates to the others in the network providing an opportunity for supply network distortions (Slack & Lewis, 2017). A supply network perspective, therefore, helps to make sense of competitive, relationship, and longer-term operation issues (Slack et al., 2016).

2.1.2.3. Process Technology Strategy

Process technology is a vital aspect of operations as it has led to a massive growth in productivity (Greasley, 2020). Process technologies are the machine's equipment and devices that help processes transform materials, information and customers (Slack & Brandon-Jones, 2021).

Although process technologies range from milking machines to marking software, body scanners to bread ovens, and mobile phones to milling machines; they can be divided into three types; material-processing technologies, information-processing technology and customer-processing technology (Slack et al., 2016).

Process technology strategy is the collection of decisions that defines the strategic role, plays in the overall operations strategy of the organisation, and arranges the general features that help to evaluate alternative technologies (Slack & Lewis, 2017). Operations managers should understand enough about process technology to evaluate technologies (Slack et al., 2016).

Process technology strategy includes issues as follows (Slack & Lewis, 2017);

- ✓ Characterising process technologies,
- ✓ Understanding the general characteristics of process technologies over time,
- ✓ The effect of new forms of technology on performance,
- ✓ Evaluating process technology,

- ✓ The impact of process technology on performance objectives.

Process technology in high-volume, low-variety processes is relatively automated, large-scale and closely unified compared to that in low-volume, high-variety circles (Slack & Brandon-Jones, 2021). Process technology management consists of three stages as follows (Slack et al., 2016);

- ✓ Stage 1- understand the process technology
- ✓ Stage 2- evaluate the process technology
- ✓ Stage 3- implement the process technology

2.1.2.4. Development and Organization Strategy

Recently things have changed; first, the speed and scale of market and technology changes have increased; second, there is a better understanding of how closely connected the processes by which products and services are developed and the outcomes of these processes (Slack & Lewis, 2017).

Operations managers play a vital role in establishing a human resources strategy (Slack et al., 2016). Almost all products and service developments take place under conditions of uncertainty, and like all decisions about uncertainty, they are affected by several behavioural factors (Slack & Lewis, 2017). It is called *behavioural operations management* or simply *behavioural operations*, and it explores the interaction of human behaviours and operational systems and processes (Slack & Brandon-Jones, 2021), influenced by cognitive biases, social preferences, and cultural norms (Loch & Wu, 2005). Most behavioural operations management research has focused on studying decisions and the behaviour of individuals or small groups of individuals (Lewis, 2020).

Development and organization strategy includes issues as follows (Slack & Lewis, 2017);

- ✓ Relating product and process development,
- ✓ Managing product/service development as a process,
- ✓ Meeting market requirements for new products and services,
- ✓ Managing product/service development resources.

Some typical questions should be addressed in development and organization strategy decisions as follows (Slack et al., 2011).

- ✓ What role should the people who staff the operation play in its management?
- ✓ How should responsibility for the activities of the operations function be allocated between different groups in operation?
- ✓ What skills should be developed in the staff of the operation?

2.1.3. Competitive Priorities / Performance Objectives

Since many authors on operations strategy have their own set of performance objectives, no overall agreement exists on terminology, and they are referred to variously as “performance criteria”, “operations strategic dimensions”, “performance dimensions”, “competitive priorities” and “strategic priorities” (Slack & Lewis, 2017).

It will be used as “*competitive priorities/performance objectives*” in this dissertation.

Running operations at an operational (functional) level requires a more tightly defined set of objectives, and these are named operations competitive priorities or performance objectives (Slack et al., 2016). Competitive Priorities / Performance Objectives are the aspects of operations performance that satisfy market requirements and, therefore, the operation is expected to pursue (Slack & Lewis, 2017).

Competitive Priorities / Performance Objectives are the capabilities that the operations function can develop to give an organization a competitive advantage in its market (R. D. Reid & Sanders, 2013). In other words, Competitive Priorities / Performance Objectives are the strategic priorities that help increase market share (Karuppan et al., 2016).

Since one of the critical tasks during developing strategy is that operations managers are aware of competitive factors and can activate capabilities to deal with such competitive requirements, the link between competitive requirements and operations capabilities is presented in Table 2.2. (Brown et al., 2005).

Table 2. 2: The Link Between Competitive Requirements and Operations Capabilities

Competitive Factors	Operations Task
Offer Consistently Low Defect Rates	Process Quality
Offer Dependable Delivery	Delivery Reliability
Provide High-Performance Products or Amenities	Product Quality
Offer Fast Deliveries	Delivery Speed
Customize Products and Services to Customer Needs	Flexibility
Profit in Price-Competitive Markets	Low-Cost Production
Introduce New Products Quickly	Rapid Innovation
Offer a Broad Product Line	Flexibility
Make Rapid Volume Changes	Flexibility
Make Rapid Product Mix Changes	Customization, Flexibility
Make Product Easily Available	Delivery Speed/Reliability (Distribution)
Make Rapid Changes in The Design	Flexibility

Source: (Brown et al., 2005)

An organization must be balanced and ready to meet future market opportunities (Brown et al., 2005), as depicted in Table 2.2.

There are differences between authors as to precisely what these performance dimensions are; there are many commonly used categories (Slack & Lewis, 2017). While in one of these commonly used categories, Competitive Priorities / Performance Objectives are subsumed as a set of five competitive priorities/performance objectives; Quality, Speed, Dependability, Flexibility and Cost (Slack et al., 2011, 2016; Slack & Brandon-Jones, 2021; Slack & Lewis, 2017), in another of these commonly used categories, Competitive Priorities / Performance Objectives are subsumed as a set of four competitive priorities/performance objectives; Quality, Cost, Delivery and Flexibility (Karuppan et al., 2016).

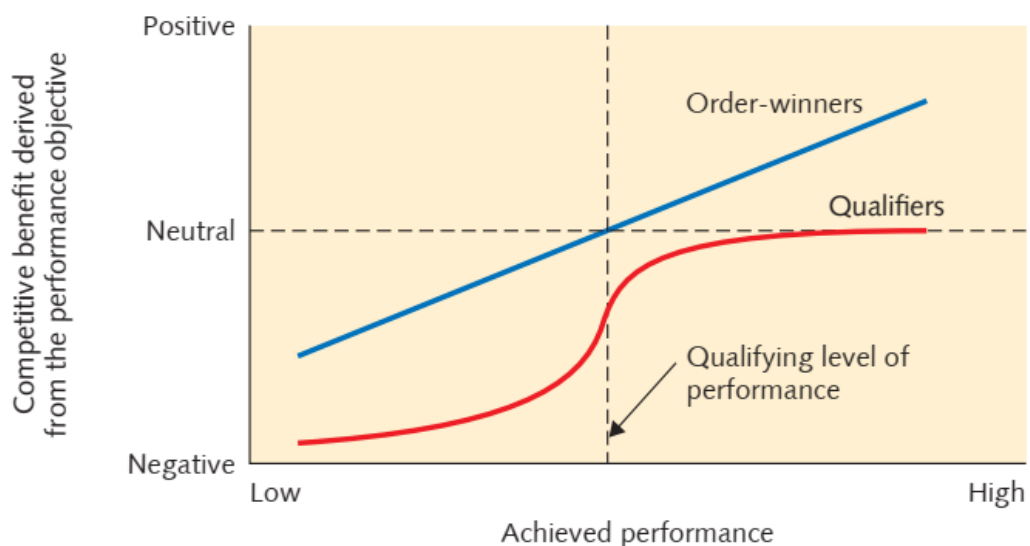
Since the second one is subsumed in the healthcare area, Competitive Priorities / Performance Objectives are assumed as *Quality, Cost, Delivery and Flexibility* in this dissertation.

Competitive Priorities / Performance Objectives can be classified as “order-winners” and “qualifiers (Slack et al., 2016). An useful way to determine the relative importance of competitive concepts is to distinguish between “order-winners” and

“qualifiers” concept (Slack et al., 2011). In formulating a successful strategy, organizations must consider order qualifiers and order winners (Stevenson, 2021).

These concepts are developed by Terry Hill, a professor at Oxford University, and while qualifiers are those criteria that an organization must meet for a customer even to consider it as a possible supplier, order-winners are those criteria that win the order (Hill, 2000). While performance below this ‘qualifying’ level will result in the organization being disqualified by many customers (Slack et al., 2011). It is essential to understand that order winners and order qualifiers change over time (R. D. Reid & Sanders, 2013).

The difference between order-winning and qualifying objectives in terms of their utility to the organisation's competitiveness is illustrated in Figure 2.4. (Slack et al., 2016; Slack & Brandon-Jones, 2021).



Source: (Slack & Brandon-Jones, 2021)

Figure 2. 4: The Difference Between Order-Winners and Qualifiers

Figure 2.4. shows the relative amount of competitiveness as the operation’s performance at the factor varies (Slack et al., 2016). In the healthcare area, as order-winners means attracting patients and health insurers to consume your services instead of your competitors, Competitive Priorities / Performance Objectives are assumed as Quality, Cost, Delivery and Flexibility (Karuppan et al., 2016).

The Competitive Priorities / Performance Objectives (Quality, Cost, Delivery and Flexibility) are explained in detail as follows.

2.1.3.1. Quality

Quality is vital to businesses but can be hard to define (Charantimath, 2017). Many definitions of quality refer to the “specification” of a good or service, usually meaning high specification (Slack & Lewis, 2017).

According to (Juran & Godfrey, 1999); the many meanings of the word “quality”, two are of critical importance to managing quality;

- ✓ Quality means those features of products which meet customer needs and thus provide customer satisfaction,
- ✓ Quality means freedom from deficiencies.

All definition of quality has some standard features as follows (Charantimath, 2017);

- ✓ Conformance to requirements
- ✓ A degree of excellence
- ✓ The totality of characteristics which act to satisfy a need
- ✓ Fitness for use
- ✓ Fitness for purpose
- ✓ Freedom from defects
- ✓ Delighting customers

In the mathematical method, quality (Q) is defined as the ratio of performance (P) to expectation (E); if $P > E$, it means quality is best; if $P = E$, it means quality is good; if $P < E$, it means quality is worst (Luthra et al., 2021).

Healthcare quality is the degree to which health services increase the likelihood of desired health outcomes for individuals and populations (Spath, 2019). According to the Donabedian Model, there are three dimensions to evaluate healthcare quality; the first of these is whether the outcome of care is, in fact, the relevant measure, the second of these is to examine the process of care itself rather than its outcomes, the third of these is to study not the process of care itself (Donabedian, 2005).

2.1.3.2. Cost

Since cost is clearly a major performance objective for organizations that compete directly on price, the lower the cost of producing their goods and services, the lower can be the price to their customers and intended populations (Slack & Lewis, 2017). Even if the organization does not compete directly on price, the cost is always a competitive priority/performance objective for operations management (Slack et al., 2016).

Cost means doing operations cheaply and producing goods and services at a cost that enables them to be priced appropriately for the market (Slack & Brandon-Jones, 2021). Since the operation will spend its money on staff, facilities, technology and equipment and materials (Slack et al., 2016), to improve this competitive priority/performance objective, the operations function has to focus primarily on cutting costs in the system, such as costs of labour, materials, and facilities (R. D. Reid & Sanders, 2013).

Cost is taken into account to be the finances required to obtain the inputs) and manage the transformation process that produces finished goods and services (Greasley, 2020). Cost is the total cost each good or service will incur across the entire organization (Kamauff, 2010). Cost is usually a monetary valuation of some concepts as follows (Karuppan et al., 2016);

- ✓ Effort,
- ✓ Material,
- ✓ Resources,
- ✓ Time and utilities consumed,
- ✓ Risks incurred,
- ✓ Opportunities have been forgone in producing a product and delivering a service.

Cost management with improved financial performance is an achievable objective for organizations willing to engage with discipline, and the primary tools for cost reduction in the healthcare area are the use of evidence-based medicine (EBM) supported by electronic health records and advanced healthcare analytics (McLaughlin et al., 2022)

2.1.3.3. Delivery

Delivery is a competitive priority/performance objective focusing on speed and on-time delivery (R. D. Reid & Sanders, 2013). Speed refers to the time between the beginning of an operations process and its end (Slack & Lewis, 2017).

In other words, speed minimizes the time between a customer asking for services or goods and the customer receiving them in full (Slack et al., 2011). The other side of delivery, also known as dependability, is keeping the delivery promises to customers, i.e., doing things on-time (Slack & Brandon-Jones, 2021).

Since rapid delivery refers to how quickly an order is received (R. D. Reid & Sanders, 2013), a company may win orders through its ability to deliver more quickly than competitors or to meet the delivery date required (Hill, 2000). Besides, since on-time delivery refers to how often deliveries are made on time (R. D. Reid & Sanders, 2013), The need to identify on-time delivery different expectations is a vital step here as with other order-winners and qualifiers (Hill, 2000).

While an advantage of rapid delivery is that it can be used to reduce costs and delivery time, leading to better customer service, on-time delivery can also lead to lower costs to ensure things happen on time (Greasley, 2020). Occasionally organizations set a standard for providing delivery, and one should measure adherence to this standard (Ronen et al., 2006).

While in Donabedian Model, the process involves the actual delivery of care as well as its management (Buchbinder & Shanks, 2017; Donabedian, 2005), According to (Karuppan et al., 2016), delivery consists of three concepts: process analysis and design, capacity and demand and, scheduling.

While rapid delivery to external customers is greatly helped by speedy decision-making and speedy movement of materials and information inside the operation, internal customers will judge each other's performance by how reliable the other processes are in delivering material or information on-time delivery (Slack et al., 2016).

2.1.3.4. Flexibility

Flexibility is the ability to vary or adapt the operation's activities to cope with unexpected conditions, i.e., changing what you do or how you do it (Slack & Brandon-Jones, 2021). Changing far enough and fast enough to meet customer requirements give a flexibility advantage (Slack et al., 2011). There are three layers of flexibility: strategic, process, and resource (Karuppan et al., 2016). Customers will need the operation to change so that it can provide four types of requirements as follows (Slack et al., 2016; Slack & Lewis, 2017);

- ✓ *Product/Service Flexibility*; the ability to introduce novel goods and services;
- ✓ *Mix Flexibility*; the ability to produce a wide range or mix of goods and services within a given time;
- ✓ *Volume Flexibility*; the ability to change the level of the operation's aggregated output;
- ✓ *Delivery Flexibility*; the ability to change the timing of the delivery of goods or services.

The term flexibility is used to describe several different requirements, two of which relate to volume; the first concerns demand increases, and the second refers to the ability of a process to produce low quantities at required cost levels (Hill, 2000).

Since flexibility is the ability to respond with little penalty in time, cost, or customer value (Heizer et al., 2020), flexible organizations are in a tendency to have more general-purpose equipment that can be used to produce many different kinds of goods and services (R. D. Reid & Sanders, 2013).

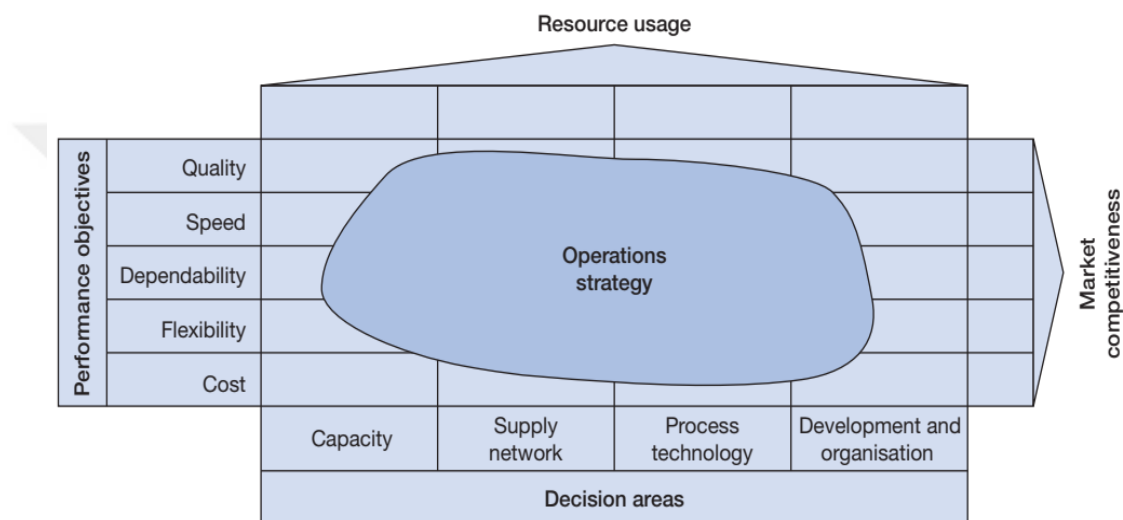
The changes in the global environment and risks have made flexibility one of the competencies organizations have to cope with (Y. Gong, 2013). Developing a flexible operation can have advantages to the internal customers within the operation as follows (Slack et al., 2016);

- ✓ Flexibility speeds up response,
- ✓ Flexibility saves time,
- ✓ Flexibility maintains on-time delivery.

2.1.4. The Operations Strategy Matrix

Market requirements and operations resources perspectives can be aggregated to form the dimensions of a matrix named The Operations Strategy Matrix (Slack & Lewis, 2017). The Operations Strategy Matrix is one method of checking the reconciliation between the inside-out (operations resources) and outside-in (market requirements) perspectives (Slack & Brandon-Jones, 2021).

The Operations Strategy Matrix is illustrated in Figure 2.5.



Source: (Slack & Lewis, 2017)

Figure 2. 5: The Operations Strategy Matrix

As depicted in Figure 2.5., It describes operations strategy as the intersection of an organization's competitive priorities/performance objectives and the strategic decision areas (Slack & Brandon-Jones, 2021). It emphasises the crossroads between what is required from the operations function and how the operation tries to achieve this through the set of choices made in each strategic decision area (Slack & Lewis, 2017).

The operations strategy matrix is a good model for testing whether market requirements and the operations capability perspectives fit together (Slack & Brandon-Jones, 2021). Each of the four strategic decision areas can affect an organization's ability to perform in each of the competitive priorities/performance objectives (Tan & Matthews, 2009). In other words, the matrix helps operations strategies to be comprehensive (Slack & Lewis, 2017).

2.1.5. Related Works

Examining the operations strategy literature to determine what has been learned and to suggest new directions for further study is vital (Boyer et al., 2009).

The works on Operations Strategy applied to the healthcare area are summarised based on Author(s) and Year, Title, and Brief Summary indicators in the Table 2.3.

Table 2. 3: Related Works on Operations Strategy

No	Author(s) and Year	Title	Brief Summary
1	(Özdemir et al., 2021)	Efficiency Assessment of Operations Strategy Matrix in Healthcare Systems of US States Amid COVID-19: Implications for Sustainable Development Goals	This study aims to assess the efficiency of the operations strategy matrix in the healthcare system of U.S. states amid COVID-19.
2	(Matthias & Brown, 2016)	Implementing operations strategy through Lean processes within health care, the example of NHS in the UK	This study investigates how operations strategy and lean concepts can be applied within a healthcare organisation.
3	(Tomaszewski et al., 2016)	Operations strategy for health care services: analysis of competitive criteria and operational recommendations	This study aims to help managers with a consistent set of decisions about service operations.
4	(W. Wu, 2014)	Hospital Competitive Strategies and Performance Outcomes	This study aims to examine several hospital competitive strategies.
5	(M. Diab, 2014)	Using the Competitive Dimensions to Achieve Competitive Advantage A Study on Jordanian Private Hospitals	This study aims to know if Jordanian private hospitals are using the competitive dimensions to achieve a competitive advantage.
6	(Butler & Leong, 2000)	The impact of operations competitive priorities on hospital performance	This study examines the degree of emphasis administrators place on competitive priorities.
7	(Butler et al., 1996)	The operations management role in hospital strategic planning	This study aims to serve as a springboard for research in hospital operations strategy.

2.2. Overview of Healthcare Systems of OECD Countries

Fundamentals of Healthcare Systems, Fundamentals of OECD Countries Healthcare Systems section and Related Works section are presented as follows.

2.2.1. Fundamentals of Healthcare Systems

Each country's healthcare system reflects its history, politics, economy, and national values (T. R. Reid, 2009). A healthcare system consists of all the organizations, institutions, resources and people whose primary purpose is to improve health (WHO, 2010). Healthcare systems shape inequalities within and between societies (Beckfield et al., 2013). Healthcare decision-makers in countries are faced with five following common problems to improve the performance of their health systems (Murray & Evans, 2003);

- ✓ National discussions on health policy have frequently focused on short-term or instrumental objectives.
- ✓ There is still a lack of evidence about how to improve the performance of healthcare systems.
- ✓ Healthcare systems are fragmented, and stakeholders only consider the pieces of the puzzle in many countries.
- ✓ Attention has been focused on delivering proven technologies to improve health, such as immunization for children.
- ✓ Broad participation in national policy discussion has been limited due to the complexity of health system issues and the use of specialized technical language.

Questions motivating current research on healthcare systems are divided into four dimensions; classifications, convergence, institutions and inequalities (Beckfield et al., 2013). Various categories of health systems have been developed whose purposes are primarily descriptive (Mechanic & Rochefort, 1996). The first step in categorizing healthcare systems is to form coherent taxonomy of healthcare system types (Böhm et al., 2012; Wendt et al., 2009).

The healthcare systems can be classified according to several parameters, such as regulation, financing, delivery, economic system, that indicate the public policies

underlying them (Anderson, 1963; Freeman & Frisina, 2010). From a sustainability and long-term development perspective, healthcare systems should have some concepts (Hejduková & Kureková, 2016) and must include the following indicators; quality, access, cost, efficiency and equity (Kelley & Hurst, 2006).

Böhm et al. (2013) have classified the healthcare systems of OECD countries into five types, named Plausible Healthcare System Types based on regulation, financing and provision dimensions (Böhm et al., 2013). Böhm et al. (2013)'s classification is presented in Table 2.4.

Table 2. 4. Böhm et al. (2013)'s Plausible Healthcare System Types

Regulation	Financing	Provision	Health System Type
State	State	State	National Health Service
		Societal	Non-Profit National Health System
		Private	National Health Insurance System
	Societal	Societal	Etatist Social Health System
		Private	Etatist Social Health Insurance
	Private	Private	Etatist Private Health System
Societal	Private	Societal	Social Health System
		Private	Social Health Insurance System
	Private	Private	Corporatist Private Health System
Private	Private	Private	Private Health System

Source: (Böhm et al., 2013)

According to Reid (2009), healthcare systems tend to follow general patterns, and there are four basic arrangements (models) as follows in detail (T. R. Reid, 2009; Sarsak, 2018; Wallace, 2013);

- ✓ *The Beveridge Model* was designed by National Health Service Creator Lord William Beveridge; it provides healthcare for all citizens and is financed by the government through tax payments. In the known “socialized medicine” model, there are no medical bills; medical treatment is a public service.
- ✓ *The Bismarck Model*, named for the Prussian chancellor Otto von Bismarck, uses an insurance system and is usually financed jointly by employers and employees through payroll deduction.
- ✓ *The National Health Insurance Model* has elements of both the Beveridge and Bismarck models. It uses private-sector providers, but payment comes

from a government-run insurance program that all citizens fund through a premium or tax. Long waiting periods to access healthcare are one of the drawbacks of this system.

- ✓ *The Out-of-Pocket Model* is established in the majority of the world. It is used in countries that are very poor or disorganized to provide any kind of national health care system.

Healthcare systems of OECD (38) countries are classified according to these four basic arrangements (models) based on relevant literature (Böhm et al., 2013; T. R. Reid, 2009; Sarsak, 2018; SSA & ISSA, 2018, 2019, 2020; Wallace, 2013). The classification is presented in Table 2.5.

Table 2. 5: Classification of Healthcare Systems OECD (38) Countries

The Beveridge Model	The Bismarck Model	The National Health Insurance Model	The Out-of-Pocket Model
Denmark	Austria	Australia	Chile
Finland	Belgium	Canada	Colombia
Iceland	Czech Republic	Ireland	Costa Rica
Italy	Estonia	Korea	Mexico
New Zealand	France	United States*	United States*
Norway	Germany		
Portugal	Greece		
Spain	Hungary		
Sweden	Israel		
United Kingdom	Japan		
United States*	Latvia		
	Lithuania		
	Luxembourg		
	Netherlands		
	Poland		
	Slovak Republic		
	Slovenia		
	Switzerland		
	Türkiye		
	United States*		

* *The healthcare system of the U.S. doesn't fit into any recognized model* (T. R. Reid, 2009).

2.2.2. Fundamentals of Healthcare Systems of OECD Countries

The Organisation for Economic Co-operation and Development (OECD) is an international organisation that works to build better policies for better lives (OECD, 2022f). The List of OECD countries was presented in Table 2.6. (OECD, 2022e).

Table 2. 6: The List of OECD Countries

Country	Abbreviation	Year of Accession
Australia	AUST	1971
Austria	AUT	1961
Belgium	BEL	1961
Canada	CAN	1961
Chile	CHL	2010
Colombia	COL	2020
Costa Rica	CRI	2021
Czech Republic	CZE	1995
Denmark	DNK	1961
Estonia	EST	2010
Finland	FIN	1969
France	FRA	1961
Germany	DEU	1961
Greece	GRC	1961
Hungary	HUN	1996
Iceland	ISL	1961
Ireland	IRL	1961
Israel	ISR	2010
Italy	ITA	1962
Japan	JPN	1964
Korea	KOR	1996
Latvia	LVA	2016
Lithuania	LTU	2018
Luxembourg	LUX	1961
Mexico	MEX	1994
Netherlands	NLD	1961
New Zealand	NZL	1973
Norway	NOR	1961
Poland	POL	1996
Portugal	PRT	1961
Slovak Republic	SVK	2000
Slovenia	SVN	2010
Spain	ESP	1961
Sweden	SWE	1961
Switzerland	CHE	1961
Türkiye	TUR	1961
United Kingdom	GBR	1961
United States	USA	1961

Since the performance of a healthcare system substantially impacts the individual's health, if health services are of high quality and accessible to everyone, people's health outcomes will be better (OECD, 2021b). Undoubtedly, the quality and performance of healthcare in any country depend on some healthcare dimensions (Lyeonov et al., 2021).

Within the scope of the study, these healthcare dimensions were assumed as follows;

- ✓ The dimension of General Information,
- ✓ The dimension of Health Status,
- ✓ The dimension of Functions of Health Systems.

The dimension of General Information has included two indicators named Population and Gross Domestic Product. The Population indicator is represented by the Total Population measure/variable, and its unit is the Number. The Gross Domestic Product indicator is represented by the US Dollar Exchange Rate measure/variable, and its unit is the Per Capita.

The descriptive statistics of the dimension of General Information are presented in Table 2.7. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 7: Descriptive Statistics of The Dimension of General Information

Indicator	Sample	Minimum	Median	Mean	Maximum
Population	OECD (38)	368,800.00	10,528,950.00	36,148,973.68	331,893,700.00
Gross Domestic Product (GDP)	OECD (38)	16,871.30	47,401.15	51,156.30	137,593.70

According to Table 2.7., while the average population of OECD (38) countries is 36,148,973.68, the average Gross Domestic Product (GDP) of OECD (38) countries is 51,156.30 US Dollars.

The dimension of Health Status has included three indicators named Life Expectancy, Causes of Mortality and Potential Years of Life Lost. The Life Expectancy indicator has been represented by the "Total Population at Birth"

measure/variable, and its unit is the “Years”. Life expectancy at birth is defined as how long, on average, a new-born can expect to live if current death rates do not change (OECD, 2022h).

The Causes of Mortality indicator is represented by the “All Causes of Death” measure/variable, and its unit is the “Deaths per 100,000 Population (standardised rates)”. The Potential Years of Life Lost indicator is represented by the “All causes of Death” measure/variable, and its unit is the “Years Lost, / 100,000 Population, Aged 75 Years Old”. This indicator is a summary measure of premature mortality, providing an explicit way of weighting deaths occurring at younger ages, which may be preventable (OECD, 2022i).

The descriptive statistics of the dimension of Health Status are presented in Table 2.8. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 8: Descriptive Statistics of The Dimension of Health Status

Indicator	Sample	Minimum	Median	Mean	Maximum
Life Expectancy	OECD (38)	73.40	81.35	80.37	84.70
Causes of Mortality	OECD (38)	599.50	810.05	865.21	1,533.70
Potential Years of Life Lost	OECD (38)	2,836.50	4,044.75	4,737.17	12,474.80

According to Table 2.8., Descriptive Statistics of The Dimension of Health Status, while the average Life Expectancy of OECD (38) countries is 80.37, the average Causes of Mortality (Deaths per 100,000 Population) is 865.21, and the average Potential Years of Life Lost of is 4,737.17.

The dimension of Functions of Health Systems has included four functions named Financing, Provision of Health Services, Resource Generation and Stewardship (Murray & Evans, 2003).

While the Financing function has been represented by the Health Expenditure and Financing indicator and Current Expenditure on Health measure/variable, and its unit is “Per Capita, Current Prices, Current PPPs (US Dollars)”. This function measures the final consumption of healthcare goods and services, including personal

healthcare and collective services but excluding spending on investments (OECD, 2022g).

While the Provision of Health Services function is represented by the “Doctors Consultations” and “Dentists Consultations” indicators and the Number per Capita measure/variable, and its unit is “Number”. While the Resource Generation function has been represented by the “Medical Graduates” and “Dentists Graduates” indicators and the “Number” measure/variable, and its unit is “Number”.

While the Stewardship function has been represented by the “Government/compulsory health insurance coverage” indicator and “% of the Total Population” measure/variable, and its unit is “Percentage”.

Stewardship involves setting, implementing and monitoring the rules of the game for the health system, assuring a level playing field among all actors in the system and identifying strategic directions for the health system as a whole (Murray & Evans, 2003).

The descriptive statistics of the dimension of Functions of Health Systems are presented in Table 2.9. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 9: Descriptive Statistics of the Functions of Health Systems

Function		Sample	Minimum	Median	Mean	Maximum
Financing		OECD (38)	1,226.74	4,253.59	4,457.55	12,318.10
Provision of Health Services	Doctors Consultations	OECD (37)	1.90	5.20	5.73	14.70
	Dentists Consultations	OECD (32)	0.10	1.05	1.00	3.30
Resource Generation	Medical Graduates	OECD (38)	0.00	1,575.50	4,015.53	28,337.00
	Dentists Graduates		0.00	279.50	980.71	6,609.00
Stewardship		OECD (38)	38.10	100.00	96.00	100.00

According to Table 2.9.,

Descriptive Statistics of The Dimension of Health Status, the average Financing (Health Expenditure and Financing) of OECD (38) countries is 4,457.55 US Dollars. While the average Provision of Health Services (Doctors Consultations) of OECD (37) countries is 5.73 in Number per Capita, the average Provision of Health Services (Dentists Consultations) of OECD (32) countries is 1.00.

While the average Resource Generation (Medical Graduates) of OECD (38) countries is 4,015.53, the average Resource Generation (Dentists Graduates) of OECD (38) countries is 980.71. The average Stewardship (Government/compulsory health insurance coverage) of OECD (38) countries is 96.00% of the total population.

OECD countries use various institutional arrangements to provide health insurance coverage and finance and deliver health care (Docteur & Oxley, 2003).

The healthcare systems of OECD (38) countries are summarised below based on the selected indicators mentioned above.

2.2.2.1. Overview of the Australia Healthcare System

Australia uses *The National Health Insurance Model* as a Healthcare System Type, and General Information about the Australia Healthcare System is presented in Table 2.10. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 10: General Information of the Australia Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	25,738,100
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	60,575.40

According to Table 2.10., the population of Australia is 25,738,100, which is below the OECD (38) average; the Gross Domestic Product (GDP) of Australia is 60,575.40 US Dollars, which is above the OECD (38) average.

Health Status Indicators of the AUST Healthcare System are presented in Table 2.11. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 11: Health Status Indicators of the Australia Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	83.20
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (Standardised rates)	636.30
Potential Years of Life Lost	All Causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	3,408.80

According to Table 2.11., the Life Expectancy in Australia is 83.20 years, which is above the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in Australia is 636.30, which is below the OECD (38) average; the Potential Years of Life Lost in Australia is 3,408.80, which is below the OECD (38) average.

Functions of Health Systems Indicators of the Australia Healthcare System are presented in Table 2.12. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 12: Functions of Health Systems Indicators of the Australia Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	5,627.32
Provision of Health Services	Doctors Consultations	Number per Capita	Number	6.10
	Dentists Consultations	Number per Capita	Number	1.10
Resource Generation	Medical Graduates	Number	Number	3,839
	Dentists Graduates	Number	Number	814
Stewardship	Government/ Compulsory Health Insurance Coverage	% of the Total Population	Percentage	100.00

According to Table 2.12.,

The Financing function (Health Expenditure and Financing) in Australia is 5,627.32 US Dollars based on Current Expenditure on Health, which is above the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in Australia is 6.10 Number per Capita, which is above the OECD (37) average, the Provision of Health Services (Dentists Consultations) in Australia is 1.10 Number per Capita, which is above the OECD (32) average.

While the Resource Generation (Medical Graduates) in Australia is 3,839, which is below the OECD (38) average, the Resource Generation (Dentists Graduates) in Australia is 814, which is below the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in Australia is 100.00%, which is above the OECD (38) average.

2.2.2.2. Overview of the Austria Healthcare System

Austria uses *The Bismarck Model* as a Healthcare System Type, and General Information about the Austria Healthcare System is presented in Table 2.13. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 13: General Information of the Austria Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	8,932,700
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	59,543.00

According to Table 2.13., the population of Austria is 8,932,700, which is below the OECD (38) average; the Gross Domestic Product (GDP) of Austria is 59,543.00 US Dollars, which is above the OECD (38) average.

Health Status Indicators of the Austria Healthcare System are presented in Table 2.14. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 14: Health Status Indicators of the Austria Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	81.30
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (Standardised rates)	844.30
Potential Years of Life Lost	All Causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	3,715.00

According to Table 2.14., the Life Expectancy in Austria is 81.30 years, which is above the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in Australia is 844.30, which is below the OECD (38) average; the Potential Years of Life Lost in Austria is 3,715.00, which is below the OECD (38) average.

Functions of Health Systems Indicators of the Austria Healthcare System are presented in Table 2.15. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 15: Functions of Health Systems Indicators of the Austria Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	6,693.31
Provision of Health Services	Doctors Consultations	Number per Capita	Number	5.80
	Dentists Consultations	Number per Capita	Number	1.00
Resource Generation	Medical Graduates	Number	Number	1,288
	Dentists Graduates	Number	Number	230
Stewardship	Government/ Compulsory Health Insurance Coverage	% of the Total Population	Percentage	99.90

According to Table 2.15.,

The Financing function (Health Expenditure and Financing) in Austria is 6,693.31 US Dollars based on Current Expenditure on Health, which is above the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in Austria is 5.80 Number per Capita, which is above the OECD (37) average, the Provision of Health Services (Dentists Consultations) in Austria is 1.00 Number per Capita, which is equal to the OECD (32) average.

While the Resource Generation (Medical Graduates) in Austria is 1,288, which is below the OECD (38) average, the Resource Generation (Dentists Graduates) in Austria is 230, which is below the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in Austria is 99.90%, which is above the OECD (38) average.

2.2.2.3. Overview of the Belgium Healthcare System

Belgium uses *The Bismarck Model* as a Healthcare System Type, and General Information about the Belgium Healthcare System is presented in Table 2.16. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 16: General Information of the Belgium Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	11,554,800
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	60,125.80

According to Table 2.16., the population of Belgium is 11,554,80, which is below the OECD (38) average; the Gross Domestic Product (GDP) of Belgium is 60,125.80 US Dollars, which is above the OECD (38) average.

Health Status Indicators of the Belgium Healthcare System are presented in Table 2.17. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 17: Health Status Indicators of the Belgium Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	81.90
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (Standardised rates)	796.80
Potential Years of Life Lost	All Causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	4,039.80

According to Table 2.17., the Life Expectancy in Belgium is 81.90 years, which is above the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in Belgium is 796.80, which is below the OECD (38) average; the Potential Years of Life Lost in Belgium is 4,039.80, which is below the OECD (38) average.

Functions of Health Systems Indicators the Belgium Healthcare System are presented in Table 2.18. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 18: Functions of Health Systems Indicators of the Belgium Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	5,274.09
Provision of Health Services	Doctors Consultations	Number per Capita	Number	6.20
	Dentists Consultations	Number per Capita	Number	1.10
Resource Generation	Medical Graduates	Number	Number	1,898
	Dentists Graduates	Number	Number	279
Stewardship	Government/Compulsory Health Insurance Coverage	% of the Total Population	Percentage	98.60

According to Table 2.18.,

The Financing function (Health Expenditure and Financing) in Belgium is 5,274.09 US Dollars based on Current Expenditure on Health, which is above the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in Belgium is 6.20 Number per Capita, which is above the OECD (37) average, the Provision of Health Services (Dentists Consultations) in Belgium is 1.10 Number per Capita, which is above the OECD (32) average.

While the Resource Generation (Medical Graduates) in Belgium is 1,898, which is below the OECD (38) average, the Resource Generation (Dentists Graduates) in Belgium is 279, which is below the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in Belgium is 98.60%, which is above the OECD (38) average.

2.2.2.4. Overview of the Canada Healthcare System

Canada uses *The National Health Insurance Model* as a Healthcare System Type, and General Information about the Canada Healthcare System is presented in Table 2.19. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 19: General Information of the Canada Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	38,246,100
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	50,722.50

According to Table 2.19., the population of Canada is 38,246,100, which is above the OECD (38) average; the Gross Domestic Product (GDP) of Canada is 50,722.50 US Dollars, which is below the OECD (38) average.

Health Status Indicators of the Canada Healthcare System are presented in Table 2.20. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 20: Health Status Indicators of the Canada Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	81.70
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (Standardised rates)	712.40
Potential Years of Life Lost	All Causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	4,087.60

According to Table 2.20., the Life Expectancy in Canada is 81.70 years, which is above the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in Canada is 712.40, which is below the OECD (38) average; the Potential Years of Life Lost in Canada is 4,087.60, which is below the OECD (38) average.

Functions of Health Systems Indicators of the Canada Healthcare System are presented in Table 2.21. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 21: Functions of Health Systems Indicators of the Canada Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	5,904.94
Provision of Health Services	Doctors Consultations	Number per Capita	Number	6.60
	Dentists Consultations	Number per Capita	Number	1.50
Resource Generation	Medical Graduates	Number	Number	2,888
	Dentists Graduates	Number	Number	550
Stewardship	Government/ Compulsory Health Insurance Coverage	% of the Total Population	Percentage	100.00

According to Table 2.21.,

The Financing function (Health Expenditure and Financing) in Canada is 5,904.94 US Dollars based on Current Expenditure on Health, which is above the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in Canada is 6.60 Number per Capita, which is above the OECD (37) average, the Provision of Health Services (Dentists Consultations) in Canada is 1.50 Number per Capita, which is above the OECD (32) average.

While the Resource Generation (Medical Graduates) in Canada is 2,888, which is below the OECD (38) average, the Resource Generation (Dentists Graduates) in Canada is 550, which is below the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in Canada is 100.00%, which is above the OECD (38) average.

2.2.2.5. Overview of the Chile Healthcare System

Chile uses *The Out-of-Pocket Model* as a Healthcare System Type, and General Information about the Chile Healthcare System is presented in Table 2.22. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 22: General Information of the Chile Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	19,678,400
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	28,083.80

According to Table 2.22., the population of Chile is 19,678,400, which is below the OECD (38) average; the Gross Domestic Product (GDP) of Chile is 28,083.80 US Dollars, which is below the OECD (38) average.

Health Status Indicators of the Chile Healthcare System are presented in Table 2.23. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 23: Health Status Indicators of the Chile Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	81.00
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	780.60
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	4,895.40

According to Table 2.23., the Life Expectancy in Chile is 81.00 years, which is above the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in Chile is 780.60, which is below the OECD (38) average; the Potential Years of Life Lost in Chile is 4,895.40, which is above the OECD (38) average.

Functions of Health Systems Indicators of the Chile Healthcare System are presented in Table 2.24. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 24: Functions of Health Systems Indicators of the Chile Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	2,595.85
Provision of Health Services	Doctors Consultations	Number per Capita	Number	2.20
	Dentists Consultations	Number per Capita	Number	0.30
Resource Generation	Medical Graduates	Number	Number	1,768
	Dentists Graduates	Number	Number	1,694
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	77.40

According to Table 2.24.,

The Financing function (Health Expenditure and Financing) in Chile is 2,595.85 US Dollars based on Current Expenditure on Health, which is below the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in Chile is 2.20 Number per Capita, which is below the OECD (37) average, the Provision of Health Services (Dentists Consultations) in Chile is 0.30 Number per Capita, which is below the OECD (32) average.

While the Resource Generation (Medical Graduates) in Chile is 1,768, which is below the OECD (38) average, the Resource Generation (Dentists Graduates) in Chile is 1,694, which is above the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in Chile is 77.40%, which is below the OECD (38) average.

2.2.2.6. Overview of the Colombia Healthcare System

Colombia uses *The Out-of-Pocket Model* as a Healthcare System Type, and General Information about the Colombia Healthcare System is presented in Table 2.25. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 25: General Information of the Colombia Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	51,207,700
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	16,871.30

According to Table 2.25., the population of Colombia is 51,207,700, which is above the OECD (38) average; the Gross Domestic Product (GDP) of Colombia is 16,871.30 US Dollars, which is below the OECD (38) average.

Health Status Indicators of the Colombia Healthcare System are presented in Table 2.26. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 26: Health Status Indicators of the Colombia Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	76.80
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	855.00
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	6,373.80

According to Table 2.26., the Life Expectancy in Colombia is 76.80 years, which is below the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in Colombia is 855.00, which is below the OECD (38) average; the Potential Years of Life Lost in Colombia is 6,373.80, which is above the OECD (38) average.

Functions of Health Systems Indicators of the Colombia Healthcare System are presented in Table 2.27. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 27: Functions of Health Systems Indicators of the Colombia Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	1,335.88
Provision of Health Services	Doctors Consultations	Number per Capita	Number	2.60
	Dentists Consultations	Number per Capita	Number	0.30
Resource Generation	Medical Graduates	Number	Number	6,319
	Dentists Graduates	Number	Number	1,534
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	94.70

According to Table 2.27.,

The Financing function (Health Expenditure and Financing) in Colombia is 1,335.88 US Dollars based on Current Expenditure on Health, which is below the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in Colombia is 2.60 Number per Capita, which is below the OECD (37) average, the Provision of Health Services (Dentists Consultations) in Colombia is 0.30 Number per Capita, which is below the OECD (32) average.

While the Resource Generation (Medical Graduates) in Colombia is 6,319, which is above the OECD (38) average, the Resource Generation (Dentists Graduates) in Colombia is 1,534, which is above the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in Colombia is 94.70%, which is below the OECD (38) average.

2.2.2.7. Overview of the Costa Rica Healthcare System

Costa Rica uses *The Out-of-Pocket Model* as a Healthcare System Type, and General Information about the Costa Rica Healthcare System is presented in Table 2.28. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 28: General Information of the Costa Rica Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	5,163,000
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	24,566.60

According to Table 2.28., the population of Costa Rica is 5,163,000, which is below the OECD (38) average; the Gross Domestic Product (GDP) of Costa Rica is 24,566.60 US Dollars, which is above the OECD (38) average.

Health Status Indicators of the Costa Rica Healthcare System are presented in Table 2.29. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 29. Health Status Indicators of the Costa Rica Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	80.80
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	775.90
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	5,712.20

According to Table 2.29., the Life Expectancy in Costa Rica is 80.80 years, which is above the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in Costa Rica is 775.90, which is below the OECD (38) average; the Potential Years of Life Lost in Costa Rica is 5,712.2, which is above the OECD (38) average.

Functions of Health Systems Indicators of the Costa Rica Healthcare System are presented in Table 2.30. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 30: Functions of Health Systems Indicators of the Costa Rica Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	1,622.35
Provision of Health Services	Doctors Consultations	Number per Capita	Number	1.90
	Dentists Consultations	Number per Capita	Number	0.10
Resource Generation	Medical Graduates	Number	Number	679
	Dentists Graduates	Number	Number	20
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	91.80

According to Table 2.30.,

The Financing function (Health Expenditure and Financing) in Costa Rica is 1,622.35 US Dollars based on Current Expenditure on Health, which is below the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in Costa Rica is 1.90 Number per Capita, which is below the OECD (37) average, the Provision of Health Services (Dentists Consultations) in Costa Rica is 0.10 Number per Capita, which is below the OECD (32) average.

While the Resource Generation (Medical Graduates) in Costa Rica is 679, which is below the OECD (38) average, the Resource Generation (Dentists Graduates) in Costa Rica is 20, which is below the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in Costa Rica is 91.80%, which is below the OECD (38) average.

2.2.2.8. Overview of the Czech Republic Healthcare System

The Czech Republic uses *The Bismarck Model* as a Healthcare System Type, and General Information about the Czech Republic Healthcare System is presented in Table 2.31. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 31: General Information of the Czech Republic Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	10,701,800
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	44,899.60

According to Table 2.31., the population of the Czech Republic is 10,701,800, which is below the OECD (38) average; the Gross Domestic Product (GDP) of Czech Republic is 44,899.60 US Dollars, which is below the OECD (38) average.

Health Status Indicators of the CZE Healthcare System are presented in Table 2.32. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 32: Health Status Indicators of the Czech Republic Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	77.40
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	1,117.20
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	5,047.60

According to Table 2.32., the Life Expectancy in the Czech Republic is 77.40 years, which is below the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in the Czech Republic is 1,117.20, which is above the OECD (38) average; the Potential Years of Life Lost in the Czech Republic is 5,047.60, which is above the OECD (38) average.

Functions of Health Systems Indicators of the Czech Republic Healthcare System are presented in Table 2.33. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

**Table 2. 33: Functions of Health Systems Indicators of the Czech Republic
Healthcare System**

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	3,805.14
Provision of Health Services	Doctors Consultations	Number per Capita	Number	7.30
	Dentists Consultations	Number per Capita	Number	1.50
Resource Generation	Medical Graduates	Number	Number	1,771
	Dentists Graduates	Number	Number	283
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	100.00

According to Table 2.33.,

The Financing function (Health Expenditure and Financing) in the Czech Republic is 3,805.14 US Dollars based on Current Expenditure on Health, which is below the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in the Czech Republic is 7.30 Number per Capita, which is above the OECD (37) average, the Provision of Health Services (Dentists Consultations) in the Czech Republic is 1.50 Number per Capita, which is above the OECD (32) average.

While the Resource Generation (Medical Graduates) in the Czech Republic is 1,771, which is below the OECD (38) average, the Resource Generation (Dentists Graduates) in the Czech Republic is 283, which is below the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in the Czech Republic is 100.00%, which is above the OECD (38) average.

2.2.2.9. Overview of the Denmark Healthcare System

Denmark uses *The Beveridge Model* as a Healthcare System Type, and General Information about the Denmark Healthcare System is presented in Table 2.34. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 34: General Information of the Denmark Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	5,840,000
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	65,825.50

According to Table 2.34, the population of Denmark is 5,840,000, which is below the OECD (38) average; the Gross Domestic Product (GDP) of Denmark is 65,825.50 US Dollars, which is above the OECD (38) average.

Health Status Indicators of the Denmark Healthcare System are presented in Table 2.35. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 35: Health Status Indicators of the Denmark Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	81.40
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	863.20
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	3,852.80

According to Table 2.35., the Life Expectancy in Denmark is 81.40 years, which is above the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in Denmark is 863.20, which is below the OECD (38) average; the Potential Years of Life Lost in Denmark is 3,852.80, which is below the OECD (38) average.

Functions of Health Systems Indicators of the Denmark Healthcare System are presented in Table 2.36. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 36: Functions of Health Systems Indicators of the Denmark Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	6,384.17
Provision of Health Services	Doctors Consultations	Number per Capita	Number	3.80
	Dentists Consultations	Number per Capita	Number	0.80
Resource Generation	Medical Graduates	Number	Number	1,233
	Dentists Graduates	Number	Number	131
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	100.00

According to Table 2.36.,

The Financing function (Health Expenditure and Financing) in Denmark is 6,384.17 US Dollars based on Current Expenditure on Health, which is above the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in Denmark is 3.80 Number per Capita, which is below the OECD (37) average, the Provision of Health Services (Dentists Consultations) in Denmark is 0.80 Number per Capita, which is below the OECD (32) average.

While the Resource Generation (Medical Graduates) in Denmark is 1,233, which is below the OECD (38) average, the Resource Generation (Dentists Graduates) in Denmark is 131, which is below the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in Denmark is 100.00%, which is above the OECD (38) average.

2.2.2.10. Overview of the Estonia Healthcare System

Estonia uses *The Bismarck Model* as a Healthcare System Type, and General Information about the Estonia Healthcare System is presented in Table 2.37. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 37: General Information of the Estonia Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	1,330,100
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	42,891.30

According to Table 2.37., the population of Estonia is 1,330,100, which is below the OECD (38) average; the Gross Domestic Product (GDP) of Estonia is 42,891.30 US Dollars, which is below the OECD (38) average.

Health Status Indicators of the Estonia Healthcare System are presented in Table 2.38. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 38. Health Status Indicators of the Estonia Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	76.90
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	960.60
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	5,977.70

According to Table 2.38., the Life Expectancy in Estonia is 76.90 years, which is below the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in Estonia is 960.60, which is below the OECD (38) average; the Potential Years of Life Lost in Estonia is 5,977.70, which is above the OECD (38) average.

Functions of Health Systems Indicators of the Estonia Healthcare System are presented in Table 2.39. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 39: Functions of Health Systems Indicators of the Estonia Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	2,989.13
Provision of Health Services	Doctors Consultations	Number per Capita	Number	4.10
	Dentists Consultations	Number per Capita	Number	1.30
Resource Generation	Medical Graduates	Number	Number	157
	Dentists Graduates	Number	Number	25
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	95.90

According to Table 2.39.,

The Financing function (Health Expenditure and Financing) in Estonia is 2,989.13 US Dollars based on Current Expenditure on Health, which is below the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in Estonia is 4.10 Number per Capita, which is below the OECD (37) average, the Provision of Health Services (Dentists Consultations) in Estonia is 1.30 Number per Capita, which is above the OECD (32) average.

While the Resource Generation (Medical Graduates) in Estonia is 157, which is below the OECD (38) average, the Resource Generation (Dentists Graduates) in Estonia is 25, which is below the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in Estonia is 95.90%, which is below the OECD (38) average.

2.2.2.11. Overview of the Finland Healthcare System

Finland uses *The Beveridge Model* as a Healthcare System Type, and General Information about the Finland Healthcare System is presented in Table 2.40. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 40: General Information of the Finland Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	5,533,800
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	55,845.30

According to Table 2.40., the population of Finland is 5,533,800, which is below the OECD (38) average; the Gross Domestic Product (GDP) of Finland is 55,845.30 US Dollars, which is above the OECD (38) average.

Health Status Indicators of the Finland Healthcare System are presented in Table 2.41. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 41: Health Status Indicators of the Finland Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	82.00
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	768.00
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	3,930.20

According to Table 2.41., the Life Expectancy in Finland is 82.00 years, which is above the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in Finland is 768.00, which is below the OECD (38) average; the Potential Years of Life Lost in Finland is 3,930.20, which is below the OECD (38) average.

Functions of Health Systems Indicators of the Finland Healthcare System are presented in Table 2.42. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 42: Functions of Health Systems Indicators of the Finland Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	4,565.51
Provision of Health Services	Doctors Consultations	Number per Capita	Number	4.20
	Dentists Consultations	Number per Capita	Number	0.90
Resource Generation	Medical Graduates	Number	Number	674
	Dentists Graduates	Number	Number	188
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	100.00

According to Table 2.42.,

The Financing function (Health Expenditure and Financing) in Finland is 4,565.51 US Dollars based on Current Expenditure on Health, which is above the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in Finland is 4.20 Number per Capita, which is below the OECD (37) average, the Provision of Health Services (Dentists Consultations) in Finland is 0.90 Number per Capita, which is below the OECD (32) average.

While the Resource Generation (Medical Graduates) in Finland is 674, which is below the OECD (38) average, the Resource Generation (Dentists Graduates) in Finland is 188, which is below the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in Finland is 100.00%, which is above the OECD (38) average.

2.2.2.12. Overview of the France Healthcare System

France uses *The Bismarck Model* as a Healthcare System Type, and General Information about the France Healthcare System is presented in Table 2.43. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 43: General Information of the France Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	67,656,700
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	51,445.70

According to Table 2.43., the population of France is 67,656,700, which is above the OECD (38) average; the Gross Domestic Product (GDP) of France is 51,445.70 US Dollars, which is above the OECD (38) average.

Health Status Indicators of the France Healthcare System are presented in Table 2.44. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 44: Health Status Indicators of the France Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	82.50
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	714.90
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	4,102.40

According to Table 2.44., the Life Expectancy in France is 82.50 years, which is above the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in France is 714.90, which is below the OECD (38) average; the Potential Years of Life Lost in France is 4,102.40, which is below the OECD (38) average.

Functions of Health Systems Indicators of the France Healthcare System are presented in Table 2.45 based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 45: Functions of Health Systems Indicators of the France Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	5,468.42
Provision of Health Services	Doctors Consultations	Number per Capita	Number	5.00
	Dentists Consultations	Number per Capita	Number	1.20
Resource Generation	Medical Graduates	Number	Number	6,708
	Dentists Graduates	Number	Number	1,426
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	99.90

According to Table 2.45.,

The Financing function (Health Expenditure and Financing) in France is 5,468.42 US Dollars based on Current Expenditure on Health, which is above the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in France is 5.00 Number per Capita, which is below the OECD (37) average, the Provision of Health Services (Dentists Consultations) in France is 1.20 Number per Capita, which is above the OECD (32) average.

While the Resource Generation (Medical Graduates) in France is 6,708, which is above the OECD (38) average, the Resource Generation (Dentists Graduates) in France is 1,426, which is above the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in France is 99.90%, which is above the OECD (38) average.

2.2.2.13. Overview of the Germany Healthcare System

Germany uses *The Bismarck Model* as a Healthcare System Type, and General Information about the Germany Healthcare System is presented in Table 2.46. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 46: General Information of the Germany Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	83,155,000
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	58,703.80

According to Table 2.46., the population of Germany is 83,155,00, which is above the OECD (38) average; the Gross Domestic Product (GDP) of Germany is 58,703.80 US Dollars, which is above the OECD (38) average.

Health Status Indicators of the Germany Healthcare System are presented in Table 2.47. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 47: Health Status Indicators of the Germany Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	80.90
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	850.00
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	4,040.60

According to Table 2.47., the Life Expectancy in Germany is 80.90 years, which is above the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in Germany is 850.00, which is below the OECD (38) average; the Potential Years of Life Lost in Germany is 4,040.60, which is below the OECD (38) average.

Functions of Health Systems Indicators of the Germany Healthcare System are presented in Table 2.48. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 48: Functions of Health Systems Indicators of the Germany Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	7,382.63
Provision of Health Services	Doctors Consultations	Number per Capita	Number	9.50
	Dentists Consultations	Number per Capita	Number	1.40
Resource Generation	Medical Graduates	Number	Number	10,007
	Dentists Graduates	Number	Number	2,312
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	99.90

According to Table 2.48.,

The Financing function (Health Expenditure and Financing) in Germany is 7,382.63 US Dollars based on Current Expenditure on Health, which is above the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in Germany is 9.50 Number per Capita, which is above the OECD (37) average, the Provision of Health Services (Dentists Consultations) in Germany is 1.40 Number per Capita, which is above the OECD (32) average.

While the Resource Generation (Medical Graduates) in Germany is 10,007, which is above the OECD (38) average, the Resource Generation (Dentists Graduates) in Germany is 2,312, which is above the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in Germany is 99.90%, which is above the OECD (38) average.

2.2.2.14. Overview of the Greece Healthcare System

Greece uses *The Bismarck Model* as a Healthcare System Type, and General Information about the Greece Healthcare System is presented in Table 2.49. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 49: General Information of the Greece Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	10,678,600
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	31,795.20

According to Table 2.49., the population of Greece is 10,678,600, which is below the OECD (38) average; the Gross Domestic Product (GDP) of Greece is 31,795.20 US Dollars, which is below the OECD (38) average.

Health Status Indicators of the Greece Healthcare System are presented in Table 2.50. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 50: Health Status Indicators of the Greece Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	80.30
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	801.20
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	4,048.90

According to Table 2.50., the Life Expectancy in Greece is 80.30 years, which is below the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in Greece is 801.20, which is below the OECD (38) average; the Potential Years of Life Lost in Greece is 4,048.90, which is below the OECD (38) average.

Functions of Health Systems Indicators of the Greece Healthcare System are presented in Table 2.51. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 51: Functions of Health Systems Indicators of the Greece Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	2,486.09
Provision of Health Services	Doctors Consultations	Number per Capita	Number	2.70
	Dentists Consultations	Number per Capita	Number	N/A
Resource Generation	Medical Graduates	Number	Number	1,449
	Dentists Graduates	Number	Number	204
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	100.00

According to Table 2.51.,

The Financing function (Health Expenditure and Financing) in Greece is 2,486.09 US Dollars based on Current Expenditure on Health, which is below the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in Greece is 2.70 Number per Capita, which is below the OECD (37) average, the Provision of Health Services (Dentists Consultations) in Greece is Not Available (N/A) in OECD Health Statistics.

While the Resource Generation (Medical Graduates) in Greece is 1,449, which is below the OECD (38) average, the Resource Generation (Dentists Graduates) in Greece is 204, which is below the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in Greece is 100.00%, which is above the OECD (38) average.

2.2.2.15. Overview of the Hungary Healthcare System

Hungary uses *The Bismarck Model* as a Healthcare System Type, and General Information about the Hungary Health System is presented in Table 2.52. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 52: General Information of the Hungary Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	9,730,800
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	37,224.10

According to Table 2.52., the population of Hungary is 9,730,800, which is below the OECD (38) average; the Gross Domestic Product (GDP) of Hungary is 37,224.10 US Dollars, which is below the OECD (38) average.

Health Status Indicators of the Hungary Healthcare System are presented in Table 2.53. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 53. Health Status Indicators of the Hungary Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	74.50
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	1,197.00
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	6,883.90

According to Table 2.53, the Life Expectancy in Hungary is 74.50 years, which is below the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in Hungary is 1,197.00, which is above the OECD (38) average; the Potential Years of Life Lost in Hungary is 6,883.90, which is above the OECD (38) average.

Functions of Health Systems Indicators of the Hungary Healthcare System are presented in Table 2.54. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 54. Functions of Health Systems Indicators of the Hungary Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	2,402.00
Provision of Health Services	Doctors Consultations	Number per Capita	Number	9.70
	Dentists Consultations	Number per Capita	Number	0.40
Resource Generation	Medical Graduates	Number	Number	1,532
	Dentists Graduates	Number	Number	331
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	94.00

According to Table 2.54,

The Financing function (Health Expenditure and Financing) in Hungary is 2,402.00 US Dollars based on Current Expenditure on Health, which is below the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in Hungary is 9.70 Number per Capita, which is above the OECD (37) average, the Provision of Health Services (Dentists Consultations) in Hungary is 0.40 Number per Capita, which is below the OECD (32) average.

While the Resource Generation (Medical Graduates) in Hungary is 1,532, which is below the OECD (38) average, the Resource Generation (Dentists Graduates) in Hungary is 331, which is below the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in Hungary is 94.00%, which is below the OECD (38) average.

2.2.2.16. Overview of the Iceland Healthcare System

Iceland uses *The Beveridge Model* as a Healthcare System Type, and General Information about the Iceland Healthcare System is presented in Table 2.55. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 55: General Information of the Iceland Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	368,800
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	58,407.00

According to Table 2.55., the population of Iceland is 368,800, which is below the OECD (38) average; the Gross Domestic Product (GDP) of Iceland is 58,407.00 US Dollars, which is above the OECD (38) average.

Health Status Indicators of the Iceland Healthcare System are presented in Table 2.56. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 56: Health Status Indicators of the Iceland Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	83.20
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	718.10
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	3,312.10

According to Table 2.56., the Life Expectancy in Iceland is 83.20 years, which is above the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in Iceland is 718.10, which is below the OECD (38) average; the Potential Years of Life Lost in Iceland is 3,312.10, which is below the OECD (38) average.

Functions of Health Systems Indicators of the Iceland Healthcare System are presented in Table 2.57. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 57: Functions of Health Systems Indicators of the Iceland Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	5,096.44
Provision of Health Services	Doctors Consultations	Number per Capita	Number	5.90
	Dentists Consultations	Number per Capita	Number	N/A
Resource Generation	Medical Graduates	Number	Number	41
	Dentists Graduates	Number	Number	7
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	99.60

According to Table 2.57.,

The Financing function (Health Expenditure and Financing) in Iceland is 5,096.44 US Dollars based on Current Expenditure on Health, which is above the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in Iceland is 5.90 Number per Capita, which is above the OECD (37) average, the Provision of Health Services (Dentists Consultations) in Iceland is Not Available (N/A) in OECD Health Statistics.

While the Resource Generation (Medical Graduates) in Iceland is 41, which is below the OECD (38) average, the Resource Generation (Dentists Graduates) in Iceland is 7, which is below the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in Iceland is 99.60%, which is above the OECD (38) average.

2.2.2.17. Overview of the Ireland Healthcare System

Ireland uses *The National Health Insurance Model* as a Healthcare System Type, and General Information about the Ireland Healthcare System is presented in Table 2.58. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 58: General Information of the Ireland Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	5,006,300
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	108,578.20

According to Table 2.58., the population of Ireland is 5,006,300, which is below the OECD (38) average; the Gross Domestic Product (GDP) of Ireland is 108,578.20 US Dollars, which is above the OECD (38) average.

Health Status Indicators of the Ireland Healthcare System are presented in Table 2.59. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 59: Health Status Indicators of the Ireland Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	82.60
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	824.10
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	3,512.90

According to Table 2.59., the Life Expectancy in Ireland is 82.60 years, which is above the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in Ireland is 824.10, which is below the OECD (38) average; the Potential Years of Life Lost in Ireland is 3,512.90, which is below the OECD (38) average.

Functions of Health Systems Indicators of the Ireland Healthcare System are presented in Table 2.60. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 60. Functions of Health Systems Indicators of the Ireland Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	5,836.34
Provision of Health Services	Doctors Consultations	Number per Capita	Number	5.80
	Dentists Consultations	Number per Capita	Number	0.40
Resource Generation	Medical Graduates	Number	Number	1,268
	Dentists Graduates	Number	Number	89
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	100.00

According to Table 2.60.,

The Financing function (Health Expenditure and Financing) in Ireland is 5,836.34 US Dollars based on Current Expenditure on Health, which is above the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in Ireland is 5.80 Number per Capita, which is above the OECD (37) average, the Provision of Health Services (Dentists Consultations) in Ireland is 0.40 Number per Capita, which is below the OECD (32) average.

While the Resource Generation (Medical Graduates) in Ireland is 1,268, which is below the OECD (38) average, the Resource Generation (Dentists Graduates) in Ireland is 89, which is below the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in Ireland is 100.00%, which is above the OECD (38) average.

2.2.2.18. Overview of the Israel Healthcare System

Israel uses *The Bismarck Model* as a Healthcare System Type, and General Information about the Israel Healthcare System is presented in Table 2.61. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 61: General Information of the Israel Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	9,365,100
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	43,814.40

According to Table 2.61, the population of Israel is 9,365,100, which is below the OECD (38) average; the Gross Domestic Product (GDP) of Israel is 43,814.40 US Dollars, which is below the OECD (38) average.

Health Status Indicators of the Israel Health System are presented in Table 2.62. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 62: Health Status Indicators of the Israel Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	82.60
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	734.70
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	3,172.90

According to Table 2.62., the Life Expectancy in Israel is 82.60 years, which is above the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in Israel is 734.70, which is below the OECD (38) average; the Potential Years of Life Lost in Israel is 3,172.90, which is below the OECD (38) average.

Functions of Health Systems Indicators of the Israel Healthcare System are presented in Table 2.63. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 63: Functions of Health Systems Indicators of the Israel Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	3,057.41
Provision of Health Services	Doctors Consultations	Number per Capita	Number	7.10
	Dentists Consultations	Number per Capita	Number	N/A
Resource Generation	Medical Graduates	Number	Number	639
	Dentists Graduates	Number	Number	69
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	100.00

According to Table 2.63.,

The Financing function (Health Expenditure and Financing) in Israel is 3,057.41 US Dollars based on Current Expenditure on Health, which is below the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in Israel is 7.10 Number per Capita, which is above the OECD (37) average, the Provision of Health Services (Dentists Consultations) in Israel is Not Available (N/A) in OECD Health Statistics.

While the Resource Generation (Medical Graduates) in Israel is 639, which is below the OECD (38) average, the Resource Generation (Dentists Graduates) in Israel is 69, which is below the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in Israel is 100.00%, which is above the OECD (38) average.

2.2.2.19. Overview of the Italy Healthcare System

Italy uses *The Beveridge Model* as a Healthcare System Type, and General Information about the Italy Healthcare System is presented in Table 2.64. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 64: General Information of the Italy Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	59,236,200
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	46,513.10

According to Table 2.64., the population of Italy is 59,236,200, which is below the OECD (38) average; the Gross Domestic Product (GDP) of Italy is 46,513.10 US Dollars, which is below the OECD (38) average.

Health Status Indicators of the Italy Healthcare System are presented in Table 2.65. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 65: Health Status Indicators of the Italy Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	82.90
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	729.20
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	3,190.90

According to Table 2.65., the Life Expectancy in Italy is 82.90 years, which is above the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in Italy is 729.20, which is below the OECD (38) average; the Potential Years of Life Lost in Italy is 3,190.90, which is below the OECD (38) average.

Functions of Health Systems Indicators of the Italy Healthcare System are presented in Table 2.66. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 66: Functions of Health Systems Indicators of the Italy Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	4,037.79
Provision of Health Services	Doctors Consultations	Number per Capita	Number	5.20
	Dentists Consultations	Number per Capita	Number	1.30
Resource Generation	Medical Graduates	Number	Number	11,089
	Dentists Graduates	Number	Number	1,123
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	100.00

According to Table 2.66.,

The Financing function (Health Expenditure and Financing) in Italy is 4,037.79 US Dollars based on Current Expenditure on Health, which is below the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in Italy is 5.20 Number per Capita, which is below the OECD (37) average, the Provision of Health Services (Dentists Consultations) in Italy is 1.30 Number per Capita, which is above the OECD (32) average.

While the Resource Generation (Medical Graduates) in Italy is 11,089, which is above the OECD (38) average, the Resource Generation (Dentists Graduates) in Italy is 1,123, which is above the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in Italy is 100.00%, which is above the OECD (38) average.

2.2.2.20. Overview of the Japan Healthcare System

Japan uses *The Bismarck Model* as a Healthcare System Type, and General Information about the Japan Healthcare System is presented in Table 2.67. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 67: General Information of the Japan Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	125,502,300
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	44,624.90

According to Table 2.67., the population of Japan is 125,502,300, which is above the OECD (38) average; the Gross Domestic Product (GDP) of Japan is 44,624.90 US Dollars, which is below the OECD (38) average.

Health Status Indicators of the Japan Healthcare System are presented in Table 2.68. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 68: Health Status Indicators of the Japan Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	84.70
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	599.50
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	2,994.80

According to Table 2.68., the Life Expectancy in Japan is 84.70 years, which is above the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in Japan is 599.50, which is below the OECD (38) average; the Potential Years of Life Lost in Japan is 2,994.80, which is below the OECD (38) average.

Functions of Health Systems Indicators of the Japan Healthcare System are presented in Table 2.69. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 69: Functions of Health Systems Indicators of the Japan Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	4,665.64
Provision of Health Services	Doctors Consultations	Number per Capita	Number	12.40
	Dentists Consultations	Number per Capita	Number	3.30
Resource Generation	Medical Graduates	Number	Number	9,013
	Dentists Graduates	Number	Number	2,186
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	100.00

According to Table 2.69.,

The Financing function (Health Expenditure and Financing) in Japan is 4,665.64 US Dollars based on Current Expenditure on Health, which is above the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in Japan is 12.40 Number per Capita, which is above the OECD (37) average, the Provision of Health Services (Dentists Consultations) in Japan is 3.30 Number per Capita, which is above the OECD (32) average.

While the Resource Generation (Medical Graduates) in Japan is 9,013, which is below the OECD (38) average, the Resource Generation (Dentists Graduates) in Japan is 2,186, which is below the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in Japan is 100.00%, which is above the OECD (38) average.

2.2.2.21. Overview of the Korea Healthcare System

Korea uses *The National Health Insurance Model* as Healthcare System Type, and General Information about the Korea Healthcare System is presented in Table 2.70. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 70: General Information of the Korea Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	51,744,900
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	49,181.50

According to Table 2.70., the population of Korea is 51,744,900, which is above the OECD (38) average; the Gross Domestic Product (GDP) of Korea is 49,181.50US Dollars, which is below the OECD (38) average.

Health Status Indicators of the Korea Healthcare System are presented in Table 2.71 based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 71: Health Status Indicators of the Korea Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	83.50
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	635.80
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	3,146.90

According to Table 2.71, the Life Expectancy in Korea is 83.50 years, which is above the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in Korea is 635.80, which is below the OECD (38) average; the Potential Years of Life Lost in Korea is 3,146.90, which is below the OECD (38) average.

Functions of Health Systems Indicators of the Korea Healthcare System are presented in Table 2.72. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 72: Functions of Health Systems Indicators of the Korea Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	3,913.74
Provision of Health Services	Doctors Consultations	Number per Capita	Number	14.70
	Dentists Consultations	Number per Capita	Number	1.50
Resource Generation	Medical Graduates	Number	Number	3,742
	Dentists Graduates	Number	Number	765
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	100.00

According to Table 2.72.,

The Financing function (Health Expenditure and Financing) in Korea is 3,913.74 US Dollars based on Current Expenditure on Health, which is below the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in Korea is 14.70 Number per Capita, which is above the OECD (37) average, the Provision of Health Services (Dentists Consultations) in Korea is 1.50 Number per Capita, which is above the OECD (32) average.

While the Resource Generation (Medical Graduates) in Korea is 3,742, which is below the OECD (38) average, the Resource Generation (Dentists Graduates) in Korea is 765, which is below the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in Korea is 100.00%, which is above the OECD (38) average.

2.2.2.22. Overview of the Latvia Healthcare System

Latvia uses *The Bismarck Model* as a Healthcare System Type, and General Information about the Latvia Healthcare System is presented in Table 2.73. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 73: General Information of the Latvia Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	1,893,200
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	34,847.60

According to Table 2.73., the population of Latvia is 1,893,200, which is below the OECD (38) average; the Gross Domestic Product (GDP) of Latvia is 34,847.60 US Dollars, which is below the OECD (38) average.

Health Status Indicators of the Latvia Healthcare System are presented in Table 2.74. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 74: Health Status Indicators of the Latvia Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	73.40
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	1,217.70
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	8,137.50

According to Table 2.74., the Life Expectancy in Latvia is 73.40 years, which is below the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in Australia is 1,217.70, which is above the OECD (38) average; the Potential Years of Life Lost in Australia is 8,137.50, which is above the OECD (38) average.

Functions of Health Systems Indicators of the Latvia Healthcare System are presented in Table 2.75. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 75: Functions of Health Systems Indicators of the Latvia Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	2,201.91
Provision of Health Services	Doctors Consultations	Number per Capita	Number	5.10
	Dentists Consultations	Number per Capita	Number	0.90
Resource Generation	Medical Graduates	Number	Number	428
	Dentists Graduates	Number	Number	61
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	100.00

According to Table 2.75.,

The Financing function (Health Expenditure and Financing) in Latvia is 2,201.91 US Dollars based on Current Expenditure on Health, which is below the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in Latvia is 5.10 Number per Capita, which is below the OECD (37) average, the Provision of Health Services (Dentists Consultations) in Latvia is 0.90 Number per Capita, which is above the OECD (32) average.

While the Resource Generation (Medical Graduates) in Latvia is 428, which is below the OECD (38) average, the Resource Generation (Dentists Graduates) in Latvia is 61, which is below the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in Latvia is 100.00%, which is above the OECD (38) average.

2.2.2.23. Overview of the Lithuania Healthcare System

Lithuania uses *The Bismarck Model* as a Healthcare System Type, and General Information about the Lithuania Healthcare System is presented in Table 2.76. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 76: General Information of the Lithuania Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	2,795,700
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	43,453.50

According to Table 2.76., the population of Lithuania is 2,795,700, which is below the OECD (38) average; the Gross Domestic Product (GDP) of Lithuania is 43,453.50 US Dollars, which is below the OECD (38) average.

Health Status Indicators of the Lithuania Healthcare System are presented in Table 2.77. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 77: Health Status Indicators of the Australian Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	74.50
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	1,261.70
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	8,626.90

According to Table 2.77., the Life Expectancy in Lithuania is 74.50 years, which is below the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in Lithuania is 1,261.70, which is above the OECD (38) average; the Potential Years of Life Lost in Lithuania is 8,626.90, which is above the OECD (38) average.

Functions of Health Systems Indicators of the Lithuania Healthcare System are presented in Table 2.78. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 78: Functions of Health Systems Indicators of the Lithuania Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	3,309.03
Provision of Health Services	Doctors Consultations	Number per Capita	Number	6.30
	Dentists Consultations	Number per Capita	Number	1.30
Resource Generation	Medical Graduates	Number	Number	588
	Dentists Graduates	Number	Number	162
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	98.80

According to Table 2.78.,

The Financing function (Health Expenditure and Financing) in Lithuania is 3,309.03 US Dollars based on Current Expenditure on Health, which is below the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in Lithuania is 6.30 Number per Capita, which is above the OECD (37) average, the Provision of Health Services (Dentists Consultations) in Lithuania is 1.30 Number per Capita, which is above the OECD (32) average.

While the Resource Generation (Medical Graduates) in Lithuania is 588, which is below the OECD (38) average, the Resource Generation (Dentists Graduates) in Lithuania is 162, which is below the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in Lithuania is 98.80%, which is above the OECD (38) average.

2.2.2.24. Overview of the Luxembourg Healthcare System

Luxembourg uses *The Bismarck Model* as a Healthcare System Type, and General Information about the Luxembourg Healthcare System is presented in Table 2.79. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 79: General Information of the Luxembourg Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	634,700
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	137,593.70

According to Table 2.79., the population of Luxembourg is 634,700, which is below the OECD (38) average; the Gross Domestic Product (GDP) of Luxembourg is 137,593.70 US Dollars, which is above the OECD (38) average.

Health Status Indicators of the Luxembourg Healthcare System are presented in Table 2.80. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 80: Health Status Indicators of the Luxembourg Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	82.80
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	691.60
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	2,941.30

According to Table 2.80., the Life Expectancy in Luxembourg is 82.80 years, which is above the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in Luxembourg is 691.60, which is below the OECD (38) average; the Potential Years of Life Lost in Luxembourg is 2,941.30, which is below the OECD (38) average.

Functions of Health Systems Indicators of the Luxembourg Healthcare System are presented in Table 2.81. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 81: Functions of Health Systems Indicators of the Luxembourg Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	5,596.38
Provision of Health Services	Doctors Consultations	Number per Capita	Number	4.40
	Dentists Consultations	Number per Capita	Number	1.20
Resource Generation	Medical Graduates	Number	Number	0
	Dentists Graduates	Number	Number	0
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	100.00

According to Table 2.81.,

The Financing function (Health Expenditure and Financing) in Luxembourg is 5,596.38 US Dollars based on Current Expenditure on Health, which is above the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in Luxembourg is 4.40 Number per Capita, which is below the OECD (37) average, the Provision of Health Services (Dentists Consultations) in Luxembourg is 1.20 Number per Capita, which is above the OECD (32) average.

While the Resource Generation (Medical Graduates) in Luxembourg is 0, which is below the OECD (38) average, the Resource Generation (Dentists Graduates) in Luxembourg is 0, which is below the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in Luxembourg is 100.00%, which is above the OECD (38) average.

2.2.2.25. Overview of the Mexico Healthcare System

Mexico uses *The Out-of-Pocket Model* as a Healthcare System Type, and General Information about the Mexico Healthcare System is presented in Table 2.82. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 82: General Information of the Mexico Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	128,972,400
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	20,520.60

According to Table 2.82., the population of Mexico is 128,972,400, which is above the OECD (38) average; the Gross Domestic Product (GDP) of Mexico is 20,520.60 US Dollars, which is below the OECD (38) average.

Health Status Indicators of the Mexico Healthcare System are presented in Table 2.83. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 83: Health Status Indicators of the Mexico Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	75.20
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	1,533.70
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	12,474.80

According to Table 2.83., the Life Expectancy in Mexico is 75.20 years, which is below OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in Mexico is 1,533.70, which is above the OECD (38) average; the Potential Years of Life Lost in Mexico is 12,474.80, which is above the OECD (38) average.

Functions of Health Systems Indicators of the Mexico Healthcare System are presented in Table 2.84. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 84: Functions of Health Systems Indicators of the Mexico Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	1,226.74
Provision of Health Services	Doctors Consultations	Number per Capita	Number	2.10
	Dentists Consultations	Number per Capita	Number	0.10
Resource Generation	Medical Graduates	Number	Number	14,838
	Dentists Graduates	Number	Number	6,383
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	72.40

According to Table 2.84.,

The Financing function (Health Expenditure and Financing) in Mexico is 1,226.74 US Dollars based on Current Expenditure on Health, which is below the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in Mexico is 2.10 Number per Capita, which is below the OECD (37) average, the Provision of Health Services (Dentists Consultations) in Mexico is 0.10 Number per Capita, which is below the OECD (32) average.

While the Resource Generation (Medical Graduates) in Mexico is 14,838, which is above the OECD (38) average, the Resource Generation (Dentists Graduates) in Mexico is 6,383, which is above the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in Mexico is 72.40%, which is below the OECD (38) average.

2.2.2.26. Overview of the Netherlands Healthcare System

The Netherlands uses *The Bismarck Model* as a Healthcare System Type, and General Information about the Netherlands Healthcare System is presented in Table 2.85. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 85: General Information of the Netherlands Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	17,475,400
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	64,985.80

According to Table 2.85., the population of the Netherlands is 17,475,400, which is below the OECD (38) average; the Gross Domestic Product (GDP) of the Netherlands is 64,985.80 US Dollars, which is above the OECD (38) average.

Health Status Indicators of the Netherlands Healthcare System are presented in Table 2.86. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 86: Health Status Indicators of the Netherlands Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	81.50
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	821.20
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	3,533.80

According to Table 2.86., the Life Expectancy in the Netherlands is 81.50 years, which is above the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in the Netherlands is 821.20, which is below the OECD (38) average; the Potential Years of Life Lost in the Netherlands is 3,533.80, which is below the OECD (38) average.

Functions of Health Systems Indicators of the Netherlands Healthcare System are presented in Table 2.87. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

**Table 2. 87. Functions of Health Systems Indicators of the Netherlands
Healthcare System**

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	6,189.72
Provision of Health Services	Doctors Consultations	Number per Capita	Number	8.40
	Dentists Consultations	Number per Capita	Number	2.50
Resource Generation	Medical Graduates	Number	Number	2,500
	Dentists Graduates	Number	Number	250
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	99.90

According to Table 2.87.,

The Financing function (Health Expenditure and Financing) in the Netherlands is 6,189.72 US Dollars based on Current Expenditure on Health, which is above the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in the Netherlands is 8.40 Number per Capita, which is above the OECD (37) average, the Provision of Health Services (Dentists Consultations) in the Netherlands is 2.50 Number per Capita, which is above the OECD (32) average.

While the Resource Generation (Medical Graduates) in the Netherlands is 2,500, which is below the OECD (38) average, the Resource Generation (Dentists Graduates) in the Netherlands is 250, which is below the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in the Netherlands is 99.90%, which is above the OECD (38) average.

2.2.2.27. Overview of the New Zealand Healthcare System

New Zealand uses *The Beveridge Model* as a Healthcare System Type, and General Information about the New Zealand Healthcare System is presented in Table 2.88. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 88: General Information of the New Zealand Health System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	5,112,800
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	48,289.20

According to Table 2.88., the population of New Zealand is 5,112,800, which is below the OECD (38) average; the Gross Domestic Product (GDP) of New Zealand is 48,289.20 US Dollars, which is below the OECD (38) average.

Health Status Indicators of the New Zealand Healthcare System are presented in Table 2.89. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 89: Health Status Indicators of the New Zealand Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	82.30
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	749.30
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	4,065.60

According to Table 2.89., the Life Expectancy in New Zealand is 82.30 years, which is above the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in New Zealand is 749.30, which is below the OECD (38) average; the Potential Years of Life Lost in New Zealand is 4,065.60, which is below the OECD (38) average.

Functions of Health Systems Indicators of the New Zealand Healthcare System are presented in Table 2.90. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 90: Functions of Health Systems Indicators of the New Zealand Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	4,469.38
Provision of Health Services	Doctors Consultations	Number per Capita	Number	3.80
	Dentists Consultations	Number per Capita	Number	N/A
Resource Generation	Medical Graduates	Number	Number	528
	Dentists Graduates	Number	Number	122
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	100.00

According to Table 2.90.,

The Financing function (Health Expenditure and Financing) in New Zealand is 4,469.38 US Dollars based on Current Expenditure on Health, which is below the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in New Zealand is 3.80 Number per Capita, which is below the OECD (37) average, the Provision of Health Services (Dentists Consultations) in New Zealand is Not Available (N/A) in OECD Health Statistics.

While the Resource Generation (Medical Graduates) in New Zealand is 528, which is below the OECD (38) average, the Resource Generation (Dentists Graduates) in New Zealand is 122, which is below the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in New Zealand is 100.00%, which is above the OECD (38) average.

2.2.2.28. Overview of the Norway Healthcare System

Norway uses *The Beveridge Model* as a Healthcare System Type, and General Information about the Norway Healthcare System is presented in Table 2.91. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 91: General Information of the Norway Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	5,391,400
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	68,664.00

According to Table 2.91., the population of Norway is 5,391,400, which is below the OECD (38) average; the Gross Domestic Product (GDP) of Norway is 68,664.00 US Dollars, which is above the OECD (38) average.

Health Status Indicators of the Norway Healthcare System are presented in Table 2.92. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 92: Health Status Indicators of the Norway Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	83.20
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	764.70
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	3,283.60

According to Table 2.92., the Life Expectancy in Norway is 83.20 years, which is above the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in Norway is 764.70, which is below the OECD (38) average; the Potential Years of Life Lost in Norway is 3,283.60, which is below the OECD (38) average.

Functions of Health Systems Indicators of the Norway Healthcare System are presented in Table 2.92. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 93: Functions of Health Systems Indicators of the Norway Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	7,064.76
Provision of Health Services	Doctors Consultations	Number per Capita	Number	3.90
	Dentists Consultations	Number per Capita	Number	N/A
Resource Generation	Medical Graduates	Number	Number	587
	Dentists Graduates	Number	Number	114
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	100.00

According to Table 2.93.,

The Financing function (Health Expenditure and Financing) in Norway is 7,064.76 US Dollars based on Current Expenditure on Health, which is above the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in Norway is 3.90 Number per Capita, which is below the OECD (37) average, the Provision of Health Services (Dentists Consultations) in Norway is Not Available (N/A) in OECD Health Statistics.

While the Resource Generation (Medical Graduates) in Norway is 587, which is below the OECD (38) average, the Resource Generation (Dentists Graduates) in Norway is 114, which is below the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in Norway is 100.00%, which is above the OECD (38) average.

2.2.2.29. Overview of the Poland Healthcare System

Poland uses *The Bismarck Model* as a Healthcare System Type, and General Information about the Poland Healthcare System is presented in Table 2.94. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 94: General Information of the Poland Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	37,840,000
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	38,350.60

According to Table 2.94., the population of Poland is 37,840,00, which is above the OECD (38) average; the Gross Domestic Product (GDP) of Poland is 38,350.6 US Dollars, which is below the OECD (38) average.

Health Status Indicators of the Poland Healthcare System are presented in Table 2.95. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 95: Health Status Indicators of the Poland Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	75.60
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	1,021.00
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	6,506.10

According to Table 2.95., the Life Expectancy in Poland is 75.60 years, which is below the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in Poland is 1,021.00, which is above the OECD (38) average; the Potential Years of Life Lost in Poland is 6,506.10, which is above the OECD (38) average.

Functions of Health Systems Indicators of the Poland Healthcare System are presented in Table 2.96. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 96: Functions of Health Systems Indicators of the Poland Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	2,567.72
Provision of Health Services	Doctors Consultations	Number per Capita	Number	6.80
	Dentists Consultations	Number per Capita	Number	0.70
Resource Generation	Medical Graduates	Number	Number	4,006
	Dentists Graduates	Number	Number	1,058
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	94.00

According to Table 2.96.,

The Financing function (Health Expenditure and Financing) in Poland is 2,567.72 US Dollars based on Current Expenditure on Health, which is below the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in Poland is 6.80 Number per Capita, which is above the OECD (37) average, the Provision of Health Services (Dentists Consultations) in Poland is 0.70 Number per Capita, which is below the OECD (32) average.

While the Resource Generation (Medical Graduates) in Poland is 4,006, which is below the OECD (38) average, the Resource Generation (Dentists Graduates) in Poland is 1,058, which is above the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in Poland is 94.00%, which is below the OECD (38) average.

2.2.2.30. Overview of the Portugal Healthcare System

Portugal uses *The Beveridge Model* as a Healthcare System Type, and General Information about the Australian Health System is presented in Table 2.97. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 97: General Information of the Australia Health System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	10,298,300
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	36,359.40

According to Table 2.97., the population of Portugal is 10,298,300, which is below the OECD (38) average; the Gross Domestic Product (GDP) of Portugal is 36,359.40 US Dollars, which is below the OECD (38) average.

Health Status Indicators of the Portugal Healthcare System are presented in Table 2.98. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 98: Health Status Indicators of the Portugal Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	81.20
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	818.90
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	4,181.40

According to Table 2.98., the Life Expectancy in Portugal is 81.20 years, which is above the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in Portugal is 818.90, which is below the OECD (38) average; the Potential Years of Life Lost in Portugal is 4,181.40, which is below the OECD (38) average.

Functions of Health Systems Indicators of the Portugal Healthcare System are presented in Table 2.99. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 99: Functions of Health Systems Indicators of the Portugal Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	3,816.37
Provision of Health Services	Doctors Consultations	Number per Capita	Number	4.10
	Dentists Consultations	Number per Capita	Number	0.10
Resource Generation	Medical Graduates	Number	Number	1,619
	Dentists Graduates	Number	Number	903
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	100.00

According to Table 2.99., the Financing function (Health Expenditure and Financing) in Portugal is 3,816.37 US Dollars based on Current Expenditure on Health, which is below the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in Portugal is 4.10 Number per Capita, which is below the OECD (37) average, the Provision of Health Services (Dentists Consultations) in Portugal is 0.10 Number per Capita, which is below the OECD (32) average.

While the Resource Generation (Medical Graduates) in Portugal is 1,619, which is below the OECD (38) average, the Resource Generation (Dentists Graduates) in Portugal is 903, which is below the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in Portugal is 100.00%, which is above the OECD (38) average.

2.2.2.31. Overview of the Slovak Republic Healthcare System

Slovak Republic uses *The Bismarck Model* as a Healthcare System Type and General Information about the Slovak Republic Healthcare System is presented in Table 2.100. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 100: General Information of the Slovak Republic Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	5,459,800
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	33,356.20

According to Table 2.100., the population of Slovak Republic is 5,459,800, which is below the OECD (38) average; the Gross Domestic Product (GDP) of Slovak Republic is 33,356.20 US Dollars, which is below the OECD (38) average.

Health Status Indicators of the SVK Healthcare System are presented in Table 2.101. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 101: Health Status Indicators of the Slovak Republic Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	74.80
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	1,062.20
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	6,221.60

According to Table 2.101., the Life Expectancy in SVK is 74.80 years, which is below the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in SVK is 1,062.20, which is above the OECD (38) average; the Potential Years of Life Lost in SVK is 6,221.60, which is above the OECD (38) average.

Functions of Health Systems Indicators of the Slovak Republic Healthcare System are presented in Table 2.102. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 102. Functions of Health Systems Indicators of the Slovak Republic Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	2,134.31
Provision of Health Services	Doctors Consultations	Number per Capita	Number	10.10
	Dentists Consultations	Number per Capita	Number	1.00
Resource Generation	Medical Graduates	Number	Number	1,054
	Dentists Graduates	Number	Number	131
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	94.60

According to Table 2.102.,

The Financing function (Health Expenditure and Financing) in Slovak Republic is 2,134.31 US Dollars based on Current Expenditure on Health, which is above the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in Slovak Republic is 10.10 Number per Capita, which is above the OECD (37) average, the Provision of Health Services (Dentists Consultations) in Slovak Republic is 1.00 Number per Capita, which is equal to the OECD (32) average.

While the Resource Generation (Medical Graduates) in Slovak Republic is 1,054, which is below the OECD (38) average, the Resource Generation (Dentists Graduates) in Slovak Republic is 131, which is below the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in Slovak Republic is 94.60%, which is above the OECD (38) average.

2.2.2.32. Overview of the Slovenia Healthcare System

Slovenia uses *The Bismarck Model* as a Healthcare System Type and General Information about the Slovenia Healthcare System is presented in Table 2.103. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 103: General Information of the Slovenia Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	2,109,000
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	44,199.80

According to Table 2.103., the population of Slovenia is 2,109,000, which is below the OECD (38) average; the Gross Domestic Product (GDP) of Slovenia is 44,199.80 US Dollars, which is below the OECD (38) average.

Health Status Indicators of the Slovenia Healthcare System are presented in Table 2.104. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 104: Health Status Indicators of the Slovenia Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	80.90
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	921.70
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	3,927.10

According to Table 2.104., the Life Expectancy in Slovenia is 80.90 years, which is above the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in Slovenia is 921.70, which is above the OECD (38) average; the Potential Years of Life Lost in Slovenia is 3,927.10, which is below the OECD (38) average.

Functions of Health Systems Indicators of the Slovenia Healthcare System are presented in Table 2.105. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 105: Functions of Health Systems Indicators of the Slovenia Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	3,497.55
Provision of Health Services	Doctors Consultations	Number per Capita	Number	5.20
	Dentists Consultations	Number per Capita	Number	N/A
Resource Generation	Medical Graduates	Number	Number	239
	Dentists Graduates	Number	Number	50
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	100.00

According to Table 2.105.,

The Financing function (Health Expenditure and Financing) in Slovenia is 3,497.55 US Dollars based on Current Expenditure on Health, which is below the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in Slovenia is 5.20 Number per Capita, which is below the OECD (37) average, the Provision of Health Services (Dentists Consultations) in Slovenia is Not Available (N/A) in OECD Health Statistics.

While the Resource Generation (Medical Graduates) in Slovenia is 239, which is below the OECD (38) average, the Resource Generation (Dentists Graduates) in Slovenia is 50, which is below the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in Slovenia is 100.00%, which is above the OECD (38) average.

2.2.2.33. Overview of the Spain Healthcare System

Spain uses *The Beveridge Model* as a Healthcare System Type and General Information about the Spain Healthcare System is presented in Table 2.106. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 106: General Information of the Spain Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	47,398,700
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	41,360.90

According to Table 2.106., the population of Spain is 47,398,700, which is above the OECD (38) average; the Gross Domestic Product (GDP) of Spain is 41,360.90 US Dollars, which is below the OECD (38) average.

Health Status Indicators of the Spain Healthcare System are presented in Table 2.107. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 107: Health Status Indicators of the Spain Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	83.30
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	777.70
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	3,392.60

According to Table 2.107., the Life Expectancy in Spain is 83.30, which is above the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in Spain is 777.70, which is below the OECD (38) average; the Potential Years of Life Lost in Spain is 3,392.60, which is below the OECD (38) average.

Functions of Health Systems Indicators of the Spain Healthcare System are presented in Table 2.108. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 108: Functions of Health Systems Indicators of the Spain Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	3,718.05
Provision of Health Services	Doctors Consultations	Number per Capita	Number	5.30
	Dentists Consultations	Number per Capita	Number	1.20
Resource Generation	Medical Graduates	Number	Number	6,600
	Dentists Graduates	Number	Number	1,782
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	100.00

According to Table 2.108.,

The Financing function (Health Expenditure and Financing) in Spain is 3,718.05 US Dollars based on Current Expenditure on Health, which is below the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in Spain is 5.30 Number per Capita, which is above the OECD (37) average, the Provision of Health Services (Dentists Consultations) in Spain is 1.20 Number per Capita, which is above the OECD (32) average.

While the Resource Generation (Medical Graduates) in Spain is 6,600, which is above the OECD (38) average, the Resource Generation (Dentists Graduates) in Spain is 1,782, which is above the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in Spain is 100.00%, which is above the OECD (38) average.

2.2.2.34. Overview of the Sweden Healthcare System

Sweden uses *The Beveridge Model* as a Healthcare System Type and General Information about the Sweden Healthcare System is presented in Table 2.109. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 109: General Information of the Sweden Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	10,379,300
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	60,605.90

According to Table 2.109., the population of Sweden is 10,379,300, which is below the OECD (38) average; the Gross Domestic Product (GDP) of Sweden is 60,605.90 US Dollars, which is above the OECD (38) average.

Health Status Indicators of the Sweden Healthcare System are presented in Table 2.110 based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 110: Health Status Indicators of the Sweden Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	83.20
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	761.50
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	3,225.90

According to Table 2.110., the Life Expectancy in Sweden is 83.20, which is above the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in Sweden is 761.50, which is below the OECD (38) average; the Potential Years of Life Lost in Australia is 3,225.90, which is below the OECD (38) average.

Functions of Health Systems Indicators of the Sweden Healthcare System are presented in Table 2.111. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 111: Functions of Health Systems Indicators of the Sweden Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	6,262.31
Provision of Health Services	Doctors Consultations	Number per Capita	Number	2.20
	Dentists Consultations	Number per Capita	Number	1.10
Resource Generation	Medical Graduates	Number	Number	1,405
	Dentists Graduates	Number	Number	280
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	100.00

According to Table 2.111.,

The Financing function (Health Expenditure and Financing) in Sweden is 6,262.31 US Dollars based on Current Expenditure on Health, which is above the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in Sweden is 2.20 Number per Capita, which is below the OECD (37) average, the Provision of Health Services (Dentists Consultations) in Sweden is 1.10 Number per Capita, which is above the OECD (32) average.

While the Resource Generation (Medical Graduates) in Sweden is 1,405, which is below the OECD (38) average, the Resource Generation (Dentists Graduates) in Sweden is 280, which is below the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in Sweden is 100.00%, which is above the OECD (38) average.

2.2.2.35. Overview of the Switzerland Healthcare System

Switzerland uses *The Bismarck Model* as a Healthcare System Type and General Information about the Switzerland Healthcare System is presented in Table 2.112. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 112: General Information of the Switzerland Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	8,670,300
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	77,233.60

According to Table 2.112., the population of Switzerland is 8,670,300, which is below the OECD (38) average; the Gross Domestic Product (GDP) of Switzerland is 77,233.60 US Dollars, which is above the OECD (38) average.

Health Status Indicators of the Switzerland Healthcare System are presented in Table 2.113. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 113: Health Status Indicators of the Switzerland Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	84.00
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	661.30
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	2,836.50

According to Table 2.113, the Life Expectancy in Switzerland is 84.00 years, which is above the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in Switzerland is 661.30, which is below the OECD (38) average; the Potential Years of Life Lost in Switzerland is 2,836.50, which is below the OECD (38) average.

Functions of Health Systems Indicators of the Switzerland Healthcare System are presented in Table 2.114. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 114: Functions of Health Systems Indicators of the Switzerland Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	7,178.56
Provision of Health Services	Doctors Consultations	Number per Capita	Number	4.30
	Dentists Consultations	Number per Capita	Number	1.10
Resource Generation	Medical Graduates	Number	Number	1,115
	Dentists Graduates	Number	Number	123
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	100.00

According to Table 2.114.,

The Financing function (Health Expenditure and Financing) in Switzerland is 7,178.56 US Dollars based on Current Expenditure on Health, which is above the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in Switzerland is 4.30 Number per Capita, which is below the OECD (37) average, the Provision of Health Services (Dentists Consultations) in Switzerland is 1.10 Number per Capita, which is above the OECD (32) average.

While the Resource Generation (Medical Graduates) in Switzerland is 1,115, which is below the OECD (38) average, the Resource Generation (Dentists Graduates) in Switzerland is 123, which is below the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in Switzerland is 100.00%, which is above the OECD (38) average.

2.2.2.36. Overview of the Türkiye Healthcare System

Türkiye uses *The Bismarck Model* as a Healthcare System Type and General Information about the Türkiye Healthcare System is presented in Table 2.115. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 115: General Information of the Türkiye Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	83,614,400
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	33,081.50

According to Table 2.115., the population of Türkiye is 83,614,400, which is above the OECD (38) average; the Gross Domestic Product (GDP) of Türkiye is 33,081.50 US Dollars, which is below the OECD (38) average.

Health Status Indicators of the Türkiye Healthcare System are presented in Table 2.116. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 116: Health Status Indicators of the Türkiye Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	78.60
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	968.70
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	5,072.30

According to Table 2.116., the Life Expectancy in Türkiye is 78.60 years, which is below the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in Türkiye is 968.70, which is above the OECD (38) average; the Potential Years of Life Lost in Türkiye is 5,072.30, which is above the OECD (38) average.

Functions of Health Systems Indicators of the Türkiye Healthcare System are presented in Table 2.117. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 117. Functions of Health Systems Indicators of the Türkiye Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	1,304.71
Provision of Health Services	Doctors Consultations	Number per Capita	Number	7.20
	Dentists Consultations	Number per Capita	Number	0.30
Resource Generation	Medical Graduates	Number	Number	11,909
	Dentists Graduates	Number	Number	3,859
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	98.50

According to Table 2.117.,

The Financing function (Health Expenditure and Financing) in Türkiye is 1,304.7 US Dollars based on Current Expenditure on Health, which is below the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in Türkiye is 7.20 Number per Capita, which is above the OECD (37) average, the Provision of Health Services (Dentists Consultations) in Türkiye is 0.30 Number per Capita, which is below the OECD (32) average.

While the Resource Generation (Medical Graduates) in Türkiye is 11,909, which is above the OECD (38) average, the Resource Generation (Dentists Graduates) in Türkiye is 3,859, which is above the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in Türkiye is 98.50%, which is above the OECD (38) average.

2.2.2.37. Overview of the United Kingdom Healthcare System

The United Kingdom uses *The Beveridge Model* as a Healthcare System Type and General Information about the United Kingdom Healthcare System is presented in Table 2.118. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 118. General Information of the United Kingdom Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	67,350,700
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	51,511.60

According to Table 2.118., the population of the United Kingdom is 67,350,700, which is above the OECD (38) average; the Gross Domestic Product (GDP) of the United Kingdom is 51,511.60 US Dollars, which is above the OECD (38) average.

Health Status Indicators of the UK Healthcare System are presented in Table 2.119. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 119. Health Status Indicators of the United Kingdom Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	80.40
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	895.90
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	4,473.40

According to Table 2.119., the Life Expectancy in the UK is 80.40, which is above the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in the UK is 895.90, which is above the OECD (38) average; the Potential Years of Life Lost in the UK is 4,473.40, which is below the OECD (38) average.

Functions of Health Systems Indicators of the United Kingdom Healthcare System are presented in Table 2.120. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 120: Functions of Health Systems Indicators of the United Kingdom Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	5,387.23
Provision of Health Services	Doctors Consultations	Number per Capita	Number	N/A
	Dentists Consultations	Number per Capita	Number	0.20
Resource Generation	Medical Graduates	Number	Number	8,835
	Dentists Graduates	Number	Number	1,120
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	100.00

According to Table 2.120.,

The Financing function (Health Expenditure and Financing) in the United Kingdom is 5,387.23 US Dollars based on Current Expenditure on Health, which is above the OECD (38) average.

While the Provision of Health Services (Doctors Consultations) in the United Kingdom is Not Available (N/A) in OECD Health Statistics, the Provision of Health Services (Dentists Consultations) in the United Kingdom is 0.20 Number per Capita, which is below the OECD (32) average.

While the Resource Generation (Medical Graduates) in the United Kingdom is 8,835, which is above the OECD (38) average, the Resource Generation (Dentists Graduates) in the United Kingdom is 1,120, which is above the OECD (38) average.

The Stewardship (Government/compulsory health insurance coverage) in the United Kingdom is 100.00%, above the OECD (38) average.

2.2.2.38. Overview of the United States Healthcare System

Since the healthcare system of the United States doesn't fit into any of the recognized models (T. R. Reid, 2009), it is assumed that the United States uses four basic arrangements (models) as Healthcare System Type and General Information about the United States Healthcare System is presented in Table 2.121. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 121: General Information of the United States Healthcare System

Indicator	Measure/Variable	Unit	Value
Population	Total Population	Number	331,893,700
Gross Domestic Product (GDP)	US Dollar Exchange Rate	Per Capita	69,287.50

According to Table 2.121., the population of the United States is 331,893,700, which is above the OECD (38) average; the Gross Domestic Product (GDP) of the United States is 69,287.50 US Dollars, which is above the OECD (38) average.

Health Status Indicators of the United States Healthcare System are presented in Table 2.122. based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 122. Health Status Indicators of the United States Healthcare System

Indicator	Measure/Variable	Unit	Value
Life Expectancy	Total Population at Birth	Years	77.00
Causes of Mortality	All Causes of Death	Deaths per 100,000 Population (standardised rates)	1,034.30
Potential Years of Life Lost	All causes of Death	Years Lost, / 100,000 Population, Aged 75 Years Old	7,664.80

According to Table 2.122., the Life Expectancy in the United States is 77.00 years, which is below the OECD (38) average; the Causes of Mortality (Deaths per 100,000 Population) in the United States is 1,034.30, which is below the OECD (38) average; the Potential Years of Life Lost in the United States is 7,664.80, which is below the OECD (38) average.

Functions of Health Systems Indicators of the United States Healthcare System are presented in Table 2.123 based on OECD Health Statistics in 2021 or the nearest year (OECD, 2022c).

Table 2. 123: Functions of Health Systems Indicators of the United States Healthcare System

Function	Indicator	Measure/ Variable	Unit	Value
Financing	Health Expenditure and Financing	Current Expenditure on Health	Per Capita, Current Prices, Current PPPs (US Dollars)	12,318.10
Provision of Health Services	Doctors Consultations	Number per Capita	Number	4.00
	Dentists Consultations	Number per Capita	Number	1.00
Resource Generation	Medical Graduates	Number	Number	28,337
	Dentists Graduates	Number	Number	6,609
Stewardship	Government/ compulsory health insurance coverage	% of the Total Population	Percentage	38.10

According to Table 2.123.,

The Financing function (Health Expenditure and Financing) in the United States is 12,318.10 US Dollars based on Current Expenditure on Health, which is above the OECD (38) average. While the Provision of Health Services (Doctors Consultations) in the United States is 4.00 Number per Capita, which is below the OECD (37) average, the Provision of Health Services (Dentists Consultations) in the United States is 1.00 Number per Capita, which is equal to the OECD (32) average.

While the Resource Generation (Medical Graduates) in the United States is 28,337, which is above the OECD (38) average, the Resource Generation (Dentists Graduates) in the United States is 6,609, which is above the OECD (38) average.

The Stewardship (Government/ compulsory health insurance coverage) in the United States is 38.10%, which is below the OECD (38) average.

2.2.3. Related Works

Within the OECD, most of the work on health is carried out by the Health Division of the Directorate for Employment, Labour and Social Affairs (OECD, 2021a).

Selected OECD Health Working Papers published by this division are summarized based on Author(s) and Year, Title, and Brief Summary indicators in Table 2.124.

Table 2. 124: Related Works on OECD Healthcare Systems

No	Author(s) and Year	Title	Brief Summary
1	(de Bienassis et al., 2022)	Health data and governance developments in relation to COVID-19: How OECD countries are adjusting health data systems for the new normal	This report presents findings from the 2021 OECD survey of health data development, use and governance.
2	(Morgan & James, 2022)	Investing in health systems to protect society and boost the economy: Priority investments and order-of magnitude cost estimates	This report identifies priority investment areas needed to strengthen health system resilience.
3	(Lorenzoni, Pinto, et al., 2019)	Health systems characteristics: A survey of 21 Latin American and Caribbean countries	This paper presents the information provided by 21 Latin American and Caribbean (LAC) countries.
4	(Lorenzoni, Marino, et al., 2019)	Health Spending Projections to 2030: New results based on a revised OECD methodology	OECD has produced a new set of health spending projections up to 2030 for all its member countries.
5	(Marino et al., 2017)	Future trends in health care expenditure: A modelling framework for cross-country forecasts	This paper aims to understand the main approaches used to forecast healthcare expenditure growth.

2.3. Data Envelopment Analysis (DEA)

The background of the Data Envelopment Analysis section, Mathematical Structure of Data Envelopment Analysis section, and Related Works section are presented as follows.

2.3.1. Background of Data Envelopment Analysis

Data Envelopment Analysis (DEA) is a nonparametric technique of evaluating the relative efficiency of Decision-Making Units (DMUs) that use the same inputs to produce the same outputs, such as companies or public sector organisations (Ramanathan, 2003; Tone, 2017). Since Decision Making Unit (DMU) term was used to refer to any entity that is to be evaluated in terms of its abilities to convert inputs into outputs, these evaluations can involve countries, states, governmental agencies and Non-Governmental Organizations (NGOs) as well as business firms (Cooper, Seiford, et al., 2011).

The most important advantage of using Data Envelopment Analysis (DEA) is that no production function has to be specified (Kohl et al., 2019). Therefore, Data Envelopment Analysis (DEA) is extensively used in many fields, such as healthcare, education, market research, banking, auditing, and agriculture (Charnes et al., 1994; Emrouznejad & Cabanda, 2014; Gök, 2012; Gok & Sezen, 2011; Ozcan, 2009, 2014; J. Zhu, 2014).

Although M. J. Farrell measured single-output/input technical efficiency in 1957 (Farrell, 1957), the story of Data Envelopment Analysis (DEA) begins with Edwardo Rhodes's PhD dissertation research under the supervision of W. W. Cooper (Charnes et al., 1994) and the first paper introducing Data Envelopment Analysis (DEA) entitled "*Measuring the efficiency of decision-making units*" was published in 1978 (Charnes et al., 1978).

According to (Charnes et al., 1994), the underlying framework of the Data Envelopment Analysis (DEA) has four basic models. The framework makes it clear that the choice of Data Envelopment Analysis (DEA) formulation requires the following;

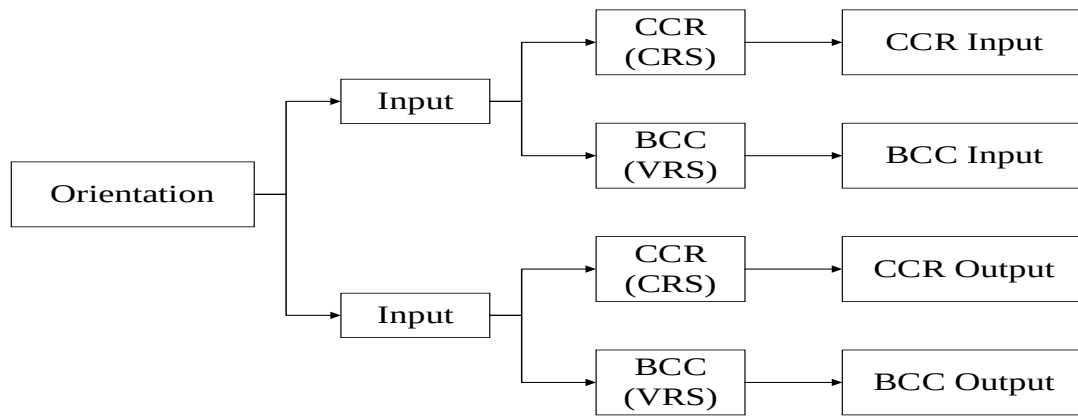
- ✓ a selection of orientation minimization of inputs or maximization of outputs or no orientation,
- ✓ a scale assumption -constant returns to scale (CRS) or variable returns to scale (VRS).

In terms of model orientation, Data Envelopment Analysis (DEA) models can be either input-orientated or output-orientated; in the input-orientated case, the Data Envelopment Analysis (DEA) technique identifies the frontier by seeking the maximum possible proportional reduction in input usage while maintaining the current levels of outputs; in the output orientated case, the Data Envelopment Analysis (DEA) technique seeks the maximum proportional increase in output production while keeping the current levels of inputs (Emrouznejad et al., 2014; Ozcan, 2014; Sherman & Zhu, 2006; J. Zhu, 2014). Besides, while input orientation assumes organization managers have more control over inputs than over outputs, output orientation assumes organization managers have more control over outputs than inputs (Ozcan, 2014).

In terms of scale assumption, Data Envelopment Analysis (DEA) models can be divided into two main types; Constant Returns to Scale (CRS), also known as CCR (Charnes-Cooper-Rhodes) model, was initially introduced by Charnes et al. in 1978 (Charnes et al., 1978), and Variable Returns to Scale (VRS), also known as BCC (Banker-Charnes-Cooper) model, was later developed by Banker et al. in 1984 (Banker et al., 1984). While the CCR (CRS) model yields an objective assessment of overall efficiency, identifies the sources, and estimates the number of inefficiencies in this way, the BCC (VRS) model distinguishes between technical and scale inefficiencies by estimating pure technical efficiency and identifying possible increasing, decreasing, or constant returns to scale (Charnes et al., 1994).

While CCR (CRS) models can assume that economies of scale do not change as the size of the service facility increases, BCC (VRS) models cannot believe that economies of scale do not change as the size of the service facility increases (Ozcan, 2014). Unlike CCR (CRS) models, input and output efficiency are equal, and BCC (VRS) models yield different input and output efficiencies (Emrouznejad & Cabanda, 2014).

Figure 2.6. shows the basic DEA models, also known as Basic Envelopment Models, based on returns to scale and model orientation (Ozcan, 2014).



Source: (Ozcan, 2014)

Figure 2. 6: DEA Model Classifications (Basic Envelopment Models)

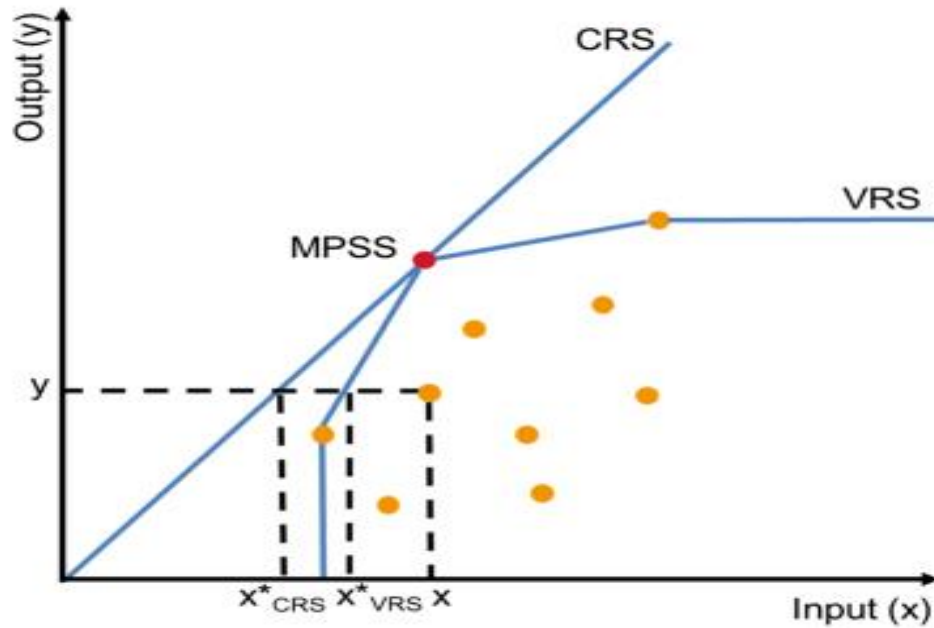
According to Figure 2.6.,

There are four DEA model classifications (Basic Envelopment Models): CCR (CRS)-Input Orientation, CCR (CRS)-Output Orientation, BCC (VRS)-Input Orientation, and BCC (VRS)-Output Orientation.

The BCC (VRS) efficiency scores are pure technical efficiency scores, while CCR (CRS) efficiency scores are technical efficiency scores. On the other hand, scale efficiency can be calculated by dividing CCR (CRS) efficiency scores by BCC (VRS) efficiency scores (Charnes et al., 1994; Cooper et al., 2006; Cooper, Seiford, et al., 2011; Ozcan, 2014; Ramanathan, 2003; Ray, 2004).

Besides other conditions being equal, the BCC (VRS) model gives the highest efficiency score, while the CCR (CRS) model gives the lowest efficiency score (Ramanathan, 2003).

Since the level of efficiency may be considered as productivity in production economics and business (Sueyoshi & Goto, 2018), when the BCC (VRS) efficiency score equals the CCR (CRS) efficiency score, the Decision-Making Unit (DMU) is said to be operating at the Most Productive Scale Size (MPSS) (Charles & Kumar, 2012a). It is shown in Figure 2.7.



Source: (Lefèvre et al., 2022)

Figure 2. 7: Most Productive Scale Size (MPSS)

The heart of Data Envelopment Analysis (DEA) lies in evaluating the best virtual Decision-Making Unit (DMU) for each actual Decision-Making Unit (DMU) (Charles & Kumar, 2012a). These evaluations result in an efficiency score that represents the degree of efficiency (Cooper et al., 2006).

Data Envelopment Analysis (DEA) identifies the production function for each Decision-Making Unit (DMU), and Data Envelopment Analysis (DEA) calculates the efficiency of that single Decision-Making Unit (DMU) by comparing it with the efficiency of other Decision-Making Units (DMUs) (Omrani et al., 2022).

Data Envelopment Analysis (DEA) provides four basic benchmarking information as follows (Gregoriou & Zhu, 2005);

- ✓ an efficiency score for each Decision-Making Unit (DMU),
- ✓ an efficiency reference set with peer Decision-Making Units (DMUs),
- ✓ a target for inefficient Decision-Making Units (DMUs),
- ✓ improvement options for inefficient Decision-Making Units (DMUs), i.e. information on how much inputs can be decreased, or outputs can be increased to improve performance.

The efficiency score of each Decision-Making Unit (DMU) is evaluated relative to optimal patterns of production, which are calculated from the performance

of Decision Making Unit (DMU) with input/output combinations that are the best of any peer Decision-Making Unit (DMU) (Ozcan, 2009).

When the efficiency score for each Decision-Making Unit (DMU) is a score of 1, it represents efficiency (Färe et al., 2015; Ozcan, 2009; J. Zhu, 2009). While Decision Making Units (DMUs) with an efficiency score ranging from zero to one are defined as inefficient in the input-oriented models, Decision Making Units (DMUs) with an efficiency score greater than 1 are defined as inefficient in the output-oriented models (Ozcan, 2014).

Once Data Envelopment Analysis (DEA) sets the efficient frontier, it improves the performance of inefficient Decision-Making Units (DMUs) by either increasing the current output levels or decreasing the current input levels (Hua & Bian, 2007).

For this purpose, an efficiency reference set with peer Decision-Making Units (DMUs), also known as best practices, is identified for each inefficient Decision-Making Units (DMUs) (Cooper et al., 2006; Cooper, Seiford, et al., 2011; Emrouznejad & Cabanda, 2014; Ozcan, 2009, 2014; Ramanathan, 2003; Tone, 2017).

Since the efficiency score is measured by subtracting the level of inefficiency from unity (Sueyoshi & Goto, 2018), the performance of Decision-Making Units (DMUs) can be assessed either as fully efficient or weakly efficient (Ozcan, 2014).

While the slack value in an input “ i ” represents an additional inefficient use of input “ i ”, the slack value in an output “ r ” represents an additional inefficient in the production of output “ r ” (Ozcan, 2014; Sherman & Zhu, 2006; Sueyoshi & Goto, 2018; J. Zhu, 2009), and if and only if one Decision-Making Unit’s efficiency score is 1 and all slack values (both input slack and output slacks) are 0, it is considered fully efficient otherwise, as weakly efficient (Charles & Kumar, 2012b; Ozcan, 2014).

2.3.2. Mathematical Structure of Data Envelopment Analysis

The basic efficiency measure is the ratio of total outputs to total inputs (Emrouznejad & Cabanda, 2014; Ramanathan, 2003).

$$Efficiency = \frac{\sum_r u_r y_{rj}}{\sum_i v_i x_{rj}} \quad (2.1)$$

where;

y_{rj} = the amount of r^{th} output from DMU j ,

u_r = the weight given to the r^{th} output,

x_{ij} = the amount of i^{th} the input used by DMU j ,

v_i = the weight given to the i^{th} input.

The basic DEA models, also known as Basic Envelopment Analysis, are based on returns to scale and model orientation; CCR (CRS)-Input Orientation, CCR (CRS)-Output Orientation, BCC (VRS)-Input Orientation, BCC (VRS)-Output Orientation (Ozcan, 2014). As follows, the calculation of DEA scores is shortly explained using mathematical notations; the efficiency scores for a group peer DMUs ($j = 1 \dots n$) are computed for selected outputs ($y_{rj}, r = 1, \dots, s$) and inputs ($x_{ij}, i = 1, \dots, m$) using the following fractional programming formula (Cooper et al., 2006; Emrouznejad & Cabanda, 2014; Ozcan, 2014):

CCR (CRS)-Input Orientation
(CCR-I);

$$\begin{aligned} & \text{Min } \Phi \\ & \lambda, h, s_i^-, s_r^+ \\ & \text{s.t.} \\ & \sum_j \lambda_j x_{ij} + s_i^- = \Phi x_{ij_0} \quad \forall i \\ & \sum_j \lambda_j y_{rj} - s_r^+ = y_{rj_0} \quad \forall r \\ & s_i^-, s_r^+ \geq 0 \quad \forall i, \forall r \\ & \lambda_j \geq 0 \end{aligned} \quad (2.2)$$

CCR (CRS)-Output Orientation
(CCR-O);

$$\begin{aligned}
 & \min_{\lambda, h, S_i^-, S_r^+} h \\
 & \text{s.t.} \\
 & \sum_j \lambda_j x_{ij} + S_i^- = x_{ij_0} \quad \forall i \\
 & \sum_j \lambda_j y_{rj} - S_r^+ = h y_{rj_0} \quad \forall r \\
 & s_i^-, s_i^+ \geq 0 \quad \forall i, \forall r \\
 & \lambda_j \geq 0
 \end{aligned} \tag{2.3}$$

BCC (VRS)-Input Orientation
(BCC-I);

$$\begin{aligned}
 & \min_{\lambda, \Phi, S_i^-, S_r^+} \Phi \\
 & \text{s.t.} \\
 & \sum_j \lambda_j x_{ij} + S_i^- = \Phi x_{ij_0} \quad \forall i \\
 & \sum_j \lambda_j y_{rj} - S_r^+ = y_{rj_0} \quad \forall r \\
 & \sum_j \lambda_j = 1 \\
 & s_i^-, s_i^+ \geq 0 \quad \forall i, \forall r \\
 & \lambda_j \geq 0 \quad \forall j.
 \end{aligned} \tag{2.4}$$

BCC (VRS)-Output Orientation
(BCC-O);

$$\begin{aligned}
 & \max_{\lambda, \theta, S_i^-, S_r^+} \theta \\
 & \text{s.t.} \\
 & \sum_j \lambda_j x_{ij} + S_i^- = x_{ij_0} \quad \forall i \\
 & \sum_j \lambda_j y_{rj} - S_r^+ = \theta y_{rj_0} \quad \forall r \\
 & \sum_j \lambda_j = 1 \\
 & s_i^-, s_i^+ \geq 0 \quad \forall i, \forall r \\
 & \lambda_j \geq 0 \quad \forall j.
 \end{aligned} \tag{2.5}$$

2.3.3. Related Works

The efficiency evaluation of healthcare systems is one of the most sensitive topics in Health Economics (Popescu et al., 2014). The efficiency of healthcare systems, therefore, becomes a relevant topic for scientists and health policy makers (Asandului et al., 2014).

Data Envelopment Analysis (DEA) has been used widely in the evaluation of healthcare efficiency around the world at different levels of Decision-Making Units (DMUs) to shed light on the efficiency of various aspects of national health systems (Kirigia et al., 2008; Ozcan, 2014).

Data Envelopment Analysis (DEA) has rapidly grown, with over 20,000 papers published in the last four decades, and applications of Data Envelopment Analysis (DEA) appeared in many areas, including healthcare, operational research, finance, economics, accounting, information management, engineering etc. to measure efficiency scores Decision-Making Units (DMUs) (Emrouznejad et al., 2022). The healthcare sector represents the main application area for Data Envelopment Analysis (DEA) (Kohl et al., 2019).

The Healthcare field has been one of the ten most actively implemented fields of Data Envelopment Analysis (DEA) methods in the past two years, as well as energy, banking, education, environment, public policy, supply chain, transportation, agriculture, and sociology fields (Emrouznejad et al., 2022). Decision-Making Units (DMUs) can represent different levels of healthcare, such as countries, districts, hospitals, specific service providers, departments, or individual physicians (Stefko et al., 2018).

In this context, since this dissertation focuses on efficiency at the level of OECD countries, selected works published since 2018 and indexed/abstracted Web of Science on Data Envelopment Analysis applied to healthcare at the level of countries/states/regions is summarised based on Author(s) and Year, Inputs, Outputs, DMUs (Sample), Model(s), and Data Period indicators in the Table 2.125.

Table 2. 125: Selected DEA Research in Healthcare

No	Author(s) and Year	Inputs	Outputs	DMUs (Sample)	DEA Model(s)	Data Period
1	(Pereira et al., 2022)	1-Health expenditure 2-Costs with instruments used in COVID-19 diagnostic testing 3-Costs with disinfection and sterilisation products 4-Costs with oxygen therapy equipment	1-Non-infected population 2-Home recoveries 3-Hospitalisation recoveries 4-ICU recoveries 5-Hospitalisation deaths 6-ICU deaths	55 countries	Output and input oriented Network DEA	From COVID-19 declaration to end of 2020
2	(Ramalho et al., 2022)	1-Number of doctors 2-Number of nurses 3-Number of intern doctors	1-Diabetes short-term complications admission rate 2-Diabetes long-term complications admission rate 3-Uncontrolled diabetes admission rate 4-Lower-extremity amputation among patients with a diabetes rate 5-Prevention quality diabetes composite	54 Portuguese health centre groupings (ACES)	Output- oriented BCC (VRS) Model	2016 - 2017

Table 2.125: (continued)

3	(İlgün & Şahin, 2022)	1-Primary healthcare budget allowance per capita (TL) 2-Number of physicians (per 100,000 population) 3-Number of nurses and midwives (per 100,000 population) 4-Number of other health personnel (per 100,000 population)	1-Number of visits to primary healthcare services per capita 2-Average number of follow-ups per pregnant 3-Average number of follow-ups per infant 4-Infant mortality rate (%)	Turkey (Based on 81 provinces)	Input- oriented BCC (VRS) Model	2012 - 2014
4	(Klumpp et al., 2022)	1-Health expenditures in US dollars per inhabitant 2-Number of doctors per 1,000,000 inhabitants 3-Number of hospital beds per 1,000,000 inhabitants 4-Number of COVID-19 tests per 1,000,000 inhabitants	1-Number of COVID-19 deaths per 1,000,000 inhabitants 2-Number of patients recovered from COVID-19 per 1,000,000 inhabitants 3-Number of COVID-19 cases per 1,000,000 inhabitants 4-Unemployed individuals per 1,000,000 inhabitants assigned to the labour force	19 OECD Countries	DEA Window Analysis	From COVID-19 declaration to 16.11.2020

Table 2.125: (continued)

5	(El Hussein, 2022)	1- Current health expenditure as a percentage of GDP 2-Physician's density 3-Hospital beds density	1- Life expectancy at birth 2-Infant survival rate	20 Arab countries	Input- oriented and Output-oriented BCC (VRS) Model	2019 and 2020
6	(Özdemir et al., 2021)	1-Capacity 2-Supply Network 3-Process Technology 4-Development and Organization	1-Quality 2-Cost 3-Delivery 4-Flexibility	50 US States	Output Orientation BCC (VRS) Model	17 months (from 22 January 2020 to 27 June 2021)
7	(Gavurova et al., 2021)	<i>Public health sub-division:</i> 1-Alcohol consumption 2-Tobacco consumption <i>Medical care sub-division</i> 1-Medical technology 2-Employment in healthcare	<i>Public health sub-division:</i> 1-Health-adjusted life expectancy <i>Medical care sub-division</i> 1-Inpatient discharges 2-Consultations	36 OECD Countries	Input- oriented Dynamic Network Data Envelopment Analysis (DNDEA) and Malmquist Index	2000, 2008, 2016

Table 2.125: (continued)

8	(Ekiz Bozdemir et al., 2021)	1- GDP share of current expenditure on health 2- Number of graduates of medical faculties per 100 000 population 3- Deaths per 1000 live births	1- Number of beds per 1000 population 2- Life expectancy at birth 3- Percentage of the total population 65 age and over	Estonia, Hungary, Israel, Latvia, Lithuania, Mexico, Poland, Slovenia, Turkey, and the United Kingdom	Super Efficiency (SE) Model	2003 - 2016
9	(Olejnik et al., 2021)	1-The number of medical doctors 2-The number of hospital beds 3-Financial resource	1-Mortality rate 2-Age-standardised death rate	European NUTS 2 regions	Spatial Data Envelopment Analysis (SDEA)	2013 - 2015
10	(Kang et al., 2021)	1-Individuals with diabetes 2-Primary Care Physicians (PCPs) 3-Advanced practice nurses 4-Eye doctors, including optometrists and ophthalmologists	1-Annual eye exams 2-Annual foot exams 3-Annual doctor visits for diabetes 4-One or more A1c tests in the past 12 months	1,112 US counties (Across 35 states)	Output Orientation BCC (VRS) Model	2010 - 2013

Table 2.125: (continued)

11	(Gómez-Gallego et al., 2021)	1-Total health expenditure 2-Total number of doctors 3-Total number of beds	1-Life expectancy 2-Child survival ratio 3-Self-perceived health	28 EU Countries	Fuzzy DEA	2017
12	(Mourad et al., 2021)	1-Number of affected cases 2-Medical practitioners 3-Hospital beds 4-Conducted COVID-19 tests	1-Number of recovered and death cases related to COVID-19	29 Countries	Output and input-oriented models	January 2020-September 2020
13	(Shen et al., 2020)	1-Square meters of area 2-The volume of services 3-Professionals	1- Human resource management 2-Rehabilitation quality management 3-Problem solving ability	Taiwan (Based on 38 halfway houses)	Input- oriented CRS Model and Input- oriented VRS Model	2014
14	(Top et al., 2020)	1-Health Expenditure/GDP 2-Physicians per 1,000 3-Nurses per 1,000 4-Hospital beds per 1,000 5-Unemployment Rate 6-Gini Coefficient	1-Life Expectancy at Birth 2-Infant Mortality Rate	36 African countries	Input- oriented VRS	2015 or the nearest year

Table 2.125: (continued)

15	(Kočiřová et al., 2020)	1-A number of cardiologists and angiography equipment per 100,000 inhabitants 2-Total healthcare costs of CVD patients per 100,000 inhabitants	<i>First Model:</i> 1-The number of surgical operations and procedures related to disease of the circulatory system per 100,000 inhabitants 2-Hospital discharge rates for in-Patients with diseases of the circulatory system	18 OECD countries	Input-oriented CRS	2015
			<i>Second Model:</i> 1-Survival rates of patients with diseases of the circulatory system			
16	(Jordi et al., 2020)	1-Current health expenditure	1-UHC service coverage index 2-Proxy for financial risk protection	172 countries	Input-oriented Double Bootstrap VRS-DEA	2015
17	(G. Gong et al., 2019)	1-Health technicians per 1000 Persons 2-Beds per 1000 Persons 3-Per capital total health expenditure	1-Maternal mortality rate 2-Perinatal survival rate 3-Life expectancy	30 China provinces	Input-oriented network DEA	2009 - 2016

Table 2.125: (continued)

18	(Abolghasem et al., 2019)	1- Population 2- Specialist surgical 3- Birthrate 4-Total fertility Rate 5-Hospital beds 6-Nurses and midwives 7-Physicians	1-Mortality	120 countries around the world	Cross-Efficiency DEA	2010-2017
19	(Stefko et al., 2018)	1-Number of beds 2-Number of medical staff 3-Number of computed tomography (CT) devices 4-Number of magnetic resonance (MR) devices 5-Number of all medical devices	1- Bed Occupancy Rate 2-Ratio of treatment days to the total number of hospitalised patients	Slovak Republic (Based on regions)	Output- oriented models, CCR and BCC, based on the DEA window analysis	2008 - 2015
20	(Ibrahim & Daneshvar, 2018)	1-Health expenditure, total (% of GDP) 2-Hospital beds (per 1,000 people)	1-Life expectancy at birth, total (years) 2-Modeled estimate (per 100,000 live births) 3-Mortality rate, infant (per 1,000 live births) 4-Adults (aged 15+) and children (aged 0–14) newly infected with HIV	Lebanon	Input-oriented modified VRS model	2000 - 2015

Table 2.125: (continued)

21	(Önen & Sayın, 2018)	1- Number of Physicians 2- Number of nurses 3- Number of hospitals beds	1- Infant Survival Rate (ISR) 2- Life expected at birth	34 OECD Countries	Output-Oriented BCC	2008 and 2012
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2.4. Artificial Neural Network (ANN)

Background of the Artificial Neural Network (ANN) section, The Integration of DEA and ANN: DEA-ANN Models section, and the Related Works section are presented as follows.

2.4.1. Background of Artificial Neural Network (ANN)

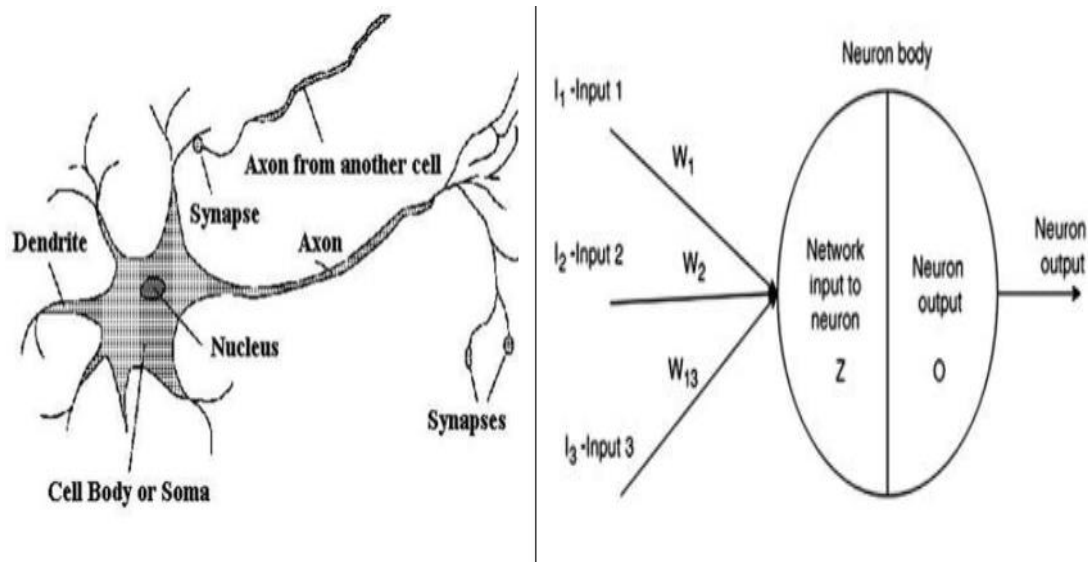
Artificial intelligence as a discipline was born in the 1950s (Livshin, 2022a). The new era of the world uses Artificial Intelligence (AI), and machine learning and the combination of AI and machine learning is called an Artificial Neural Network (ANN) (Gurjar & Patel, 2022).

An Artificial Neural Network (ANN), also known as a neural network or network, can be described as a collection of elementary neurons inspired by biological (human) neuron architectures and organised in several layers (Banerjee Roy & Bhattacharya, 2022), wherein the neurons compute output values from inputs (Puri et al., 2016).

For simplicity, two terms, neural network and network, will be used interchangeably for the rest of this dissertation (Livshin, 2022b).

Biological neural networks and artificial neural networks have some standard features, and biological plausibility describes various artificial neural network algorithms and demonstrates how close an artificial neural network algorithm is to a biological neural network (Heaton, 2015).

While a schematic image of the human neuron is presented on the left side of Figure 2.8., an artificial neuron, also known as a perceptron, mimics the biological neuron and consists of a neuron body and connections to other neurons, is presented on the right side of the Figure 2.8. (Livshin, 2022b).



Source: (Livshin, 2022b)

Figure 2. 8: Biological Neuron and Single Artificial Neuron

The architecture of an artificial neural network defines how its several neurons are placed about each other (da Silva et al., 2017a). While a single Artificial Neural Network (ANN) neuron, a perceptron, with one input and one output node, Artificial Neural Networks (ANNs) generally consist of three types of layers as follows (Young II et al., 2014);

- ✓ Input
- ✓ Hidden
- ✓ Output

The input layer comprises the inputs taken in the model, the hidden layer, the hidden layer links weights to the inputs, and the output layer provides model estimates (Sharma et al., 2020).

Some special nonlinear functions named the activation or transfer functions that establish bounds for the output of neurons are applied to calculate output (Heaton, 2015; Livshin, 2022b). A trial-and-error procedure can be used to determine which activation to use (Young II et al., 2014).

The commonly used activation functions for a single perceptron are presented in Table 2.126. (Duch & Jankowski, 1997; Young II et al., 2014).

Table 2. 126: Common Activation Functions

Activation Functions	Definitions	Range
Exponential	e^{-x}	$(0, \infty)$
Hyperbolic	$\frac{e^x - e^{-x}}{e^x + e^{-x}}$	$(-1, 1)$
Linear	x	$(-\infty, +\infty)$
Logistic / Sigmoid	$\frac{1}{(1 + e^{-x})}$	$(0,1)$
Sine	$\sin(x)$	$(-1,1)$
SoftMax	$\frac{e^{-x}}{\sum_i x_i}$	$(0,1)$
Square Root	$\sqrt{x}$	$(0, \infty)$
Step	$\{0, x < 0 \ 1, x \geq 0\}$	$(0,1)$
Unit Sum	$\frac{x}{\sum_i x_i}$	$(0,1)$

Source: (Duch & Jankowski, 1997; Young II et al., 2014)

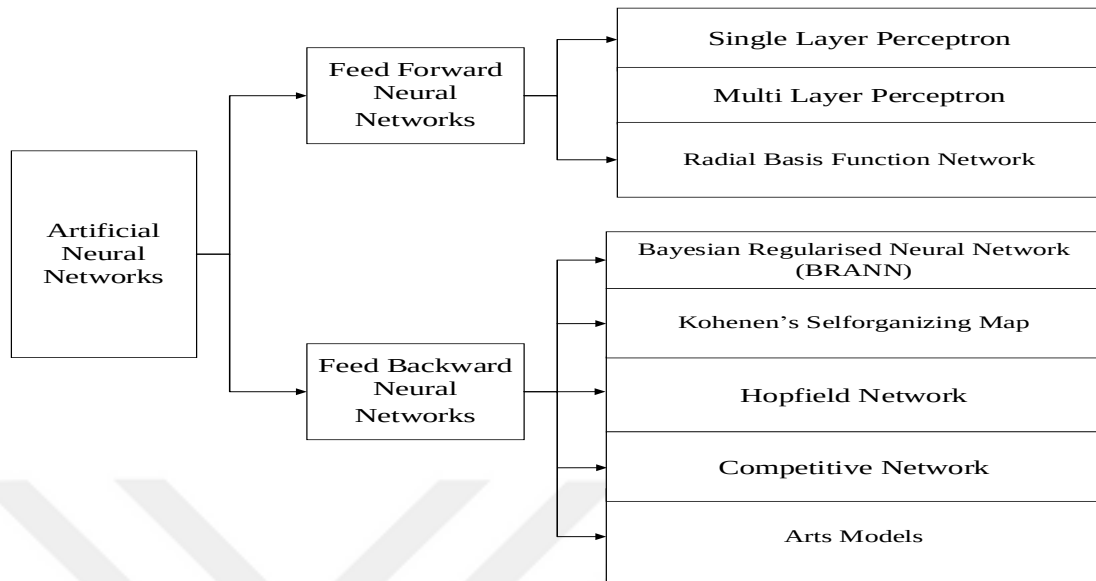
Two prominent and significant steps in Artificial Neural Network (ANN) models are the training and testing stages (M. S. Ahmed, 2016; Aslani et al., 2009). However, the validation stage is considered the third of the main steps (Çelebi & Bayraktar, 2008). Hence, a set of data, referred to as the training data set used to train the neural network, is needed (Banerjee Roy & Bhattacharya, 2022).

While validation data are used to test the network performance and stop the processing in case of overfitting, testing data is an independent operation, and it has no effect on Artificial Neural Network (ANN) operation during training (Puri et al., 2016).

On the other hand, while the training stage involves repeatedly presenting the data to the network, testing is performed in the network by interchanging the values of weighted connections between neurons (perceptron) to give rise to the output of the network closer to the desired target value (Athanasopoulos & Curram, 1996).

Artificial Neural Networks (ANNs) has recently become popular and helpful model for prediction, classification, clustering and pattern recognition in many

disciplines, such as healthcare, which can be classified as depicted in Figure 2.9. (Abiodun et al., 2018).

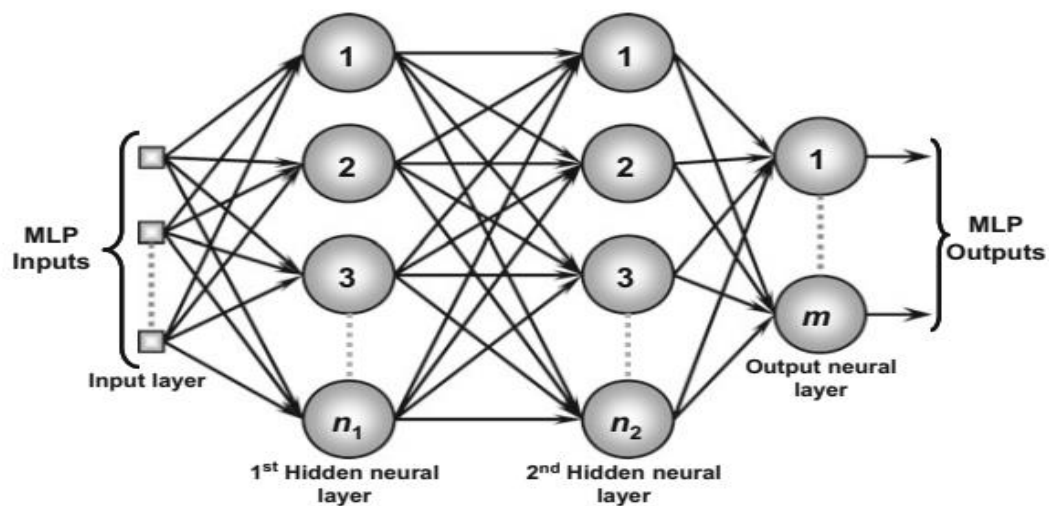


Source: (Abiodun et al., 2018)

Figure 2. 9: Artificial Neural Networks Classification

The Multi-Layer Perceptron (MLP) structure is commonly applied for prediction, and input layers, hidden layers and an output layer are layers of a multi-layer structure and neurons are organized in these structures (Amiri & Ventelou, 2011).

An illustration of a multilayer perceptron network is presented in Figure 2.10.



Source: (da Silva et al., 2017b)

Figure 2. 10: Illustration of a Multi-Layer Perceptron Network

As shown in Figure 2.10., the flow of information within the network starts in the input layer, passes through the intermediate layers, and finishes with the output neural layer (da Silva et al., 2017b). One of the vital parameters for the successful application of multi-layer perceptron on any problem is the selection of appropriate network architecture (Çelebi & Bayraktar, 2008). It should be noted that networks with a single hidden layer only can provide more accurate results (Çelebi & Bayraktar, 2008; Tsolas et al., 2020).

Most multi-layer networks are trained using the Back Propagation Neural Network (BPNN) algorithm for forecasting (Shokrollahpour et al., 2016). Back Propagation Neural Network (BPNN) has numerous advantages, such as high learning accuracy, fast recall capability, and high error tolerance (Jauhar et al., 2022).

The Back Propagation Neural Network (BPNN) algorithm takes a training set of input patterns which are used to compute the output pattern, and if there is an error, the weights are adjusted to reduce this error (Çelebi & Bayraktar, 2008; Tosun, 2012; Tsolas et al., 2020). Back Propagation Neural Network (BPNN) learning is a kind of supervised learning (Liu et al., 2013) and starts with the calculation of network outputs through a feed-forward process (Kwon, 2017).

Although several variations of the Back Propagation Neural Network (BPNN) have been proposed to avoid inconvenience and enhance the efficiency of its convergence, such as Basic Gradient Descent, Gradient Descent With Momentum, Resilient Back-Propagation, Adaptive Learning Rate, Levenberg–Marquardt Algorithm (LM), and Bayesian Regularization, among the most used optimization technique the Levenberg-Marquardt algorithm introduced by Levenberg (1944) and expanded by Marquardt (1963) stands out (Banerjee Roy & Bhattacharya, 2022; da Silva et al., 2017b; Levenberg, 1944; Marquardt, 1963).

The Levenberg-Marquardt method can outperform the Multi-Layer Perceptron (MLP) training and testing process faster than the other Back Propagation Neural Network (BPNN) algorithm (M. S. Ahmed, 2016; da Silva et al., 2017b).

Since the Levenberg–Marquardt algorithm is a very efficient training and testing method for neural networks, every neural network programmer should consider this training and testing algorithm (Heaton, 2015).

2.4.2. The Integration of DEA and ANN: DEA-ANN Model

Data Envelopment Analysis (DEA) and Artificial Neural Networks (ANNs) are non-parametric methods, therefore there are no assumptions made regarding the functional form that connects the inputs and outputs used to identify an operating process (Athanasopoulos & Curram, 1996). Both these methods have been used in several research fields independently, and techniques have their benefits and drawbacks (Shahi et al., 2022).

Despite its wide range of successful applications, Data Envelopment Analysis (DEA) lacks predictive capability (Kwon, 2017), which is a strength of Artificial Neural Networks (ANNs) (Jahangoshai Rezaee et al., 2018; Jauhar et al., 2022).

A new evaluation method by integrating Artificial Neural Networks (ANNs) with Data Envelopment Analysis (DEA) was proposed to demonstrate the possible future benchmarks to cope with and overcome the drawbacks associated with the homogeneity and accuracy assumption of Data Envelopment Analysis (DEA) (Athanasopoulos & Curram, 1996; Çelebi & Bayraktar, 2008; Shokrollahpour et al., 2016).

The idea of integration of these methods for classification and/or prediction was first introduced by Athanasopoulos and Curram (1996), and it has been used in many industries, including healthcare analytics (Athanasopoulos & Curram, 1996; Misiunas et al., 2016; Shahi et al., 2022; Tosun, 2012).

2.4.3. Related Works

Although they have been frequently used as a benchmarking tool in the literature, traditional Data Envelopment Analysis (DEA) models lack predictive capabilities, therefore to overcome these drawbacks, some hybrid methods combining Data Envelopment Analysis (DEA) and Artificial Neural Networks (ANNs) named DEA-ANN Models are proposed as framework for analysing healthcare performance in the healthcare operations research literature (Zarrin et al., 2022).

The works on DEA-ANN Model applied to the healthcare area are summarised based on Author(s) and Year, Used Algorithm, Objective(s), and Accuracy indicators in the Table 2.127. DEA-ANN Model Research in Healthcare.

Table 2. 127: DEA-ANN Model Research in Healthcare

Author(s) and Year	Used Algorithm	Objective(s)	Accuracy (MSE: Mean Square Error) (MAPE: Mean Absolute Percentage Error)
(Taherinezhad & Alinezhad, 2022)	1-Back-Propagation Neural Network (BPNN) 2-Genetic Algorithm integrated with Neural Network (GANN) 3-Support Vector Machines (SVM) 4-Improved Support Vector Machines (ISVM) 4- ISVM: Improved Support Vector Machines	Prediction	MSE (GANN) = 0.0004 MSE (BPNN) = 0.0008 MSE (ISVM) = 0.0018 MSE (SVM) = 0.0177
(Zarrin et al., 2022)	Multi-Layer Perceptron (MLP)	Clustering and Prediction	MAPE (Cluster-1): 8% MAPE (Cluster-2): 8% MAPE (Cluster-3): 7%
(Revuelta et al., 2021)	Scaled Conjugate Gradient Backpropagation	Prediction	Accuracy: 96.30%
(Misiunas et al., 2016)	Multi-Layer Perceptron (MLP)	Prediction	Accuracy (Level-1): 0.74 Accuracy (Level-2): 0.78 Accuracy (Level-3): 0.82
(Tosun, 2012)	Back-Propagation Multi-Layer Perceptron	Classification	Accuracy: 98.70%

2.5. Data Envelopment Analysis Matrix (DEAM)

The background of the Data Envelopment Analysis Matrix section and Related Works section are presented as follows.

2.5.1. Background of Data Envelopment Analysis Matrix (DEAM)

To analyse the outputs taken from Data Envelopment Analysis models, Vafaee Najar et al. (2018) have developed a Data Envelopment Analysis Matrix (DEAM) based on the approach presented by Osman et al. (2011) (Osman et al., 2011; Vafaee Najar et al., 2018).

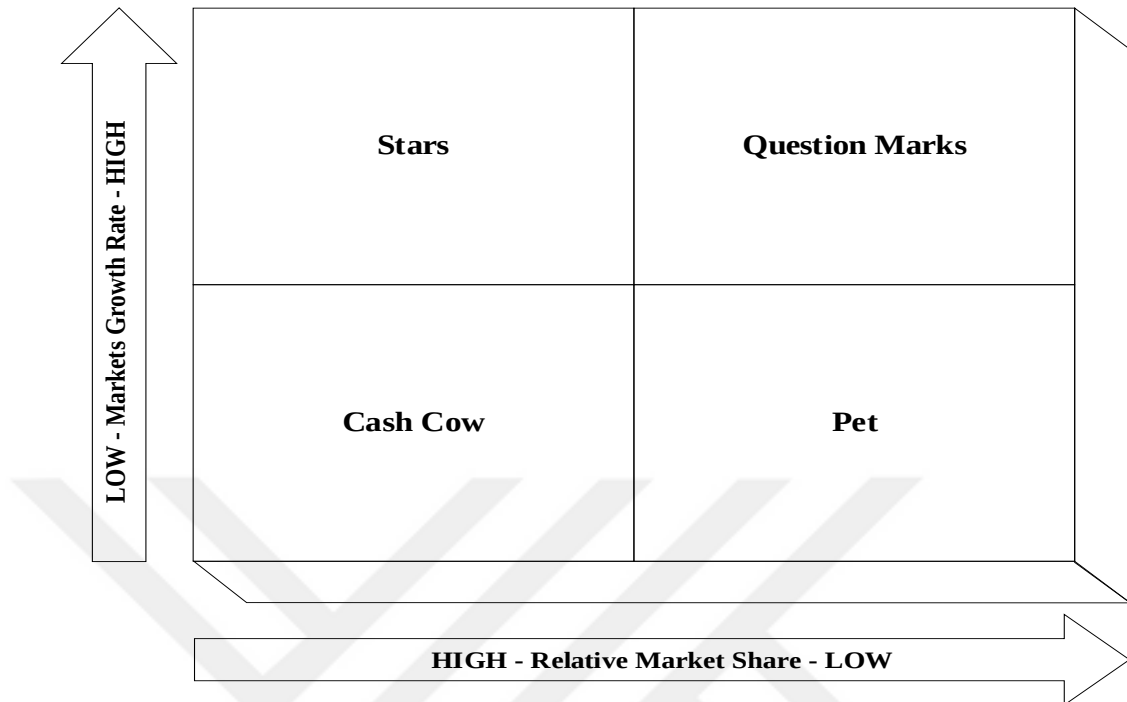
Data Envelopment Analysis Matrix (DEAM) was used to classify DMUs, and the basis for analysis in this matrix is similar to the Boston Consulting Group (BCG) Growth-Share Matrix (Osman et al., 2011; Vafaee Najar et al., 2018).

Boston Consulting Group (BCG) Growth-Share Matrix is a portfolio management framework that helps companies decide how to prioritise their different Strategic Business Units (SBUs) (BCG, 2022) and a portfolio-planning method that evaluates a company's Strategic Business Units (SBUs) in terms of its market growth rate and relative market share (Kotler & Armstrong, 2021).

While X (Horizontal) axis represents the Relative Market Share, and the Y (Vertical) axis represents Market Growth in this matrix. It is a table that splits into four quadrants; question marks, stars, pets (often represented by a dog), and cash cows (BCG, 2022).

The Strategic Business Units (SBUs) with high share and high growth belong to the Stars Group, whose high share and high growth assure the future; the Strategic Business Units (SBUs) with high market share and low growth belong to the Cash Cows Group which supplies funds for that future growth; the Strategic Business Units (SBUs) with low market share and high growth belong to the Question Marks Group to be converted into stars with the added funds; the Strategic Business Units (SBUs) with low market share and low growth belong to the Pets (Dogs) Group that are not necessary (Stern et al., 2006).

A graphical representation of the Boston Consulting Group (BCG) Growth-Share Matrix is shown in Figure 2.11. (BCG, 2022).



Source: (BCG, 2022)

Figure 2. 11: Boston Consulting Group (BCG) Growth-Share Matrix

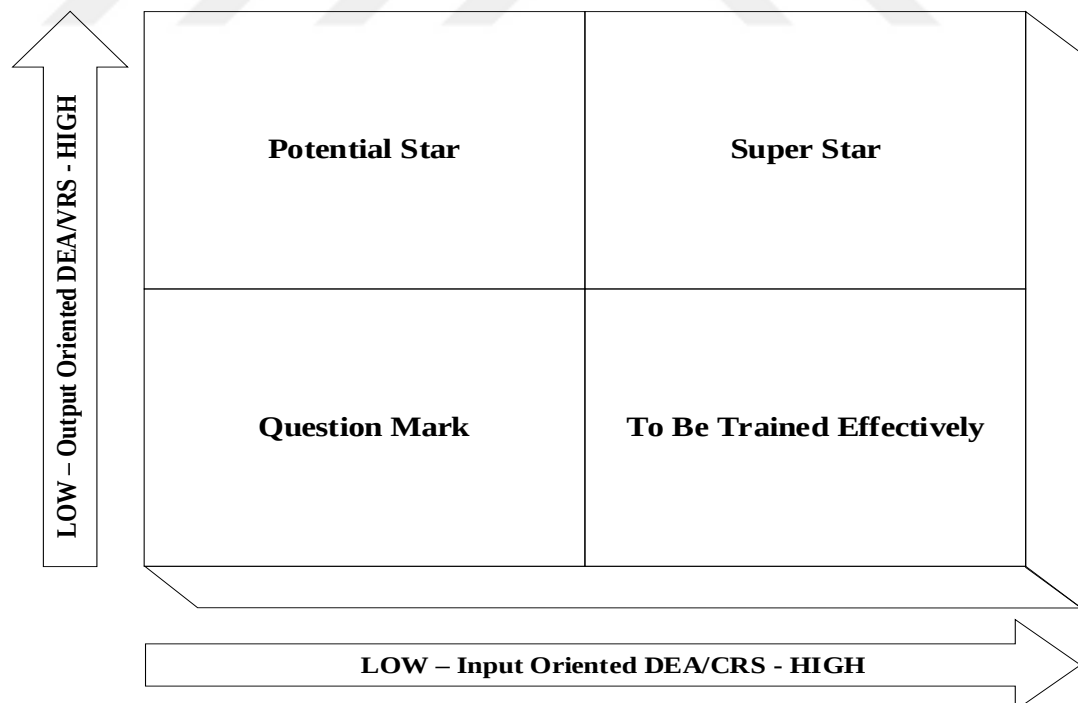
Organizations can basically fall into any one of four broad strategic categories, as depicted schematically in Figure 2.11. (Hedley, 1990). The organization must decide how much it will invest in each product or Strategic Business Unit (SBU) and whether to build, hold, harvest, or divest (Kotler & Armstrong, 2021).

According to (Osman et al., 2011; Vafae Najar et al., 2018); the DEAM is a two-dimensional matrix whose X (Horizontal) axis represents the relative efficiency score based on Input Oriented DEA-CRS and the Y (Vertical) axis represents the relative efficiency score based on Output Oriented DEA-CRS. In each axis, the relative efficiency score is between zero and one. A score from zero to average efficiency scores represents a low efficiency, and a score of average efficiency scores to one shows the high efficiency of Decision-Making Units (DMUs).

DMUs are divided into four groups based on this matrix as follows (Osman et al., 2011; Vafae Najar et al., 2018):

- ✓ The Super Stars group consists of DMUs with high relative efficiency in the Output Oriented DEA-CRS and high relative efficiency in the Input Oriented DEA-CRS.
- ✓ The Potential Stars group consists of DMUs with high relative efficiency in the Output Oriented DEA-CRS and low relative efficiency in the Input Oriented DEA-CRS.
- ✓ The Question Marks Group consists of DMUs with low relative efficiency in the Output Oriented DEA-CRS and low relative efficiency in the Input Oriented DEA-CRS.
- ✓ The To Be Governed Effectively Group consists of DMUs with low relative efficiency in the Output Oriented DEA-CRS and high relative efficiency in the Input Oriented DEA-CRS.

A graphical representation of the Data Envelopment Analysis Matrix (DEAM) is shown in Figure 2.12. (Vafae Najar et al., 2018).



Source: (Vafae Najar et al., 2018)

Figure 2. 12: Data Envelopment Analysis Matrix (DEAM)

2.5.2. Related Works

The works on Data Envelopment Analysis Matrix applied to the healthcare area are summarised based on Author(s) and Year, Sample, X (Horizontal) Axis, and Y (Vertical) Axis indicators in the Table 2.128. DEAM Research in Healthcare.

Table 2. 128: DEAM Research in Healthcare

No	Author(s) and Year	Sample	X (Horizontal) Axis	Y (Vertical) Axis
1	(Osman et al., 2011)	32 Nurses	Input Oriented DEA-CRS	Output Oriented DEA-CRS
2	(Vafaei Najari et al., 2018)	30 Nurses	Input Oriented DEA-CRS	Output Oriented DEA-CRS

3. MATERIALS AND METHOD

The sample section, Inputs, Outputs and Data section and Analysis Design section are presented as follows.

3.1. Sample

Data Envelopment Analysis (DEA) evaluates and compares the relative efficiency of a set of enterprises, called Decision Making Units (DMUs), with standard input and output factors (Tone, 2017).

For example, the hospitals, countries, firms, regions, nursing homes, group practices, and other facilities that are evaluated for performance using Data Envelopment Analysis (DEA) are considered as Decision Making Units (DMUs), i.e. the sample of Data Envelopment Analysis (DEA) (Ozcan, 2014).

The correct selection of Decision-Making Units (DMUs) to be compared is essential, and Decision-Making Units (DMUs) should be homogeneous. In other words, Decision Making Units (DMUs) should perform the same tasks with similar objectives using the same inputs and outputs under the same market conditions (Golany & Roll, 1989). Since Decision Making Units (DMUs) used in this study consist of all OECD (38) countries, it is assumed that these criteria are met.

The sample size is expected to be at least 2 or 3 times larger than the sum of the number of inputs and outputs (Ramanathan, 2003). Since the study has 38 Decision-Making Units (DMUs), 4 (four) inputs, and 4 (four) outputs, it is assumed that this requirement is met.

Although descriptive statistics of the sample (38 OECD countries) are presented in *Section 2.2*, it is also briefed in Table 3.1.

Table 3. 1: Sample List

Country	Abbreviation	DMU Code
Australia	AUST	DMU1
Austria	AUT	DMU2
Belgium	BEL	DMU3
Canada	CAN	DMU4
Chile	CHL	DMU5
Colombia	COL	DMU6
Costa Rica	CRI	DMU7
Czech Republic	CZE	DMU8
Denmark	DNK	DMU9
Estonia	EST	DMU10
Finland	FIN	DMU11
France	FRA	DMU12
Germany	DEU	DMU13
Greece	GRC	DMU14
Hungary	HUN	DMU15
Iceland	ISL	DMU16
Ireland	IRL	DMU17
Israel	ISR	DMU18
Italy	ITA	DMU19
Japan	JPN	DMU20
Korea	KOR	DMU21
Latvia	LVA	DMU22
Lithuania	LTU	DMU23
Luxembourg	LUX	DMU24
Mexico	MEX	DMU25
Netherlands	NLD	DMU26
New Zealand	NZL	DMU27
Norway	NOR	DMU28
Poland	POL	DMU29
Portugal	PRT	DMU30
Slovak Republic	SVK	DMU31
Slovenia	SVN	DMU32
Spain	ESP	DMU33
Sweden	SWE	DMU34
Switzerland	CHE	DMU35
Türkiye	TUR	DMU36
United Kingdom	GBR	DMU37
United States	USA	DMU38

3.2. Inputs, Outputs, and Data

Data Envelopment Analysis (DEA) uses linear programming to obtain the optimal combinations of inputs and outputs, as demonstrated in the actual performance of DMUs (Ozcan, 2009). Since the input-output combination used by DMUs should

be technically feasible, it must produce an output bundle from the input bundle (Ray, 2004).

Since, in real-world conditions, organisations encounter undesirable outputs that need to be reduced, both good (desirable) and bad (undesirable) inputs and outputs factors may be available in these bundles (Färe et al., 1989; Jahanshahloo et al., 2005; Omrani et al., 2022). Since increases in undesirable (bad) inputs and desirable (good) outputs are allowed, similarly, decreases in undesirable (bad) outputs and desirable (good) inputs are allowed in the standard DEA model, the desirable (good) and undesirable (bad) factors should be evaluated differently (Seiford & Zhu, 2002).

Data Envelopment Analysis models deal with evaluations of the relative efficiency of DMUs concerning multiple inputs or outputs, and each DMU utilizes its input resources to produce its outputs (Tone & Tsutsui, 2017). The operations strategy matrix mentioned earlier was used as the primary measurement tool in this research.

There are four inputs used in the analysis; these are Decision Areas/Strategic Decision Areas in the Operations Strategy Matrix adapted from Slack and Lewis (2017) and Karuppan et al. (2016) as the primary input framework (Karuppan et al., 2016; Slack & Lewis, 2017).

The inputs used in the study are explained in detail as follows;

Capacity (i1):

An organization's capacity refers to its potential level of productive activity (Slack & Lewis, 2017) and the number of resources or assets that exist to meet the demand (Langabeer, 2018). Most organizations need to decide on the capacity size of each of their facilities (Slack et al., 2016). Capacity decisions include total capacity and distribution between sites location (Slack & Brandon-Jones, 2021).

The capacity of healthcare systems is determined by the capacity of each server being used (Ozcan, 2009). Donabedian's Model has argued that capacity or infrastructure is the input measure of healthcare quality (Donabedian, 2005). In the healthcare area, capacity can be measured in terms of multiple resources, including the number of available beds, which is the most commonly used input measure (Langabeer, 2018; Slack et al., 2011). Total hospital beds include curative (or acute)

care beds, rehabilitative care beds, long-term care beds and other beds in hospitals (OECD, 2022a).

Therefore, in line with (Abolghasem et al., 2019; El Husseiny, 2022; Gómez-Gallego et al., 2021; G. Gong et al., 2019; Ibrahim & Daneshvar, 2018; Mourad et al., 2021; Olejnik et al., 2021; Önen & Sayın, 2018; Stefko et al., 2018; Top et al., 2020), the Capacity is represented by the “*Total Hospital Beds (Per 1,000 Population)*” indicator in this dissertation.

Supply Network (i2):

Every organization is part of a more extensive and interconnected network of other organizations (Slack et al., 2016). This circumstance is called an organization’s supply network, an arrangement of operations (Slack & Lewis, 2017). The objective of a supply network is to build a chain of suppliers that focuses on maximizing value to the ultimate customer (Heizer et al., 2020).

A supply network manages three essential flows; information, finances, and goods/services (Langabeer & Helton, 2021). In other words, materials, parts, information, ideas and sometimes people all flow through the supply network (Slack & Brandon-Jones, 2021). As operations managers have responsibilities both within their organizations and in the relationship with suppliers and distributors within the supply network (Brown et al., 2005), healthcare managers are concerned with the relationships of patients and healthcare providers with the companies at the upstream source of the goods and healthcare services to minimize their overall costs in supply management (Ozcan, 2009). The healthcare supply network consists of the government, health insurance funds, medical institutions and patients (Gao & Wang, 2019). As one of these dimensions, health insurance means financing a person’s health care expenses (Keisler-Starkey & Bunch, 2021).

Therefore, in line with (İlgün & Şahin, 2022; Özdemir et al., 2021), the Supply Network is represented by the “*Total public and primary voluntary health insurance coverage (% of the total population covered)*” indicator in this dissertation.

Process Technology (i3):

Process technologies refer to the machines, equipment and devices that help processes transform materials, information and customers (Slack & Brandon-Jones, 2021). Operations managers should understand enough about process technology to assess alternatives (Slack et al., 2016). Process technologies can be classified as material processing technologies, information processing technologies and customer processing technologies (Slack & Lewis, 2017).

The process that is going to order-winning depends on the selection of suitable equipment (Heizer et al., 2020). Equipment is an input in the healthcare transformation (Stevenson, 2021), and Donabedian's Model has argued that technology is the input measure of healthcare quality (Donabedian, 2005). New technologies, equipment and devices present opportunities for improved diagnoses and treatments (Karuppan et al., 2016). Recently, medical imaging technologies have become a prominent component of the diagnosis process (Parlak & Tolga, 2018). Medical technology divided into six components; Computed Tomography scanners, Magnetic Resonance Imaging Units, Positron Emission Tomography Scanners, Gamma Cameras, Mammographs and Radiation Therapy Equipment (OECD, 2022c).

Therefore, in line with (Gavurova et al., 2021; Özdemir et al., 2021; Stefko et al., 2018), Process Technology is represented by the “*Medical Technology (Total per IM Pop)*” indicator in this dissertation.

Development and Organization (i4):

This strategic decision area refers to broad and long-term decisions governing how the operation is run continually (Slack & Lewis, 2017). One of the critical decisions is the extent to which opportunities for teamwork may be built into the service delivery process (Johnston et al., 2021).

Donabedian's Model has argued that personnel is the input measure of healthcare quality (Donabedian, 2005). If healthcare demand is low, healthcare staffing is inadequate, and as demand increases, labour is increased, creating an alignment between healthcare capacity and demand (Langabeer & Helton, 2021). Staff scheduling involves assigning personnel to various departments and time-period

(Karuppan et al., 2016). Total health and social employment is the number of persons working in health care and social work (OECD, 2022d).

Therefore, in line with (Abolghasem et al., 2019; El Husseiny, 2022; Gavurova et al., 2021; Gómez-Gallego et al., 2021; G. Gong et al., 2019; İlgün & Şahin, 2022; Klumpp et al., 2022; Kočišová et al., 2020; Mourad et al., 2021; Olejnik et al., 2021; Önen & Sayın, 2018; Özdemir et al., 2021; Ramalho et al., 2022; Shen et al., 2020; Stefko et al., 2018; Top et al., 2020), the Development and Organization, is represented by the “*Total health and social employment (Density per 1 000 population (head counts))*” indicator in this dissertation.

There are four outputs, two of which are undesirable, used in the analysis: these are Competitive Priorities or Performance Objectives in the Operations Strategy Matrix adapted from Slack and Lewis (2017) and Karuppan et al. (2016) as the main output framework (Karuppan et al., 2016; Slack & Lewis, 2017).

The inputs used in the study are explained in detail as follows;

Quality (o1):

Quality is the focal point in the transformation of the healthcare system (Nash et al., 2019). Quality is the perception of a customer's value on an organization's outputs and the extent to which these processes and outputs meet established specifications (Langabeer & Helton, 2021).

In the healthcare area, quality means that patients receive the most appropriate treatment and the treatment is conducted correctly (Slack et al., 2016). Since quality is a primary concern for patients, they form perceptions about their healthcare experiences during care delivery and outcomes after care delivery (Karuppan et al., 2016). Perception of care is a satisfaction measure that focuses on the delivery of clinical care from the patient's/family's/caregiver's perspective (Bergeron, 2018). Donabedian's Model has argued that patient experiences and satisfaction are the output measure of healthcare quality (Donabedian, 2005).

Therefore, in line with (Gómez-Gallego et al., 2021; Özdemir et al., 2021; Shen et al., 2020), Quality is represented by the “*Perceived Health Status (Good/very good, total aged 15+) (% of the population) (crude rate)*” indicator in this dissertation.

Cost (o2):

Competing based on cost refers to offering goods and services at a low price relative to the merits of rivaling goods and services (R. D. Reid & Sanders, 2013). Even those organizations, such as countries which do not compete on price, should be interested in keeping costs low (Slack et al., 2016). Producing goods and services at a lower cost enables them to be priced appropriately for the target market (Slack & Brandon-Jones, 2021).

Cost is any financial measure that allows it to produce goods and services (Slack & Lewis, 2017). In the healthcare area, mentioned financial measures consist of various expenditures such as out-of-pocket payments, private health insurance, public health insurance, and investment in structures and equipment (Buchbinder & Shanks, 2017). Countries are intended to reduce these expenditures (Langabeer & Helton, 2021), but the low cost does not imply low healthcare quality (R. D. Reid & Sanders, 2013). Donabedian's Model has argued that financial measures are the input (*cost is assumed to be the undesirable output in this dissertation*) measure of healthcare (Donabedian, 2005).

Therefore, in line with (Ekiz Bozdemir et al., 2021; Gómez-Gallego et al., 2021; G. Gong et al., 2019; Ibrahim & Daneshvar, 2018; İlgin & Şahin, 2022; Klumpp et al., 2022; Kočíšová et al., 2020; Olejnik et al., 2021; Özdemir et al., 2021; Pereira et al., 2022; Top et al., 2020), as an undesirable (ud) output, the Cost is represented by the “*Current expenditures on health (all functions) Per capita, current PPPs - US Dollar*” indicator in this dissertation.

Delivery (o3):

Delivery means providing services on time (on-time delivery) or delivering the services faster (rapid delivery) than the competition (Karuppan et al., 2016). The healthcare delivery system is the interaction of different healthcare organizations working together in the healthcare system (Langabeer, 2018). While rapid delivery means how quickly an order is received, on-time delivery means how often deliveries are made on time (R. D. Reid & Sanders, 2013). The delivery of healthcare services consists of many repetitive workflows (Buchbinder & Shanks, 2017). For this reason, it has to be patient-focused (Spath, 2019) and should be cost-effective and wasteless

(Nash et al., 2019). In the healthcare area, while rapid delivery refers to the time between requiring treatment and receiving treatment kept to a minimum, on-time delivery refers to keeping to appointment times (Slack et al., 2016). Donabedian's Model has argued that the power of medical science to achieve specific results is an outcome measure (Donabedian, 2005).

As an outcome measure of complex clinical and administrative processes of healthcare delivery (Nash et al., 2019), the average length of stay is the average number of days a patient stays in a facility, measured from admission to discharge (Langabeer, 2018) and it is calculated as the number of patient days during a period divided by the number of discharges (Langabeer & Helton, 2021).

Therefore, in line with (Özdemir et al., 2021; Stefko et al., 2018), as an undesirable (ud) output, the Delivery is represented by the *“Hospital average length of stay by diagnostic categories (All Causes - Days)”* indicator in this dissertation.

Flexibility (o4):

Flexibility is the ability to vary or adapt the operation's activities to give patients individual treatment (Slack & Brandon-Jones, 2021). As a type of flexibility, volume flexibility is the ability to change the level of the operation's aggregated output (Slack & Lewis, 2017). Competing on flexibility refers to the ability to respond to changes with minimal penalties and uniform outcomes for healthcare services (Karuppan et al., 2016). Flexibility can be measured in terms of range, i.e., the amount of the change and response, i.e., the speed of the shift (Greasley, 2020). Healthcare operates in a highly dynamic environment (Karuppan et al., 2016).

In the healthcare area, flexibility refers to the ability to adjust the number of patients treated (Slack et al., 2016). Donabedian's Model has argued that the power of medical science to achieve specific results is an outcome measure (Donabedian, 2005). Hospital discharge is a vital outcome measure of a healthcare system (Langabeer, 2018). Hospital discharge rates measure the number of patients who leave a hospital after receiving healthcare (OECD, 2022b).

Therefore, in line with (Gavurova et al., 2021; Kočíšová et al., 2020; Mourad et al., 2021; Özdemir et al., 2021), the Flexibility is represented by the *“Hospital*

discharges by diagnostic categories (All Cause-per 100.000 population)” indicator in this dissertation.

The inputs, outputs, and indicators are summarized in Table 3.2.

Table 3. 2: The Inputs, Outputs, and Their Indicators

Inputs		Outputs	
Decision Areas	Indicator	Performance Objectives (Competitive Priorities)	Indicator
Capacity	Total Hospital Beds (Per 1,000 Population)	Quality	Perceived Health Status (Good/very good, total aged 15+) (% of the population) (crude rate)
Supply Network	Total public and primary voluntary health insurance coverage (% of the total population covered)	Cost (<i>undesirable</i>)	Current expenditures on health (all functions) Per capita, current PPPs - US Dollar
Process Technology	Medical Technology (Total per 1M Pop)	Delivery (<i>undesirable</i>)	Hospital average length of stay by diagnostic categories (All Causes - Days)
Development and Organization	Total health and social employment (Density per 1 000 population (head counts))	Flexibility	Hospital discharges by diagnostic categories (All Cause-per 100.000 population)

An operations strategy has to produce a distinctive competitive advantage to be efficient (Karuppan et al., 2016). The Operations Strategy Matrix is appropriate for formulating an operations strategy to be arranged as a matrix (Tan & Matthews, 2009). According to all explanations above, it is assumed that the input bundle used by DMUs can produce the output bundle in the Operations Strategy Matrix.

Data on inputs and outputs were collected from OECD Health Statistics in 2021 or the nearest year (OECD, 2022c). Input and Outputs Values and Summary Statistics are presented in Table 3.3.

Table 3. 3: Input and Outputs Values and Summary Statistics

DMU	i1	i2	i3	i4	o1	o2 (ud)	o3 (ud)	o4
AUST	92,826.00	100.00	137.31	68.00	85.20	5,627.32	5.30	17,392.80
AUT	62,873.00	99.90	93.99	53.56	74.00	6,693.31	8.50	20,179.20
BEL	63,634.00	98.60	120.58	57.00	75.40	5,274.09	6.10	13,903.30
CAN	96,849.00	100.00	61.73	55.48	89.00	5,904.94	8.20	7,236.30
CHL	38,435.00	94.30	55.76	26.54	50.50	2,595.85	6.50	6,837.60
COL	86,027.00	94.70	32.80	16.45	80.40	1,335.88	6.00	3,327.50
CRI	6,060.00	91.80	14.72	15.99	70.00	1,622.35	5.20	4,018.60
CZE	69,490.00	100.00	58.23	34.71	63.40	3,805.14	10.30	16,135.10
DNK	14,716.00	100.00	109.56	90.89	71.20	6,384.17	5.40	14,491.70
EST	5,934.10	95.90	56.42	29.69	58.40	2,989.13	7.80	13,549.40
FIN	15,626.00	100.00	98.80	80.17	69.80	4,565.51	7.30	14,322.30
FRA	386,918.00	99.90	63.03	58.36	68.50	5,468.42	9.10	16,060.80
DEU	650,167.00	99.90	87.12	74.00	63.80	7,382.63	8.70	21,859.50
GRC	44,817.00	100.00	167.12	25.22	78.40	2,486.09	7.00	13,607.20
HUN	66,394.00	94.00	47.26	33.25	62.00	2,402.00	10.30	14,674.30
ISL	1,039.00	100.00	100.97	70.77	76.60	5,096.44	5.90	10,608.40
IRL	14,412.00	100.00	70.86	53.41	83.70	5,836.34	5.90	11,424.70
ISR	27,240.00	100.00	41.47	51.84	75.70	3,057.41	6.30	13,600.50
ITA	189,351.00	100.00	128.96	33.63	72.80	4,037.79	8.30	9,312.90
JPN	1,593,572.00	100.00	229.60	69.80	36.60	4,665.64	28.30	13,356.40
KOR	655,888.00	100.00	156.17	45.07	31.50	3,913.74	19.10	15,352.10
LVA	10,045.00	100.00	90.96	26.98	49.70	2,201.91	8.40	13,925.40
LTU	16,802.00	98.80	72.97	34.59	44.30	3,309.03	7.70	15,753.90
LUX	2,652.00	100.00	72.48	78.54	73.50	5,596.38	8.90	15,109.00
MEX	126,449.00	72.40	21.76	9.23	65.50	1,226.74	4.70	2,786.90
NLD	50,777.00	99.90	50.80	87.44	78.00	6,189.72	4.50	7,669.60
NZL	13,635.00	100.00	95.25	58.97	88.00	4,469.38	6.30	14,553.00
NOR	18,281.00	100.00	92.19	112.03	74.50	7,064.76	5.20	15,497.00
POL	234,617.00	94.00	52.00	26.48	61.60	2,567.72	7.20	12,625.90
PRT	36,332.00	100.00	50.20	40.32	51.20	3,816.37	8.30	7,400.00
SVK	31,016.00	94.60	63.75	26.03	65.10	2,134.31	7.30	15,480.20
SVN	8,994.00	100.00	63.07	33.12	67.10	3,497.55	6.80	14,285.50
ESP	139,933.00	100.00	68.81	34.46	73.00	3,718.05	8.70	8,979.50
SWE	21,217.00	100.00	81.90	78.51	76.50	6,262.31	5.40	12,754.50
CHE	38,705.00	100.00	124.91	84.91	83.30	7,178.56	8.20	15,877.20
TUR	251,182.00	98.50	45.95	17.59	69.40	1,304.71	4.20	16,588.10
GBR	157,804.00	100.00	40.02	60.74	72.90	5,387.23	6.60	12,874.20
USA	919,559.00	90.30	217.22	62.56	87.90	12,318.10	4.80	12,549.30
Minimum	1,039.00	72.40	14.72	9.23	31.50	1,226.74	4.20	2,786.90
Median	47,797.00	100.00	71.67	52.63	72.00	4,253.59	7.10	13,755.25
Mean	164,743.90	97.83	85.18	50.43	68.91	4,457.55	7.86	12,788.42
Maximum	1,593,572.00	100.00	229.60	112.03	89.00	12,318.10	28.30	21,859.50

According to Table 3.3.,

- ✓ Iceland has the lowest Capacity (i1) value with 1,039.00, while Japan has the highest Capacity (i1) value with 1,593,572.00;
- ✓ Mexico has the lowest Supply Network (i2) value with 72.40, while Australia, Canada, Czech Republic, Denmark, Finland, Greece, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Luxembourg, New Zealand, Norway, Portugal, Slovenia, Spain, Sweden, Switzerland, Türkiye, and United Kingdom have the highest Supply Network (i2) value with 100.00;
- ✓ Costa Rica has the lowest Process Technology (i3) value with 14.72, while Japan has the highest Process Technology (i3) value with 229.60;
- ✓ Mexico has the lowest Development and Organization (i4) value with 9.23, while Norway has the highest Development and Organization (i4) value with 112.03;
- ✓ Korea has the lowest Quality (o1) value with 31.50, while Canada has the highest Quality (o1) value with 89.00;
- ✓ Mexico has the lowest Cost (o2) (ud) value with 1,226.74 while the United States has the highest Cost (o2) (ud) value with 12,318.10;
- ✓ Türkiye has the lowest Delivery (o3) (ud) value with 4.20, while Japan has the highest Delivery (o3) (ud) value with 28.30;
- ✓ Mexico has the lowest Flexibility (o4) value with 2,786.90, while Germany has the highest Flexibility (o4) value with 21,859.50

3.3. Analysis Design

In complex organisations such as countries, the production process of any goods and/or service involves several stages, and the standard Data Envelopment Analysis (DEA) is a black box model which is not capable of measuring the efficiency of the multi-stage goods and/or service production process (Emrouznejad et al., 2022), a hybrid methodology which includes Data Envelopment Analysis (DEA), the integration of Artificial Neural Network (ANN) and Data Envelopment Analysis (DEA-ANN Model), and Data Envelopment Analysis Matrix (DEAM) was conducted to evaluate the efficiency of the operations strategy matrix in healthcare systems of OECD (38) countries.

The analysis procedure consists of three stages;

- (i) the Data Envelopment Analysis (DEA) stage,
- (ii) the integration of the Artificial Neural Network (ANN) and the Data Envelopment Analysis (DEA-ANN Model) stage,
- (iii) the Data Envelopment Analysis Matrix (DEAM) stage.

In the Data Envelopment Analysis (DEA) stage;

Healthcare production processes are not linear, and thus it may be more appropriate to assume BCC (VRS) model (S. Ahmed et al., 2019; Osei et al., 2005). Besides, since managers have more control over outputs than inputs (Ozcan, 2014), and there are two undesirable (bad) outputs in the dataset, BCC (VRS)-Output Orientation Data Envelopment Analysis (DEA) model was employed in this dissertation.

There are two famous groups of methods for handling undesirable outputs; at the same time, the first of these is based on the translation invariance property in Data Envelopment Analysis (DEA), and the second of these uses the original data but is based on the concept of weak disposable reference technology (Zhou et al., 2016). Within the framework of the first group, Seiford and Zhu (2002) developed a model to incorporate undesirable outputs into the BCC (VRS)-DEA model using the concept of classification invariance (Seiford & Zhu, 2002). This model was applied to handling undesirable outputs.

Upon validation of the dataset through “The Polarity of Input and Output Variables”, “Correlations Input and Output Variables”, and “Multicollinearity Input Variables” techniques, Decision-Making Units (DMUs) were evaluated using pure technical efficiency scores, a reference set was identified for each inefficient Decision-Making Units (DMUs), a Robustness Analysis was conducted, and improvement options for inefficient Decision-Making Units (DMUs) were calculated. In addition to this, fully efficient Decision-Making Units (DMUs) were determined based on efficiency scores and slack values.

All analysis was performed using the deaR package in the R project (Coll-Serrano et al., 2018).

In the DEA-ANN Model stage;

The integrated DEA-ANN Model system is developed through the following steps; Variable Selection, Network Design, Network Application Process and, Prediction of ANN Efficiency Scores (Singh et al., 2018; Tsolas et al., 2020; N. Zhu et al., 2021).

Input and output variables of Data Envelopment Analysis (DEA) are used as inputs, and the efficiency scores of the DMUs are defined as outputs (Tosun, 2012). The network design process involves determining the network architecture, selecting the learning algorithm, and configuring training and testing data sets (Tsolas et al., 2020). After constructing the neural network through the NF Tool in MATLAB, the network is trained using inputs and outputs (Pant, 2020). Lastly, the DEA-ANN model is applied to the test data to predict the ANN Efficiency Score of each OECD (38) country.

Upon conducting all analyses, a number of statistical methods were applied to test the reliability of the DEA-ANN model scores.

All analysis was performed using the NF Tool in MATLAB (MATLAB, 2022), and the reliability tests were conducted using SPSS 28.0 (IBM Corp, 2021).

In the Data Envelopment Analysis Matrix (DEAM) stage;

In this stage, according to the approach presented by Osman et al. (2011) (Osman et al., 2011; Vafaei Najar et al., 2018), while the X (Horizontal) axis represents the relative efficiency score based on the DEA-ANN model, the Y (Vertical) axis represents the relative efficiency score based on Output Oriented DEA-VRS.

Lastly, DMUs (38 OECD countries) were divided into four groups; Super Stars, Potential Stars, Question Marks and To Be Governed Effectively based on Data Envelopment Analysis Matrix (DEAM).

4. RESULTS

Results of the Data Envelopment Analysis Stage, Results of the Artificial Neural Network Stage and Results of the Data Envelopment Analysis Matrix Stage are presented in this section.

4.1. Results of Data Envelopment Analysis (DEA) Stage

Validation of the dataset, Pure Technical Efficiency Scores, References Set of the Inefficient States, Robustness Analysis and Improvement Options for Inefficient DMUs are presented as follows.

4.1.1. Validation of Dataset

To validate the dataset, three pre-analysis techniques have been conducted respectively; The Polarity of Input and Output Variables, Correlations Input and Output Variables and Multicollinearity Input Variables.

4.1.1.1. The Polarity of Input and Output Variables

According to the polarity approach, all the inputs are considered “good” when they are numerically smaller, and conversely, all the outputs are considered “good” when they are numerically more extraordinary; in other words, all input and output variables’ values should reflect the same directional interpretation, such as, values of greater magnitude are better than smaller values or conversely, smaller values indicate better results than larger values (Agrell et al., 2000; Baker, 2011; Frontier Analyst, 2022).

Except for output variables Cost (o2) and Delivery (o3), which are undesirable outputs, the remaining input and output variables were all based on the concept that “*larger is better*”.

Undesirable outputs were evaluated according to the model proposed by Seiford and Zhu (2002); thus, these two output variables were all based on the concept that “*smaller is better*” (Seiford & Zhu, 2002).

4.1.1.2. Correlations Input and Output Variables

100% relative efficiency is reached by any DMU only when comparisons with other relevant DMUs do not provide evidence of inefficiency in using any input variables or output variables (Charnes et al., 1984).

According to (Bowlin, 1998; Castañeda & Mauricio, 2020; Chung et al., 2008; DEAzone.com, 2011; Golany & Roll, 1989; Thanassoulis, 2001), the requirement that the relationship between inputs and outputs is not erratic is called the property of isotonicity. In other words, increasing one input variable must improve each of the outputs. Therefore, increasing the value of any input while keeping other factors constant should not decrease any output but instead lead to an increase in the value of at least one output. Correlation analysis should be performed to ensure positive relationships between inputs and outputs to determine if this isotonicity property exists between the selected input and output variables. If the input variable coefficient from the correlation analysis is positive and significant, then there is support that the isotonicity assumption is not violated. On the other hand, when two factors are positively correlated, the changes of one element can be reflected by the changes of the other factor ultimately.

The Pearson correlation matrix between input and output variables (n=38) is presented in Table 4.1.

Table 4. 1: Pearson Correlation Matrix Between Input Variables and Output Variables

	i1	i2	i3	i4	o1	o2	o3	o4
i1	1							
i2	-.037	1						
i3	.643**	.244	1					
i4	.117	.464**	.368*	1				
o1	-.365*	.045	-.059	.295	1			
o2	.303	.268	.523**	.763**	.402*	1		
o3	.735**	.200	.497**	.041	-.641**	-.038	1	
o4	.155	.496**	.341*	.379*	-.080	.345*	.182	1

**Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed).

According to the correlation matrix shown in Table 4.1., it can be concluded that the property of isotonicity on the condition of using the DEA-BCC model is satisfied.

Table 4.1. demonstrates that most of the coefficients are statistically significant. This means a significant positive correlation between input and output indicators. Namely, it can thus be concluded that the inputs and outputs used in this study have “isotonicity” relationships. So it is feasible to use the Data Envelopment Analysis (DEA) method to measure the efficiency of OECD (38) countries (Golany & Roll, 1989; Y.-C. Wu et al., 2016; N. Zhu et al., 2021).

4.1.1.3. Multicollinearity Input Variables

Multicollinearity is a severe consideration in Data Envelopment Analysis (DEA). It appears when two or more input variables are highly correlated, indicating that they are not independent of each other and, therefore, are essentially contributing the same resource to the outputs. When this appears, the researcher should omit one of the correlated variables from the model (Baker, 2011; Saen et al., 2005).

Multicollinearity was assessed by examining the Pearson correlation coefficients between each input variable. According to Saen et al. (2005), while in the CCR (CRS) Model, if the correlation coefficient between two input vectors is 0.96 and above 0.96, one of the input vectors could be omitted, in the BCC (VRS) Model, if the correlation coefficient between two input vectors is 0.94 and above 0.94, one of the input vectors could be omitted (Saen et al., 2005).

Since the BCC (VRS) Model was used in our study, $r = 0.94$ is considered the cut-off point to determine multicollinearity concerning performing Data Envelopment Analysis (DEA). The Pearson correlation matrix between input variables ($n=38$) is presented in Table 4. 2.

Table 4. 2: Pearson Correlation Matrix Between Input Variables

	i1	i2	i3	i4
i1	1	-.037	.643**	.117
i2	-.037	1	.244	.464**
i3	.643**	.244	1	.368*
i4	.117	.464**	.368*	1

**Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed).

In this dissertation's dataset, the largest correlation ($r = 0.643$) occurred between the input variables Capacity (i1) and Supply Network (i3). This means none of the correlations between input variables exceeded the BCC (VRS) threshold. Consequently, all input variables remained in the dataset, ensuring the integrity of the study.

4.1.2. Pure Technical Efficiency Scores

BCC (VRS)-Output Orientation DEA model is employed, and pure technical efficiency scores of OECD (38) countries are shown in Table 4.3.

Table 4. 3: Pure Technical Efficiency Scores

DMU	Efficiency Score	State of Efficiency
Australia	1.000000	Efficient
Austria	1.000000	Efficient
Belgium	1.030200	Inefficient
Canada	1.000000	Efficient
Chile	1.056850	Inefficient
Colombia	1.000000	Efficient
Costa Rica	1.000000	Efficient
Czech Republic	1.000000	Efficient
Denmark	1.000000	Efficient
Estonia	1.000000	Efficient
Finland	1.037570	Inefficient
France	1.065100	Inefficient
Germany	1.000000	Efficient
Greece	1.000000	Efficient
Hungary	1.000000	Efficient
Iceland	1.000000	Efficient
Ireland	1.000000	Efficient
Israel	1.000000	Efficient
Italy	1.117720	Inefficient
Japan	1.307420	Inefficient
Korea	1.154530	Inefficient
Latvia	1.000000	Efficient
Lithuania	1.000000	Efficient
Luxembourg	1.000000	Efficient
Mexico	1.000000	Efficient
Netherlands	1.000000	Efficient
New Zealand	1.000000	Efficient
Norway	1.000000	Efficient
Poland	1.122240	Inefficient
Portugal	1.144140	Inefficient
Slovak Republic	1.000000	Efficient

Table 4.3: (continued)

Slovenia	1.000000	Efficient
Spain	1.123050	Inefficient
Sweden	1.001320	Inefficient
Switzerland	1.018420	Inefficient
Türkiye	1.000000	Efficient
United Kingdom	1.025130	Inefficient
United States	1.000000	Efficient
Mean	1.031676	
Median	1.000000	
Minimum	1.000000	
Maximum	1.307420	
Standard Deviation	0.064879	

According to Table 4.3.,

Australia, Austria, Canada, Colombia, Costa Rica, Czech Republic, Denmark, Estonia, Germany, Greece, Hungary, Iceland, Ireland, Israel, Latvia, Lithuania, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Slovak Republic, Slovenia, Türkiye and United States have a score of 1, and they are relatively efficient.

However, Belgium, Chile, Finland, France, Italy, Japan, Korea, Poland, Portugal, Spain, Sweden, Switzerland and the United Kingdom have scores greater than 1; thus, they are identified as inefficient in the output-oriented model.

Additionally, based on efficiency scores and slack values while Austria, Costa Rica, Germany, Greece and the United States are fully efficient DMU; Australia, Canada, Colombia, Czech Republic, Denmark, Estonia, Hungary, Iceland, Ireland, Israel, Latvia, Lithuania, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Slovak Republic, Slovenia and, Türkiye are weakly efficient DMU.



Figure 4. 1: Efficiency Distribution

As depicted in Figure 4.1., 25 of 38 DMUs are efficient, while 13 of 38 DMUs are inefficient.

4.1.3. References Set of the Inefficient States

Data Envelopment Analysis (DEA) uses multiple outputs and multiple inputs to project how inefficient Decision-Making Units (DMUs) can become more efficient by identifying the best practices set (Ozcan, 2009, 2014), this identified set is called the reference set of the inefficient Decision-Making Unit (DMU), and each element is referred as a reference Decision-Making Unit (DMU) (Mehdiloozad & Sahoo, 2016).

The frequency of efficient Decision-Making Units (DMUs) in the reference set, also known as peer count, represents the robustness of that DMU compared with other efficient Decision-Making Units (DMUs) (Agarwal et al., 2014).

As depicted in Table 4.4., based on (Ozcan, 2009, 2014), a reference set, also known as best practices, was identified for each inefficient Decision-Making Unit (DMU) to become efficient.

Table 4. 4: References Set of Inefficient States

DMU	AUST	AUT	COL	CRI	DNK	DEU	GRC	ISR	LTU	MEX	NLD	NZL	NOR	SVK	SVN	TUR
Belgium	0.6534	0	0	0.1956	0.0769	0	0	0	0	0	0	0	0	0	0.0741	0
Chile	0	0	0	0.7134	0	0	0	0.1123	0	0	0	0	0.0547	0	0	0.1196
Finland	0	0	0	0	0	0	0	0	0.0664	0	0	0.2694	0.2	0.1365	0.3277	0
France	0	0.3822	0	0	0	0	0	0.2859	0	0	0	0	0	0	0	0.3319
Italy	0	0	0.3988	0	0	0	0.0302	0	0	0	0	0.393	0	0	0	0.1779
Japan	0	0	0	0	0	0.1659	0	0	0	0	0	0	0	0	0	0.8341
Korea	0	0	0	0	0	0.2156	0	0	0	0	0	0	0	0	0	0.7844
Poland	0.0094	0	0	0	0	0	0	0	0	0.1738	0	0.014	0	0	0	0.8029
Portugal	0	0	0	0.5959	0	0	0	0.1597	0	0	0	0	0.1418	0	0	0.1026
Spain	0	0	0.4133	0	0	0	0.0719	0	0	0	0	0.3973	0	0	0	0.1175
Sweden	0.0739	0	0	0.2183	0	0	0	0	0	0	0.0263	0.1631	0.5185	0	0	0
Switzerland	0.201	0.1859	0	0	0	0	0	0	0	0	0	0.6131	0	0	0	0
United Kingdom	0	0	0.0015	0.0692	0	0	0	0.837	0	0	0	0	0	0	0	0.0923

According to Table 4.4.,

- ✓ The reference set of Belgium consists of Australia ($\lambda=0.6534$), Costa Rica ($\lambda=0.1956$), Denmark ($\lambda=0.0769$), and Slovenia ($\lambda=0.0741$).
- ✓ The reference set of Chile consists of Costa Rica ($\lambda=0.7134$), Israel ($\lambda=0.1123$), Norway ($\lambda=0.0547$), and Türkiye ($\lambda=0.1196$).
- ✓ The reference set of Finland consists of Lithuania ($\lambda=0.0664$), New Zealand ($\lambda=0.2694$), Norway ($\lambda=0.2$), Slovak Republic ($\lambda=0.1365$), and Slovenia ($\lambda=0.3277$).
- ✓ The reference set of France consists of Austria ($\lambda=0.3822$), Israel ($\lambda=0.2859$), and Türkiye ($\lambda=0.3319$).
- ✓ The reference set of Italy consists of DMU6 ($\lambda=0.3988$), DMU14 ($\lambda=0.0302$), New Zealand ($\lambda=0.393$), and Türkiye ($\lambda=0.1779$).
- ✓ The reference set of Japan consists of Germany ($\lambda=0.1659$) and Türkiye ($\lambda=0.8341$).
- ✓ The reference set of Korea consists of Germany ($\lambda=0.2156$) and Türkiye ($\lambda=0.7844$).
- ✓ The reference set of Poland consists of Australia ($\lambda=0.0094$), Mexico ($\lambda=0.1738$), New Zealand ($\lambda=0.014$), and Türkiye ($\lambda=0.8029$).
- ✓ The reference set of Portugal consists of Costa Rica ($\lambda=0.5959$), Israel ($\lambda=0.1597$), Norway ($\lambda=0.1418$), and Türkiye ($\lambda=0.1026$).
- ✓ The reference set of Spain consists of Colombia ($\lambda=0.4133$), Greece ($\lambda=0.0719$), New Zealand ($\lambda=0.3973$), and Türkiye ($\lambda=0.1175$).
- ✓ The reference set of Sweden consists of Australia ($\lambda=0.0739$), Costa Rica ($\lambda=0.2183$), Netherlands ($\lambda=0.0263$), New Zealand ($\lambda=0.1631$), and Norway ($\lambda=0.5185$).
- ✓ The reference set of Switzerland consists of Australia ($\lambda=0.201$), Austria ($\lambda=0.1859$), and New Zealand ($\lambda=0.6131$).
- ✓ The reference set of the United Kingdom consists of Colombia ($\lambda=0.0015$), Costa Rica ($\lambda=0.0692$), Israel ($\lambda=0.837$), and Türkiye ($\lambda=0.0923$).

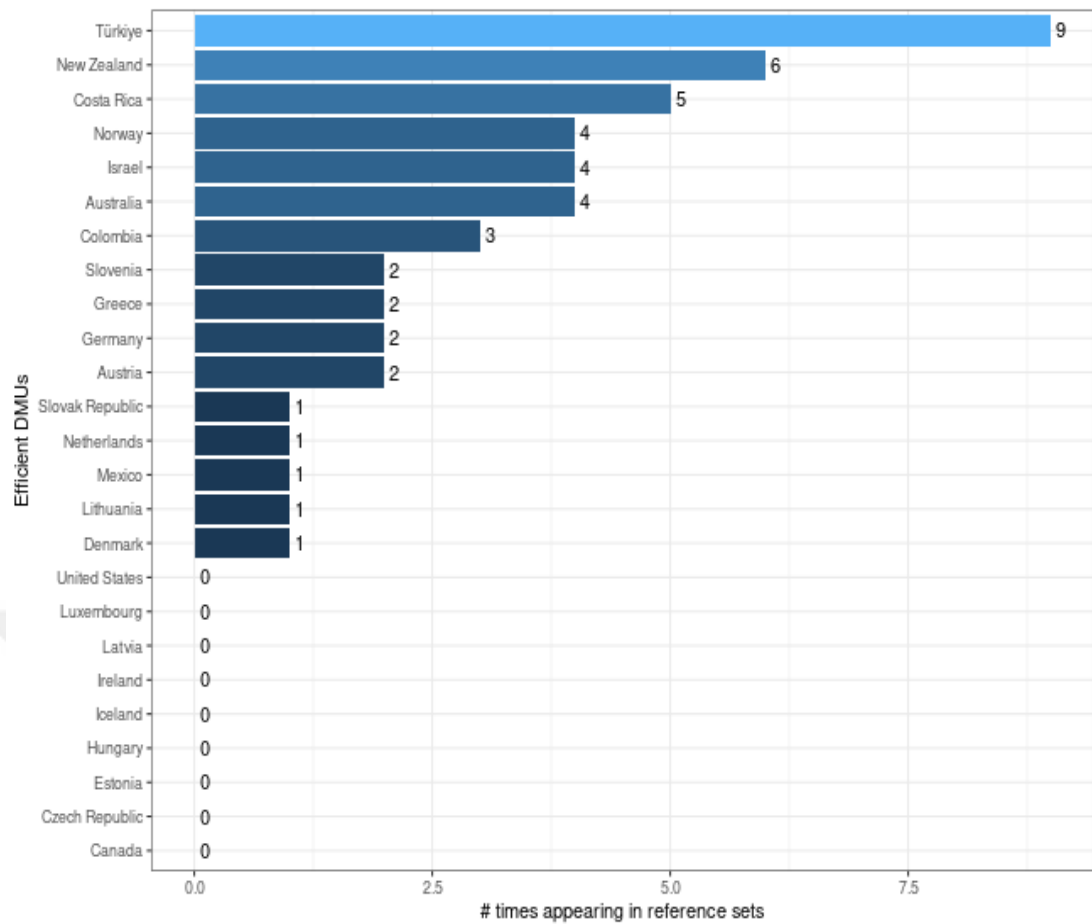


Figure 4. 2: Reference (Peer) Counts

According to Figure 4.2.; Türkiye is the most appeared Decision-Making Unit (DMU) in the reference sets with 9 (nine) peer counts. Türkiye is followed by New Zealand (6 peer counts) and Costa Rica (5 peer counts). Norway, Israel and Australia have the same peer counts with 4 (four), and Colombia has appeared 3 (three) times in the reference sets.

While Slovenia, Greece, Germany and Austria have the same peer counts with 2, Slovak Republic, Netherlands, Mexico, Lithuania, and Denmark have the same peer counts with 1.

Besides, although the United States, Luxembourg, Latvia, Ireland, Iceland, Hungary, Estonia, Czech Republic and Canada are efficient, they have not appeared in the reference sets.

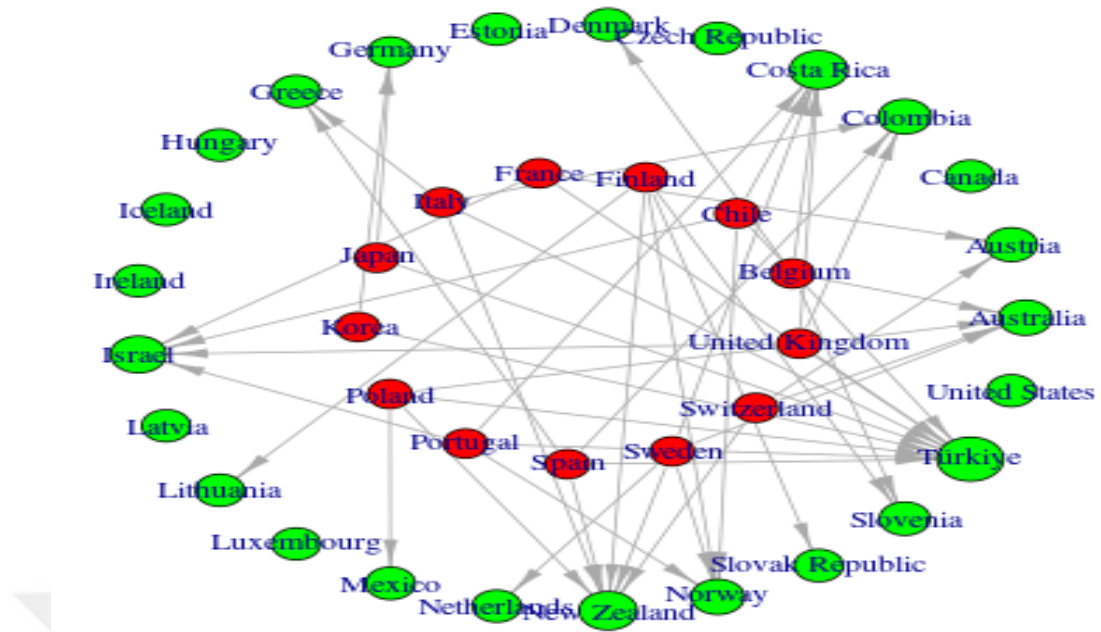


Figure 4. 3: Network Graph

In Figure 4.3., a network graph is depicted in which the green circles represent the efficient Decision-Making Units (DMUs), and the red circles are the inefficient DMUs. This graph demonstrates how inefficient Decision-Making Units (DMUs) are related to efficient peers, conveying the efficient DMUs from the efficient frontier. In addition, it is notable that not all green circles have the same size. In this case, the size of the circle aims to convey the idea of how important is the efficient Decision-Making Unit (DMU) for the set of inefficient DMUs (Benítez et al., 2021; Coll-Serrano et al., 2018).

4.1.4. Robustness Analysis

Since Data Envelopment Analysis is a non-parametric technique, determining the robustness of the efficiency scores obtained with Data Envelopment Analysis is quite difficult. For this reason, a Robustness Analysis, also known as Sensitivity Analysis or Stability Analysis, should be conducted (Agarwal et al., 2014). Hereafter, Robustness Analysis, Sensitivity Analysis and Stability Analysis will be used synonymously.

In recent years, the issue of Robustness of Data Envelopment Analysis (DEA) results has been extensively discussed and studied in the literature (J. Zhu, 2001). Robustness Analysis is used to know how sensitive the solution values and efficiency

scores of the DMUs are to the numerical observations (Agarwal et al., 2014). There are two parts of studies about Robustness Analysis in the literature; one part of the literature focuses on deleting DMU(s) from the reference set, and another part of the literature deals with increasing or decreasing the number of inputs and outputs (Cooper, Li, et al., 2011).

The model proposed by Agarwal et al. (2014) was applied for sensitivity analysis to this dissertation's dataset (Agarwal et al., 2014).

The results are presented in Table 4.5.

Table 4. 5: Results of the Robustness Analysis

DMU	Efficiency Score	Efficient DMUs		Increment in Efficiency Score		
		Türkiye	New Zealand	Türkiye	New Zealand	Mean
Australia	1.000000	1.000000	1.000000	0.000000	0.000000	0.000000
Austria	1.000000	1.000000	1.000000	0.000000	0.000000	0.000000
Belgium	1.030200	1.030200	1.030200	0.000000	0.000000	0.000000
Canada	1.000000	1.000000	1.000000	0.000000	0.000000	0.000000
Chile	1.056850	1.046820	1.056850	-0.010030	0.000000	-0.005015
Colombia	1.000000	1.000000	1.000000	0.000000	0.000000	0.000000
Costa Rica	1.000000	1.000000	1.000000	0.000000	0.000000	0.000000
Czech Republic	1.000000	1.000000	1.000000	0.000000	0.000000	0.000000
Denmark	1.000000	1.000000	1.000000	0.000000	0.000000	0.000000
Estonia	1.000000	1.000000	1.000000	0.000000	0.000000	0.000000
Finland	1.037570	1.037570	1.023060	0.000000	-0.014510	-0.007255
France	1.065100	1.055050	1.065100	-0.010050	0.000000	-0.005025
Germany	1.000000	1.000000	1.000000	0.000000	0.000000	0.000000
Greece	1.000000	1.000000	1.000000	0.000000	0.000000	0.000000
Hungary	1.000000	1.000000	1.000000	0.000000	0.000000	0.000000
Iceland	1.000000	1.000000	1.000000	0.000000	0.000000	0.000000
Ireland	1.000000	1.000000	1.000000	0.000000	0.000000	0.000000
Israel	1.000000	1.000000	1.000000	0.000000	0.000000	0.000000
Italy	1.117720	1.108290	1.112130	-0.009430	-0.005590	-0.007510
Japan	1.307420	1.229520	1.307420	-0.077900	0.000000	-0.038950
Korea	1.154530	1.089600	1.154530	-0.064930	0.000000	-0.032465
Latvia	1.000000	1.000000	1.000000	0.000000	0.000000	0.000000
Lithuania	1.000000	1.000000	1.000000	0.000000	0.000000	0.000000
Luxembourg	1.000000	1.000000	1.000000	0.000000	0.000000	0.000000
Mexico	1.000000	1.000000	1.000000	0.000000	0.000000	0.000000
Netherlands	1.000000	1.000000	1.000000	0.000000	0.000000	0.000000
New Zealand	1.000000	1.000000	0.897550	0.000000	-0.102450	-0.051225
Norway	1.000000	1.000000	1.000000	0.000000	0.000000	0.000000
Poland	1.122240	1.021270	1.121790	-0.100970	-0.000450	-0.050710
Portugal	1.144140	1.137850	1.144140	-0.006290	0.000000	-0.003145

Table 4. 5: (continued)

Slovak Republic	1.000000	1.000000	1.000000	0.000000	0.000000	0.000000
Slovenia	1.000000	1.000000	1.000000	0.000000	0.000000	0.000000
Spain	1.123050	1.108540	1.103130	-0.014510	-0.019920	-0.017215
Sweden	1.001320	1.001320	1.001170	0.000000	-0.000150	-0.000075
Switzerland	1.018420	1.018420	1.000000	0.000000	-0.018420	-0.009210
Türkiye	1.000000	0.548790	1.000000	-0.451210	0.000000	-0.225605
United Kingdom	1.025130	1.015870	1.025130	-0.009260	0.000000	-0.004630
United States	1.000000	1.000000	1.000000	0.000000	0.000000	0.000000

Table 4.5. presents the result of the robustness analysis by changing the reference set of the inefficient regions. According to Figure 4.2., Türkiye and New Zealand are the DMUs that appear the most in the reference sets 9 and 6 times, respectively. So, we exclude these DMUs one by one from the set countries by the above-stated sensitivity model. These results indicate that efficiency scores are robust and stable because removing any efficient DMUs from the set does not significantly influence the mean pure technical efficiency. The results show that both Türkiye and New Zealand are not outliers.

Besides, the results of Table 4.5. show that Switzerland becomes efficient after New Zealand is excluded from their reference sets. This reveals that Switzerland has a structure similar to New Zealand; it becomes inefficient due to the existence of New Zealand. Türkiye and New Zealand considerably influence the efficiency of many inefficient DMUs.

These results indicate the robustness of the peer counts and the pure efficiency scores.

The sensitivity can be observed in the efficiency scores of the inefficient countries in Table 4.5. According to these results, the inefficient countries are classified as follows;

- ✓ ***Insensitive Countries:*** Belgium is an insensitive inefficient country as it has a difference between the actual pure technical efficient scores and an average of the results of the sensitivity model (i.e., excluding efficient countries one by one) ranging from 0.00 to 0.00.

- ✓ **Low-Sensitive Countries:** Sweden is a low-sensitive inefficient country as it has a difference between the actual pure technical efficient scores and an average of the results of the sensitivity model (i.e., excluding efficient countries one by one) ranging from 0.000075 to 0.000075.
- ✓ **Medium-Sensitive Countries:** Portugal, United Kingdom, Chile, France, Finland, Italy and Switzerland are medium-sensitive inefficient countries as they have a difference between the actual pure technical efficient scores and an average of the results of the sensitivity model (i.e., excluding efficient countries one by one) ranging from 0.003145 to 0.009210.
- ✓ **Highly Sensitive Countries:** Spain, Korea, Japan and Poland are highly sensitive inefficient countries as they have a difference between the actual pure technical efficient scores and an average of the results of the sensitivity model (i.e., excluding efficient countries one by one) ranging from 0.017215 to 0.050710.

Table 4.5. also presents the super efficiency scores of Türkiye and New Zealand. The super-efficiency of Türkiye and New Zealand are 0.548790 and 0.897550, respectively.

4.1.5. Improvement Options for Inefficient Decision-Making Units

Reference Decision-Making Unit (DMU) on the efficient frontier determines the potential improvements or projections for the various inefficient units not on the frontier (Avkiran & Zhu, 2016).

Since the projections are based on the revealed best practices (reference set) performance, the improvement options of each input and output are indicative of inefficient Decision-Making Units (DMUs) becoming efficient and located on the efficient frontier (Charnes et al., 1994).

Improvement options for inefficient countries are shown in Table 4.6.

Table 4. 6: Improvement Options for Inefficient Decision-Making Units (DMUs)

DMU	i1	i2	i3	i4	o1	o2	o3	o4
BEL	0.00	-0.20	-14.89	0.00	4.41	-529.91	-0.70	419.91
CHL	0.00	-0.33	-30.06	-1.08	20.31	-552.73	-1.30	388.70
FIN	0.00	-0.82	-20.49	-25.18	2.62	-291.34	-0.83	538.16
FRA	-271,739.16	-0.44	0.00	-17.23	4.46	-1,603.03	-2.66	1,045.59
ITA	-103,642.47	-2.38	-65.22	0.00	8.57	-1,441.10	-2.47	1,096.30
JPN	-1,276,213.16	-1.27	-176.82	-42.85	31.87	-2,352.83	-23.35	4,106.03
KOR	-318,699.80	-1.20	-101.35	-15.32	36.69	-1,298.86	-13.93	2,372.32
POL	-9,903.67	0.00	-8.71	-9.29	7.53	-1,191.96	-2.87	1,543.33
PRT	0.00	-5.04	-17.02	-4.82	20.29	-1,225.59	-3.03	1,066.65
ESP	-66,215.87	-2.37	0.00	-0.35	8.98	-1,058.35	-2.72	1,104.91
SWE	0.00	-1.79	-3.88	0.00	0.10	-938.21	-0.03	16.89
CHE	0.00	-0.02	-21.44	-25.13	1.53	-2,063.01	-1.69	292.50
GBR	-111,271.30	-0.71	0.00	-14.59	1.83	-2,593.48	-0.57	323.47

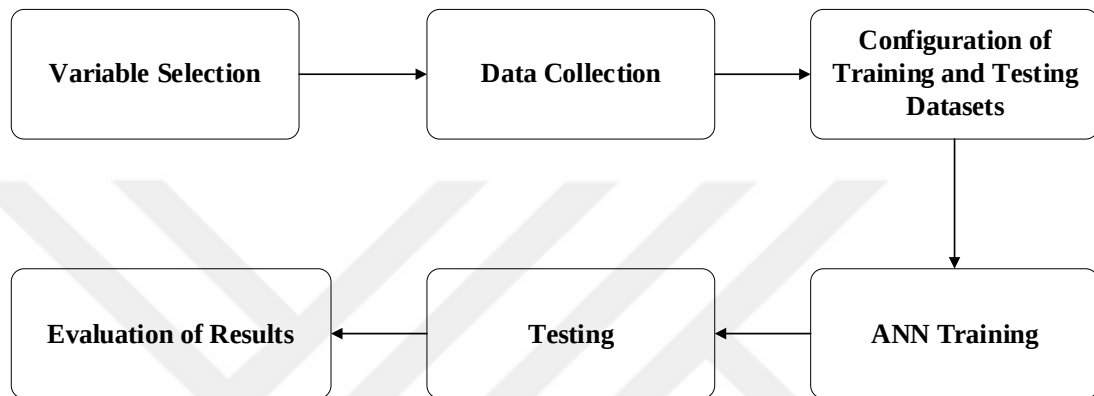
According to Table 4.6.,

- ✓ The Decision-Making Unit (DMU) that needs the most improvement in terms of Capacity (i1), Process Technology (i3), Development and Organization (i4), Delivery (o3) (ud), and Flexibility (o4) is Japan.
- ✓ The Decision-Making Unit (DMU) that needs the most improvement in terms of Supply Network (i2) is Portugal.
- ✓ The Decision-Making Unit (DMU) that needs the most improvement in terms of Quality (o1) is Korea.
- ✓ The Decision-Making Unit (DMU) that needs the most improvement in terms of Cost (o2) (ud) is the United Kingdom.

4.2. Results of DEA-ANN Model Stage

The integrated DEA-ANN Model system is developed through the following steps; Variable Selection, Network Design, Network Application Process and Prediction of ANN Efficiency Scores (Singh et al., 2018; Tsolas et al., 2020; N. Zhu et al., 2021).

The DEA-ANN system design utilized in this study is depicted in Figure 4.4.



Source: (Tsolas et al., 2020)

Figure 4. 4: The DEA-ANN Model System

In this step, ANN efficiency scores are predicted based on inputs, outputs, and Data Envelopment Analysis (DEA) efficiency scores of OECD countries using the MATLAB Deep Learning Toolbox (MATLAB, 2022).

4.2.1. Variable Selection

In the DEA-ANN system, input and output variables of Data Envelopment Analysis (DEA) are used as inputs, and the efficiency scores of the DMUs are defined as outputs (Tosun, 2012). In other words, while ANN inputs correspond to variables that can be used to conduct Data Envelopment Analysis (i.e., inputs and outputs of DEA), ANN outputs correspond to the value that should be predicted (i.e., *Data Envelopment Analysis efficiency scores*) (Emrouznejad & Shale, 2009). Namely, the DEA efficiency is the target variable, and the input and output indicators of the DEA model are feature variables (N. Zhu et al., 2021).

However, since efficiency scores in the BCC Output-Orientation DEA model range from 1 to infinite, BCC Output-Orientation Efficiency Scores are transformed

to the 0 - 1 range. The transformation process is conducted using the below formula (Ozcan, 2014).

$$\textit{Transformed Efficiency Scores} = \frac{1}{\textit{BCC DEA Scores}} \quad (4.1)$$

Inputs and output are explained in detail in Section 3.2. and database of DEA-ANN are presented in Table 4.7.;



Table 4. 7: DEA-ANN Database

DMUs	DEE-ANN Inputs								DE-ANN Output
	x1	x2	x3	x4	x5	x6	x7	x8	y1
Australia	92,826.00	100.00	137.31	68.00	85.20	5,627.32	5.30	17,392.80	1.000000
Austria	62,873.00	99.90	93.99	53.56	74.00	6,693.31	8.50	20,179.20	1.000000
Belgium	63,634.00	98.60	120.58	57.00	75.40	5,274.09	6.10	13,903.30	0.970685
Canada	96,849.00	100.00	61.73	55.48	89.00	5,904.94	8.20	7,236.30	1.000000
Chile	38,435.00	94.30	55.76	26.54	50.50	2,595.85	6.50	6,837.60	0.946208
Colombia	86,027.00	94.70	32.80	16.45	80.40	1,335.88	6.00	3,327.50	1.000000
Costa Rica	6,060.00	91.80	14.72	15.99	70.00	1,622.35	5.20	4,018.60	1.000000
Czech Republic	69,490.00	100.00	58.23	34.71	63.40	3,805.14	10.30	16,135.10	1.000000
Denmark	14,716.00	100.00	109.56	90.89	71.20	6,384.17	5.40	14,491.70	1.000000
Estonia	5,934.10	95.90	56.42	29.69	58.40	2,989.13	7.80	13,549.40	1.000000
Finland	15,626.00	100.00	98.80	80.17	69.80	4,565.51	7.30	14,322.30	0.963790
France	386,918.00	99.90	63.03	58.36	68.50	5,468.42	9.10	16,060.80	0.938879
Germany	650,167.00	99.90	87.12	74.00	63.80	7,382.63	8.70	21,859.50	1.000000
Greece	44,817.00	100.00	167.12	25.22	78.40	2,486.09	7.00	13,607.20	1.000000
Hungary	66,394.00	94.00	47.26	33.25	62.00	2,402.00	10.30	14,674.30	1.000000
Iceland	1,039.00	100.00	100.97	70.77	76.60	5,096.44	5.90	10,608.40	1.000000
Ireland	14,412.00	100.00	70.86	53.41	83.70	5,836.34	5.90	11,424.70	1.000000
Israel	27,240.00	100.00	41.47	51.84	75.70	3,057.41	6.30	13,600.50	1.000000
Italy	189,351.00	100.00	128.96	33.63	72.80	4,037.79	8.30	9,312.90	0.894678
Japan	1,593,572.00	100.00	229.60	69.80	36.60	4,665.64	28.30	13,356.40	0.764865
Korea	655,888.00	100.00	156.17	45.07	31.50	3,913.74	19.10	15,352.10	0.866153
Latvia	10,045.00	100.00	90.96	26.98	49.70	2,201.91	8.40	13,925.40	1.000000
Lithuania	16,802.00	98.80	72.97	34.59	44.30	3,309.03	7.70	15,753.90	1.000000

Table 4. 7: (continued)

Luxembourg	2,652.00	100.00	72.48	78.54	73.50	5,596.38	8.90	15,109.00	1.000000
Mexico	126,449.00	72.40	21.76	9.23	65.50	1,226.74	4.70	2,786.90	1.000000
Netherlands	50,777.00	99.90	50.80	87.44	78.00	6,189.72	4.50	7,669.60	1.000000
New Zealand	13,635.00	100.00	95.25	58.97	88.00	4,469.38	6.30	14,553.00	1.000000
Norway	18,281.00	100.00	92.19	112.03	74.50	7,064.76	5.20	15,497.00	1.000000
Poland	234,617.00	94.00	52.00	26.48	61.60	2,567.72	7.20	12,625.90	0.891075
Portugal	36,332.00	100.00	50.20	40.32	51.20	3,816.37	8.30	7,400.00	0.874019
Slovak Republic	31,016.00	94.60	63.75	26.03	65.10	2,134.31	7.30	15,480.20	1.000000
Slovenia	8,994.00	100.00	63.07	33.12	67.10	3,497.55	6.80	14,285.50	1.000000
Spain	139,933.00	100.00	68.81	34.46	73.00	3,718.05	8.70	8,979.50	0.890432
Sweden	21,217.00	100.00	81.90	78.51	76.50	6,262.31	5.40	12,754.50	0.998682
Switzerland	38,705.00	100.00	124.91	84.91	83.30	7,178.56	8.20	15,877.20	0.981913
Türkiye	251,182.00	98.50	45.95	17.59	69.40	1,304.71	4.20	16,588.10	1.000000
United Kingdom	157,804.00	100.00	40.02	60.74	72.90	5,387.23	6.60	12,874.20	0.975486
United States	919,559.00	90.30	217.22	62.56	87.90	12,318.10	4.80	12,549.30	1.000000
Minimum	<i>1,039.00</i>	<i>72.40</i>	<i>14.72</i>	<i>9.23</i>	<i>31.50</i>	<i>1,226.74</i>	<i>4.20</i>	<i>2,786.90</i>	<i>0.764865</i>
Median	<i>47,797.00</i>	<i>100.00</i>	<i>71.67</i>	<i>52.63</i>	<i>72.00</i>	<i>4,253.59</i>	<i>7.10</i>	<i>13,755.25</i>	<i>1.000000</i>
Mean	<i>164,743.90</i>	<i>97.83</i>	<i>85.18</i>	<i>50.43</i>	<i>68.91</i>	<i>4,457.55</i>	<i>7.86</i>	<i>12,788.42</i>	<i>0.972549</i>
Maximum	<i>1,593,572.00</i>	<i>100.00</i>	<i>229.60</i>	<i>112.03</i>	<i>89.00</i>	<i>12,318.10</i>	<i>28.30</i>	<i>21,859.50</i>	<i>1.000000</i>

4.2.2. Network Design

According to (Jumabaeva, 2011; G. Zhang et al., 1998), during the network design process, the most critical decision is to determine the appropriate architecture. In other words, choosing the number of layers, the number of processing elements in every layer and the number of synapses connected to each node. Other network design decisions involve selecting the appropriate activation function of the hidden and output nodes, the training algorithm, data transformation and normalization methods, training and testing sets, and performance measures.

Since the network design process deals with determining the network architecture, selecting the learning algorithm, and configuring training and testing data sets (Tsolas et al., 2020), these steps are presented as follows.

4.2.2.1. Network Architecture

A multi-layer perceptron (MLP) model is preferred due to its simple architecture and algorithm and its proven success in solving approximation problems (Çelebi & Bayraktar, 2008). An MLP network is divided into three components: the input layer, one or more hidden layers, and an output layer which refers to the desired output of the system (Tsolas et al., 2020).

In principle, before training begins in any Neural Network, the user must decide on the network topology by specifying the number of variables in the input layer, the number of hidden layers (if more than one), the number of variables in each hidden layers and the number of variables in the output layer (Emrouznejad & Shale, 2009), because the successful application of the MLP to any problem is related to the network architecture (Tsolas et al., 2020).

Although there are no clear rules as to the “best” number of hidden layer units, and network design is a trial-and-error process and may affect the accuracy of the resulting trained DEA-ANN (Emrouznejad & Shale, 2009; Tosun, 2012), the relevant theory states that networks with a single hidden layer only can provide more accurate results (Çelebi & Bayraktar, 2008; Tsolas et al., 2020).

The MLP structure to construct the prediction model and its input layer, hidden layer, and output layer are as follows (Tsolas et al., 2020);

The input layer includes six input values, which are the four inputs (*Capacity, Supply Network, Process Technology, Development and Organization*) and the four outputs (*Quality, Cost, Delivery, and Flexibility*) of the DEA model; and the DEA-transformed efficiency scores; the hidden layer consists of a hidden layer; the output layer includes one output value, which predicts the DEA scores in the 0-1 range.

Hence, there are 8 (eight) neurons in the input layer and one in the output layer.

4.2.2.2. Learning Algorithm

After choosing the architecture of the MLP, the connection weights of the network are estimated through a training procedure based on the selected training dataset. The Levenberg–Marquardt (LM), a famous Backpropagation (BP) algorithm, was preferred as the learning algorithm for training MLP due to its high level of accuracy and low complexity (Tsolas et al., 2020). The process of the Backpropagation (BP) algorithm is explained in detail in Section 2.4.

4.2.2.3. Configuration of the Training and Testing Dataset

The objective of the neural network is to detect the hidden relationship in the data and to perform the nonlinear mapping between input and output variables, known as the training of the network (Jumabaeva, 2011).

Networks are sensitive to the number of neurons in their hidden layers; while too few neurons can lead to underfitting, too many neurons could lead to overfitting (Beale et al., 2022).

The equation below was used to determine the optimum number of neurons in the hidden layer (Doig, 1999).

$$N_{hid} = \frac{\frac{1}{2}(N_{input} + N_{output}) + \sqrt{N_{cases}}}{N_{slabs}} \quad (4.2)$$

According to this equation, the optimum number of neurons in the hidden layer was calculated as “4”.

The accuracy of the neural network systems is assessed by observing the values of the average Mean Square Error, shortly MSE (Çelebi & Bayraktar, 2008). Therefore, the performance of the network is measured in terms of Mean Square Error which is defined by the equation below (M. S. Ahmed, 2016; G. Zhang et al., 1998).

$$MSE = \frac{1}{n} \sum_{j=1}^n (O_t - O_p)^2 \quad (4.3)$$

where;

O_t = is the target outputs,

O_p = is the predicted outputs,

n = is the number of data

MSE = indicates the difference between the ANN output value and the desired value.

Training is stopped at the iteration where the MSE for the validation data is minimised since this represents the point in training where the network is best able to generalise (Athanasopoulos & Curram, 1996).

Finally, the best network with the three-layer network is seen in Figure 4.5., where 8 (eight) neurons are in the input layer, 4 (four) neurons are in the hidden layer, and 1 (one) neuron is in the output layer.

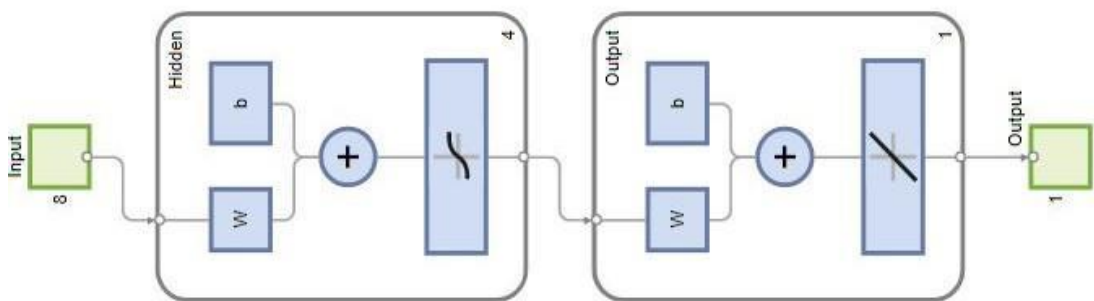


Figure 4. 5: Designed Neural Network

4.2.3. Network Application Process

After constructing the neural network through the NF Tool in MATLAB, the next step is to train the network using the input and the outputs (Pant, 2020), as mentioned in Table 4.7. DEA-ANN Database.

The MSE values, general properties and other results of the best network after the training process are presented in Table 4.8. Best Network.

Table 4. 8: Best Network

Neural Networks Properties	Network Architecture		8-4-1	
	Network Type		Feed-Forward	
	Network Algorithm		Back-Propagation (BP)	
	Training Function		Levenberg-Marquardt	
	Hidden Transfer Function		Hyperbolic Tangent Sigmoid Transfer Function	
	Output Transfer Function		Linear	
	Performance Function		Mean Squared Error (MSE)	
	Data Division		Random	
	Calculations		MEX	
Training Progress	<i>Unit</i>	<i>Initial Value</i>	<i>Stopped Value</i>	<i>Target Value</i>
	Epoch	0	10	1000
	Elapsed Time	-	00:00:01	-
	Performance	0.0176	0.000128	0
	Gradient	0.0573	0.000133	0.0000001
	Mu	0.001	0.00001	10.000.000.000
	Validation Checks	0	6	6
Training Results	<i>Observations</i>	<i>MSE</i>		<i>R</i>
	Training	26	0.000375	0.93143
	Validation	6	0.000530	0.91005
	Test	6	0.000312	0.95956
	Additional Test (All)	38	0.000390	0.92809

According to Table 4.8.,

Hyperbolic Tangent Sigmoid Transfer Function was employed as the activation function for hidden layer neurons, while the linear transfer function was employed for output layer neurons. The data from 38 OECD countries are used in the network design; the complete data set is randomly divided into three subsets: 70% of all data is used for training the network, 15% of all data is used to validate that the

network was generalising and to stop training before over-fitting, and the last 15% of all data is used as a completely independent test of network generalisation (M. S. Ahmed, 2016; Alizadeh Mansouri & Dabiri, 2021; L. Zhang, 2019).

Therefore, 26 countries are randomly chosen for the training process, 6 (six) countries for the validation process, and 6 (six) countries for the testing process.

The performance and convergence history of the training process for the best network is presented in Figure 4.6. and Figure 4.7., respectively, as well as the error histogram of this network is depicted in Figure 4.8.

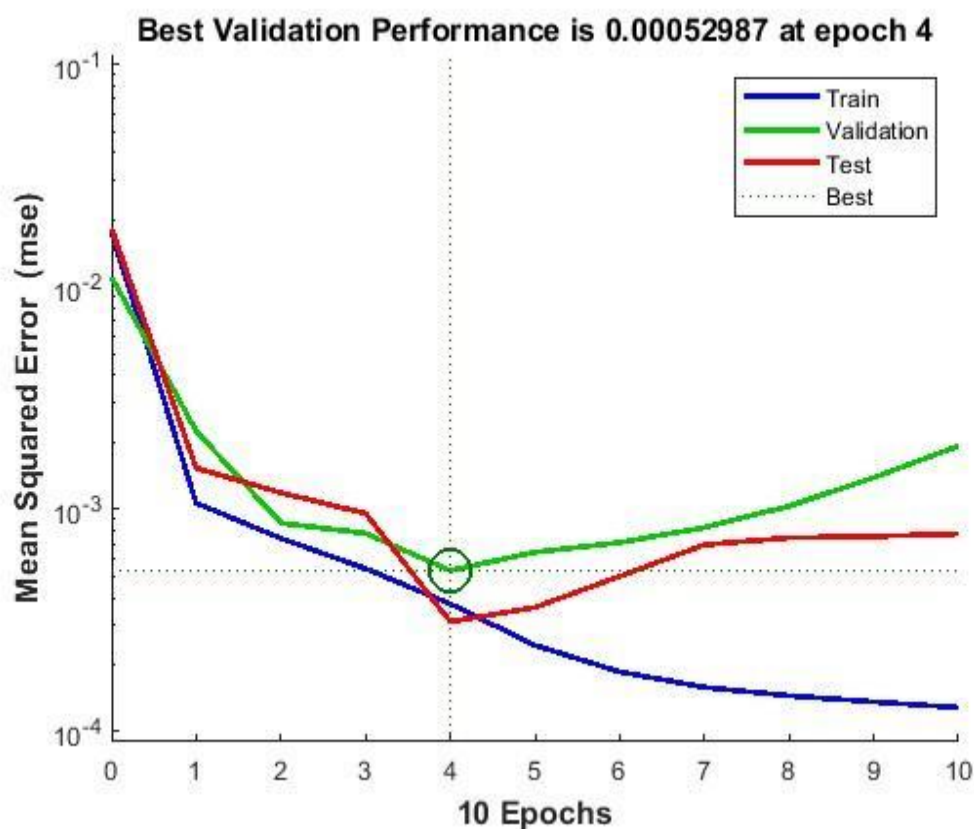


Figure 4. 6: The Performance of The Best Network

Figure 4.6. demonstrates that the network performance process has improved during the training process. Mean Squared Error (MSE) has declined rapidly along epochs while the neural network is trained. Considering this best network, it is clear that the results are reasonable. The final Mean Squared Error (MSE) is the lowest (0.000530) at 4 (four) epochs.

In this case, the final Mean Squared Error (MSE), which is the test set error of the network, is very small (0.000312) at epoch 4; hence the performance of the network can be identified and judged (M. S. Ahmed, 2016).

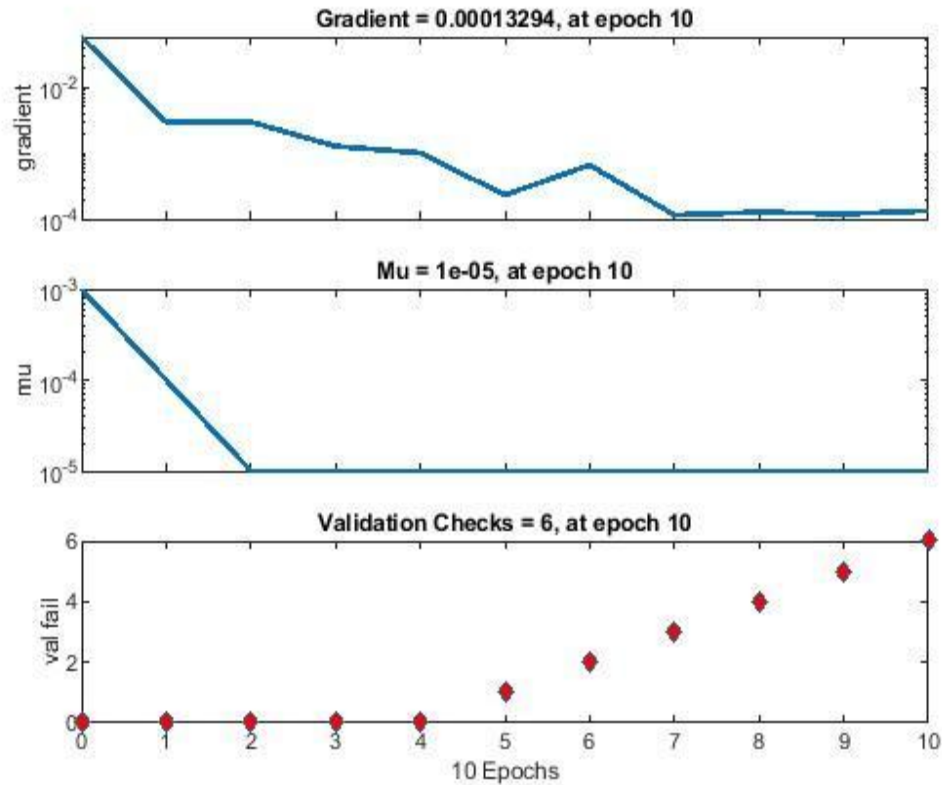


Figure 4. 7: The Convergence History of The Best Network

According to Figure 4.7.;

The convergence history of the best network (the training state plot) shows the progress of other training variables, such as the gradient magnitude, the number of validation checks, and mu. The magnitude of the gradient and the number of validation checks are used to terminate the training. The gradient will become very small as the training reaches a minimum of the performance. If the magnitude of the gradient is less than $1e-5$, the training will stop. The number of validation checks represents the number of successive iterations that the validation performance fails to decrease. If this number reaches 6 (six) (the default value), the training will stop (Beale et al., 2022).

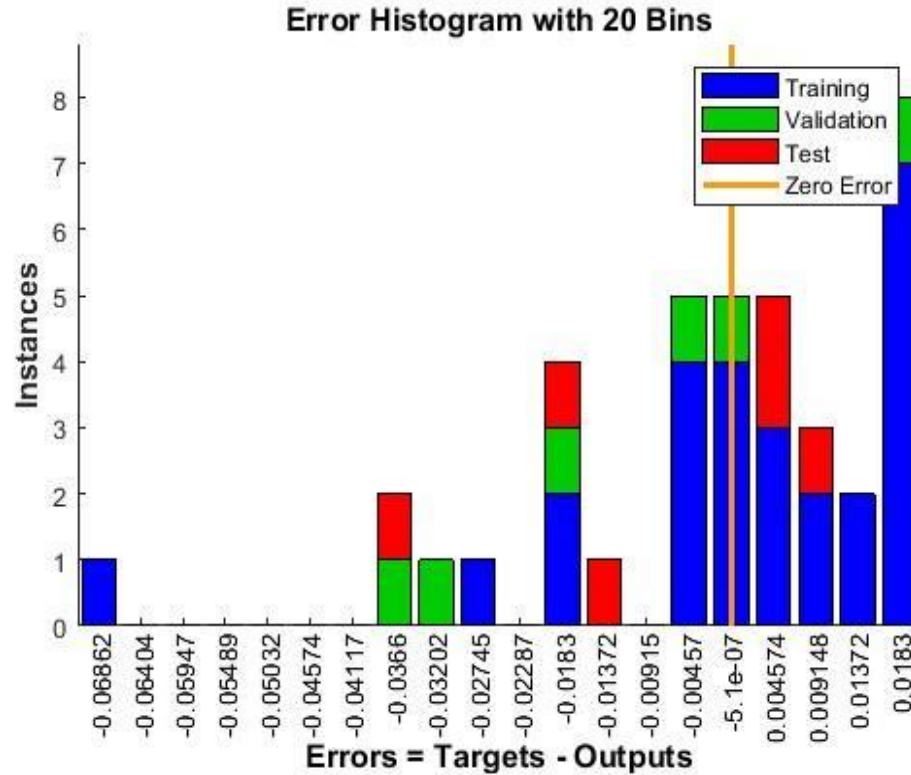


Figure 4. 8: The Error Histogram History of The Best Network

The Error Histogram History of The Best Network plot shows the distribution of the network errors in Figure 4.8. The difference between the network (estimated) outputs (y) and the target (actual) values (t) is called the error; the main objective of ANN training is to minimize error (Leema N. et al., 2022).

According to Figure 4.8., the number of errors is relatively low. In other words, the difference between the network (estimated) outputs (y) and the target (actual) values (t) is small.

Overfitting is a common issue in supervised machine learning, which cannot be avoided entirely (Ying, 2019). Overfitting occurs when a model adjusts to the given data very well but performs poorly on unseen data (Jaiswal et al., 2020). An overfit model can be diagnosed by monitoring the model's performance during training and evaluating both a training dataset and a validation dataset (Brownlee, 2019). In overfitting, the training error is minimal, while the test error is usually awful (Ghojogh & Crowley, 2019). Overfitting is detected if this error estimate is sufficiently different from the original test error rate (Werpachowski et al., 2019).

The error rate should be the same or close for training data, validation data and testing data (Suragala & PapaRao A. V., 2020). According to Figure 4.9., since the error rate for training data ($MSE=0.000375$), validation data ($MSE=0.000530$), and testing data ($MSE=0.000312$) are reasonably small and close to or equal to each other, it is considered that there is no overfitting issue in the best network.

The regression plots show a regression between network outputs and network targets (Beale et al., 2022). The regression for the training, validation, and test stages, as well as the overall regression of the network, are shown in Figure 4.9.

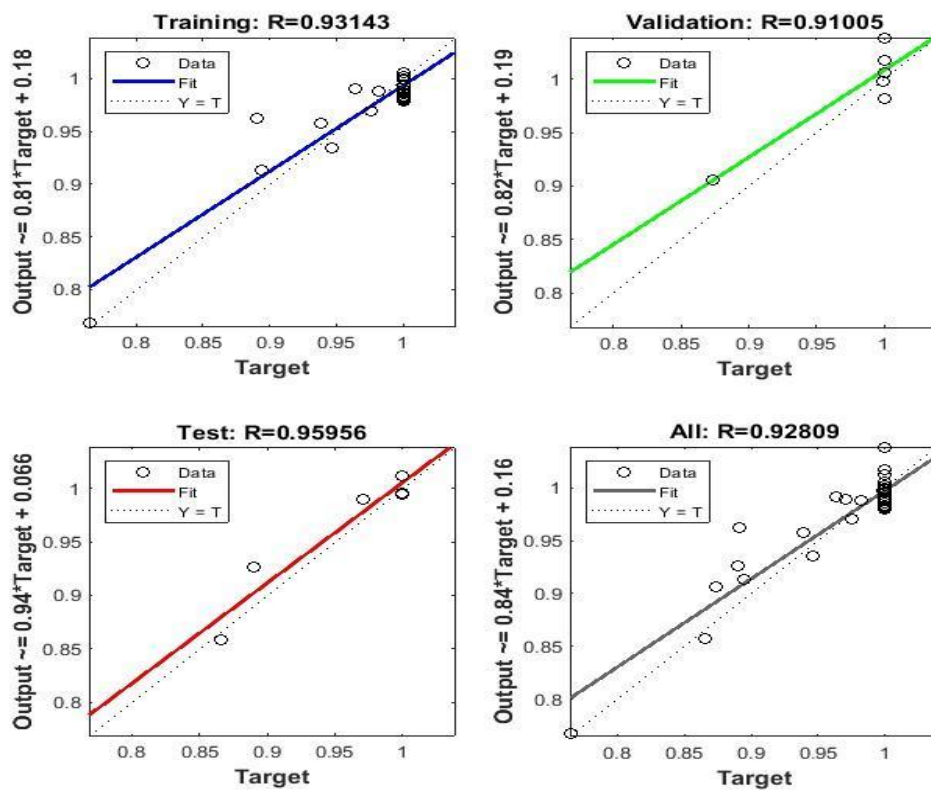


Figure 4. 9: Regression Plots of The Best Network

The four plots represent the training, validation, and testing data, as well as the overall regression of the network. While the dashed line in each plot represents the perfect result – *outputs = targets*, the solid line represents the best fit linear regression line between outputs and targets. The R-value is an indication of the relationship between the outputs and targets. While if R-value = 1, this indicates an exact linear relationship between outputs and targets; if R-value is close to zero, then there is no

linear relationship between outputs and targets (Beale et al., 2022; Cavallin et al., 2022).

In addition, since the regression plots (training, validation, testing and overall) demonstrate all outputs related to all the objectives for training, validation, and tests, to reach ideal fits, the dataset must lie against a 45-degree line except for a few outliers because this is the position where all outputs equal targets (M. S. Ahmed, 2016; Aziz et al., 2016; Mohamed Emdalel, 2020; Sinaki et al., 2022).

If the network model satisfies the evaluation standards, in other words, the accuracy and stability of the network model meet the requirements, then the better-trained network model is obtained (N. Zhu et al., 2021).

From this point of view, since R-values for training, validation, testing and overall data are 0.93143, 0.91005, 0.95956 and 0.92809, respectively, and the requirement that the dataset must lie against a 45-degree line except for a few outliers was met, it is assumed that obtained a better-trained network model.

4.2.4. Prediction of ANN Efficiency Scores

In this step, the DEA-ANN model is applied to the test data to predict the ANN Efficiency Score of each OECD (38) country. The results are presented in Table 4. 9.

Table 4. 9: DEA-ANN Predicted Efficiency Scores

DMU	Transformed DEA Efficiency Scores (t)	DEA-ANN Predicted Efficiency Scores (y)	Error (t-y)	Error % (% t-y)	10% Lower Case	10% Upper Case
AUST	1.000000	0.996035	-0.003965	-0.396457	0.900000	1.100000
AUT	1.000000	0.995123	-0.004877	-0.487693	0.900000	1.100000
BEL	0.970685	0.989587	0.018902	1.947246	0.873617	1.067754
CAN	1.000000	1.000000	0.000000	0.000000	0.900000	1.100000
CHL	0.946208	0.934938	-0.011270	-1.191111	0.851587	1.040829
COL	1.000000	0.979735	-0.020265	-2.026473	0.900000	1.100000
CRI	1.000000	0.999789	-0.000211	-0.021102	0.900000	1.100000
CZE	1.000000	0.979712	-0.020288	-2.028830	0.900000	1.100000
DNK	1.000000	0.998770	-0.001230	-0.123039	0.900000	1.100000
EST	1.000000	0.983693	-0.016307	-1.630675	0.900000	1.100000
FIN	0.963790	0.990840	0.027050	2.806597	0.867411	1.060169
FRA	0.938879	0.957724	0.018845	2.007136	0.844991	1.032767
DEU	1.000000	0.981543	-0.018457	-1.845742	0.900000	1.100000

Table 4. 9: (continued)

GRC	1.000000	0.989690	-0.010310	-1.030968	0.900000	1.100000
HUN	1.000000	0.979416	-0.020584	-2.058440	0.900000	1.100000
ISL	1.000000	0.998855	-0.001145	-0.114523	0.900000	1.100000
IRL	1.000000	0.993165	-0.006835	-0.683546	0.900000	1.100000
ISR	1.000000	0.982048	-0.017952	-1.795217	0.900000	1.100000
ITA	0.894678	0.913645	0.018966	2.119893	0.805211	0.984146
JPN	0.764865	0.768300	0.003435	0.449142	0.688379	0.841352
KOR	0.866153	0.858038	-0.008115	-0.936900	0.779538	0.952769
LVA	1.000000	0.982095	-0.017905	-1.790529	0.900000	1.100000
LTU	1.000000	1.000000	0.000000	0.000000	0.900000	1.100000
LUX	1.000000	0.981439	-0.018561	-1.856078	0.900000	1.100000
MEX	1.000000	1.000000	0.000000	0.000000	0.900000	1.100000
NLD	1.000000	1.000000	0.000000	0.000000	0.900000	1.100000
NZL	1.000000	0.987376	-0.012624	-1.262426	0.900000	1.100000
NOR	1.000000	0.998418	-0.001582	-0.158169	0.900000	1.100000
POL	0.891075	0.961979	0.070904	7.957139	0.801967	0.980182
PRT	0.874019	0.905837	0.031818	3.640389	0.786617	0.961421
SVK	1.000000	1.000000	0.000000	0.000000	0.900000	1.100000
SVN	1.000000	0.986073	-0.013927	-1.392657	0.900000	1.100000
ESP	0.890432	0.926002	0.035570	3.994685	0.801389	0.979476
SWE	0.998682	0.997807	-0.000875	-0.087617	0.898814	1.098550
CHE	0.981913	0.987783	0.005870	0.597830	0.883722	1.080104
TUR	1.000000	1.000000	0.000000	0.000000	0.900000	1.100000
GBR	0.975486	0.969963	-0.005523	-0.566172	0.877937	1.073035
USA	1.000000	0.994383	-0.005617	-0.561747	0.900000	1.100000
Minimum	0.764865	0.768300	-0.020584	-2.058440	0.688379	0.841352
Median	1.000000	0.987580	-0.001406	-0.140604	0.900000	1.100000
Mean	0.972549	0.972363	-0.000186	0.038788	0.875294	1.069804
Maximum	1.000000	1.000000	0.070904	7.957139	0.900000	1.100000
Std. Deviation	0.053305	0.046135	0.018600	2.013946	0.047974	0.058635

In Table 4.9., while column-1 represents Transformed DEA Efficiency Scores (t), which are obtained in the DEA stage, and column-2 represents DEA-ANN Predicted Efficiency Scores (y). column-3 and column-4 show prediction error in and percentage, respectively. Lastly, column-5 and column-6 show prediction intervals in 10% Lower Case and 10% Upper Case, respectively.

According to Table 4.9., Canada, Lithuania, Mexico, Netherlands, Slovak Republic, and Türkiye have a score of 1, and they are relatively efficient. In addition, while DEA-ANN Predicted Efficiency Scores range from 0.768300 to 1.000000, the mean of the DEA-ANN Predicted Efficiency Score is 0.972363.

It is a requirement to conduct some reliable statistical methods before commenting on the accuracy of the DEA-ANN prediction model with higher confidence (Jauhar et al., 2022). These statistical methods are applied to measure how close the actual values are to the values predicted using the DEA-ANN model (Shah et al., 2017).

For this purpose, the Scatter Plot of The Best Network, Common Statistical Parameters of DEA-ANN and The Difference in Efficiency Scores Between DEA and DEA-ANN techniques were used.

Figure 4.10. was generated using SPSS 28.0 (IBM Corp, 2021) and presented below.

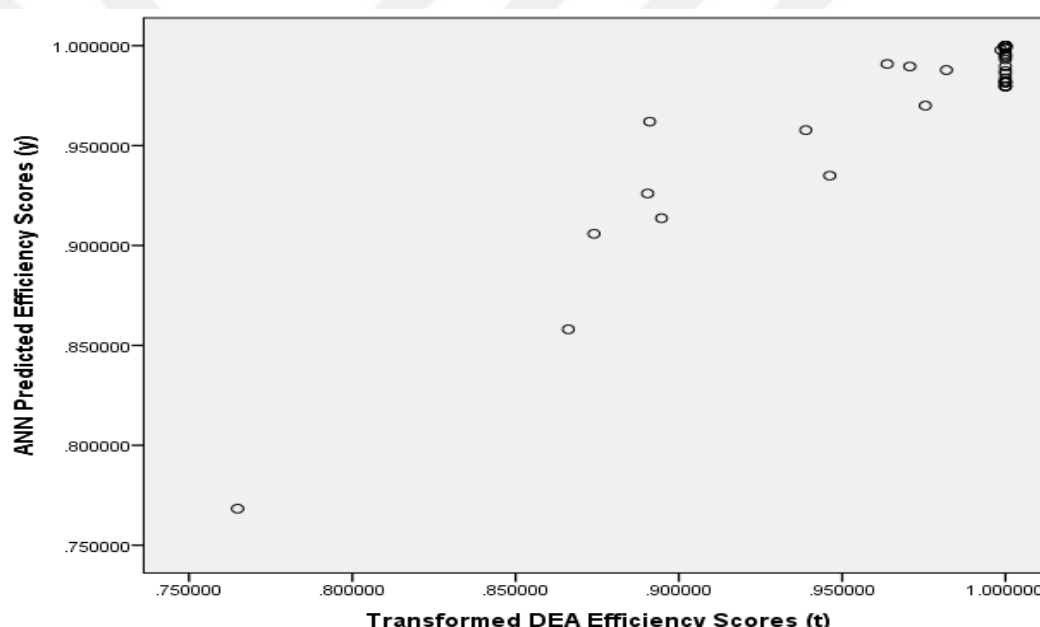


Figure 4. 10: Scatter Plot of The Best Network

Figure 4.10. shows that the DEA-ANN prediction for efficiency score appears to be a good prediction for most cases (Emrouznejad & Shale, 2009). Besides, ANN Predicted Efficiency Scores of all DMUs are within 10% Lower Case and 10% Upper Case. Therefore, these results have demonstrated that ANN Predicted Efficiency Scores are similar and close to the Transformed DEA Efficiency Scores. Based on the results of Table 4.9., common statistical parameters of the DEA-ANN algorithm are presented in Table 4.10. Common Statistical Parameters of DEA-ANN.

Table 4. 10: Common Statistical Parameters of DEA-ANN

Statistical Parameter	Value
Average Accuracy	98.70%
MSE (Training)	0.000375
MSE (Validation)	0.000530
MSE (Testing)	0.000312
MSE (Overall)	0.000390
R ² (Training)	0.93143
R ² (Validation)	0.91005
R ² (Testing)	0.95956
R ² (Overall)	0.92809
Pearson Correlation	r=0.940, p<0.01 (two-tailed)

According to Table 4.10.,

Average accuracy is an important indicator that directly reflects the predictive power of a model (N. Zhu et al., 2021). The average accuracy was calculated as 98.70% in this study.

R² (Correlation Coefficient) is a numerical measure of the type of correlation, meaning a statistical relationship between two variables (Kwon, 2017; Singh et al., 2018; N. Zhu et al., 2021). The adaptive learning capability of the DEA-ANN model can be observed by high R² values between the actual and predicted efficiencies (Shahi et al., 2022). R² values (Correlation Coefficient) for training, validation, testing and overall data are 0.93143, 0.91005, 0.95956 and 0.92809 respectively, in this dissertation.

The aim is to reduce the Mean Squared Error (MSE) for training, validation, testing and overall data (Athanassopoulos & Curram, 1996). Mean Squared Error (MSE) for training, validation, testing and overall data are 0.000375, 0.000530, 0.000312 and 0.000390, respectively, in this dissertation.

The high correlation between the actual and the predicted values demonstrates the generalized learning property of DEA-ANN (Kwon, 2017). The Pearson Correlation between Transformed DEA Efficiency Scores and ANN Predicted Efficiency Scores is calculated as 0.940, $p < 0.01$ (two-tailed).

In addition to the average accuracy indicator, to examine the accuracy of the DEA-ANN prediction model, the difference between Transformed DEA Efficiency

Scores and ANN Predicted Efficiency Scores, namely prediction error, was plotted in Figure 4.11. (Jauhar et al., 2022).

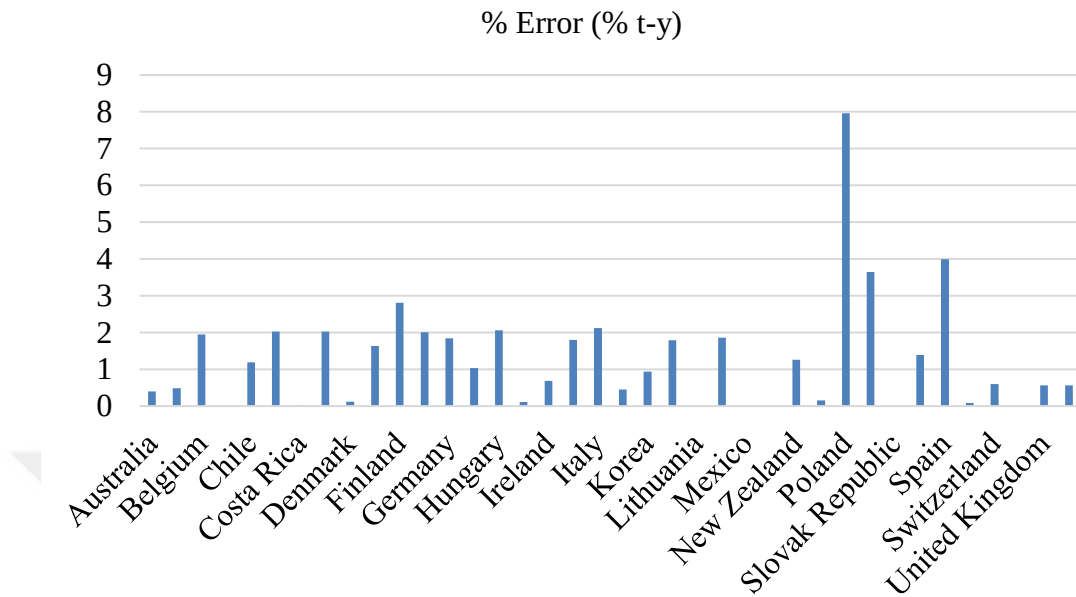


Figure 4. 11: The Difference in Efficiency Scores Between DEA and DEA-ANN

The adaptive learning capability of the DEA-ANN model should be observed by high correlations and low error rates.

As depicted in Figure 4.11., all the absolute deviations for efficiency scores are less than 10%; the Pearson Correlation between Transformed DEA Efficiency Scores and DEA-ANN Predicted Efficiency Scores is very high ($r = 0.940$, $p < 0.01$); R^2 values (Correlation Coefficient) are very high (*Training* = 0.93143, *Validation* = 0.91005, *Testing* = 0.95956 and *Overall* = 0.92809); Mean Squared Error (MSE) are very low (*Training* = 0.000375, *Validation* = 0.000530, *Testing* = 0.000312, *Overall* = 0.000390).

According to (Alizadeh Mansouri & Dabiri, 2021; Emrouznejad & Shale, 2009; Jauhar et al., 2022; Jumabaeva, 2011; Kwon et al., 2016; Tsolas et al., 2020; N. Zhu et al., 2021); these are strong pieces of evidence that the DEA-ANN model has high accuracy and DEA-ANN model is capable of predicting Transformed DEA Efficiency Scores via maximum errors of lower than 10%.

4.3. Results of Data Envelopment Analysis Matrix (DEAM) Stage

In this stage, unlike the original Data Envelopment Analysis Matrix (DEAM) developed based on the approach presented by Osman et al. (2011) by Vafae Najar et al. (2018) (Osman et al., 2011; Vafae Najar et al., 2018), while the X (Horizontal) axis represents the relative efficiency score based on DEA-ANN model, the Y (Vertical) axis represents the relative efficiency score based on Output Oriented DEA-VRS.

After identifying the relative performance of OECD countries by using the DEA-VRS model in *section 4.1* and by using the DEA-ANN model in *section 4.2*, DMUs (38 OECD countries) were divided into four groups as follows based on Data Envelopment Analysis Matrix (DEAM) (Osman et al., 2011; Vafae Najar et al., 2018);

The Super Stars Group consists of OECD countries with high relative efficiency in the output-oriented DEA-VRS and high relative efficiency in the DEA-ANN model. In other words, the DEA-VRS model and DEA-ANN model scores are higher than or equal to the average efficiency scores (**0.972549** and **0.972363**, respectively).

The Potential Stars Group consists of OECD countries with high relative efficiency in the output-oriented DEA-VRS and low relative efficiency in the DEA-ANN model. In other words, DEA-VRS mode scores are higher than or equal to the average efficiency scores (**0.972549**), and the DEA-ANN model scores less than the average efficiency scores (**0.972363**).

The Question Marks Group consists of OECD countries with low relative efficiency in the output-oriented DEA-VRS and low relative efficiency in the DEA-ANN model. In other words, DEA-VRS mode scores are less than or equal to the average efficiency scores (**0.972549**), and DEA-ANN model scores are less than the average efficiency scores (**0.972363**).

The To Be Governed Effectively Group consists of OECD countries with low relative efficiency in the output-oriented DEA-VRS and high relative efficiency in the

DEA-ANN model. In other words, DEA-VRS mode scores are less than or equal to the average efficiency scores (**0.972549**), and DEA-ANN model scores are higher than the average efficiency scores (**0.972363**).

The results are presented in Table 4.11.

Table 4. 11: DEAM Groups

DMU	Transformed Efficiency Scores	DEA-ANN Efficiency Scores	Status Relative to DEA-VRS (0.972549)	Status Relative to DEA-ANN (0.972363)	DEAM Group
Australia	1.000000	0.996035	High	High	Super Star
Austria	1.000000	0.995123	High	High	Super Star
Belgium	0.970685	0.989587	Low	High	To Be Governed Effectively
Canada	1.000000	1.000000	High	High	Super Star
Chile	0.946208	0.934938	Low	Low	Question Mark
Colombia	1.000000	0.979735	High	High	Super Star
Costa Rica	1.000000	0.999789	High	High	Super Star
Czech Republic	1.000000	0.979712	High	High	Super Star
Denmark	1.000000	0.998770	High	High	Super Star
Estonia	1.000000	0.983693	High	High	Super Star
Finland	0.963790	0.990840	Low	High	To Be Governed Effectively
France	0.938879	0.957724	Low	Low	Question Mark
Germany	1.000000	0.981543	High	High	Super Star
Greece	1.000000	0.989690	High	High	Super Star
Hungary	1.000000	0.979416	High	High	Super Star
Iceland	1.000000	0.998855	High	High	Super Star
Ireland	1.000000	0.993165	High	High	Super Star
Israel	1.000000	0.982048	High	High	Super Star
Italy	0.894678	0.913645	Low	Low	Question Mark
Japan	0.764865	0.768300	Low	Low	Question Mark
Korea	0.866153	0.858038	Low	Low	Question Mark
Latvia	1.000000	0.982095	High	High	Super Star
Lithuania	1.000000	1.000000	High	High	Super Star
Luxembourg	1.000000	0.981439	High	High	Super Star
Mexico	1.000000	1.000000	High	High	Super Star
Netherlands	1.000000	1.000000	High	High	Super Star
New Zealand	1.000000	0.987376	High	High	Super Star
Norway	1.000000	0.998418	High	High	Super Star
Poland	0.891075	0.961979	Low	Low	Question Mark
Portugal	0.874019	0.905837	Low	Low	Question Mark

Table 4.11. (continued)

Slovak Republic	1.000000	1.000000	High	High	Super Star
Slovenia	1.000000	0.986073	High	High	Super Star
Spain	0.890432	0.926002	Low	Low	Question Mark
Sweden	0.998682	0.997807	High	High	Super Star
Switzerland	0.981913	0.987783	High	High	Super Star
Türkiye	1.000000	1.000000	High	High	Super Star
United Kingdom	0.975486	0.969963	High	Low	Potential Star
United States	1.000000	0.994383	High	High	Super Star

According to Table 4.11.,

There are 27 countries in the Super Star Group, 1 (one) country in the Potential Star Group, 2 (two) countries in the To Be Governed Effectively Group and 8 (eight) countries in the Question Mark Group.

Data Envelopment Analysis Matrix is formed based on Table 4.11. and presented in Figure 4.12.

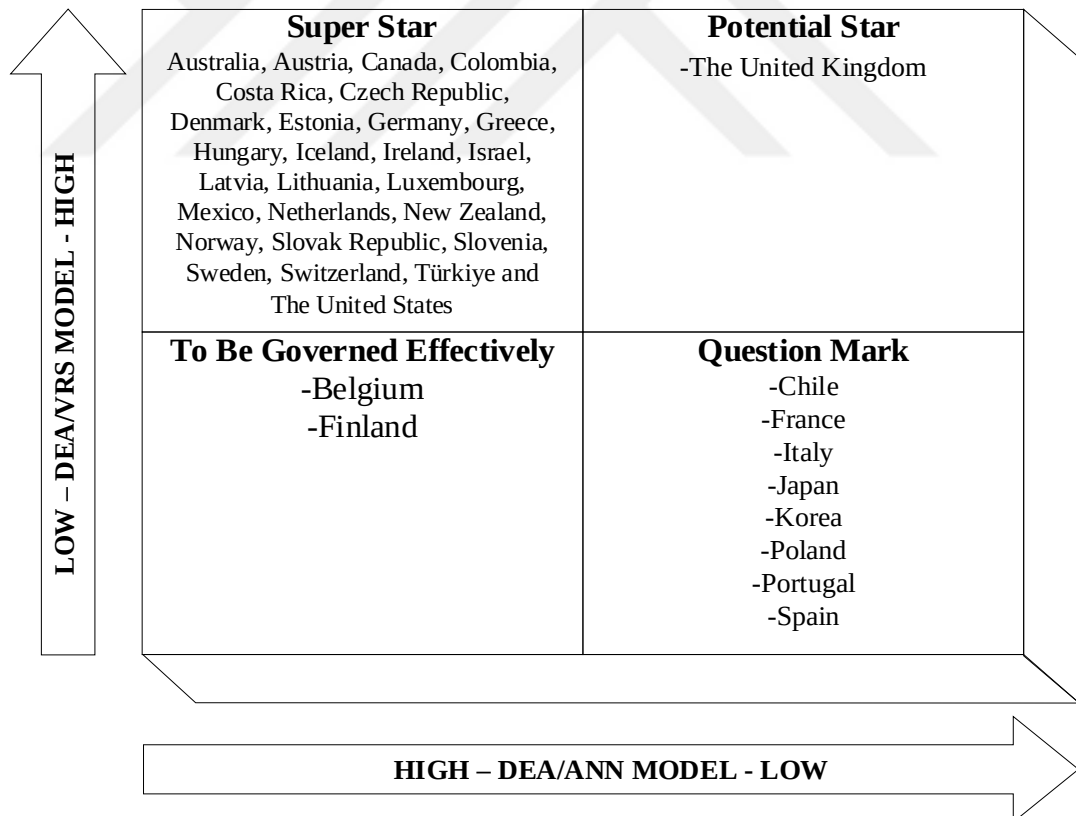


Figure 4. 12: Distributing of the OECD Countries According to Their DEAM

According to Figure 4.12.,

- ✓ Australia, Austria, Canada, Colombia, Costa Rica, Czech Republic, Denmark, Estonia, Germany, Greece, Hungary, Iceland, Ireland, Israel, Latvia, Lithuania, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Slovak Republic, Slovenia, Sweden, Switzerland, Türkiye and the United States fall into in the ***Super Stars Group***;
- ✓ United Kingdom falls into in the ***Potential Stars Group***;
- ✓ Belgium and Finland fall into in the ***To Be Governed Effectively Group***;
- ✓ Chile, France, Italy, Japan, Korea, Poland, Portugal and Spain fall into in the ***Question Marks Group***.



5. DISCUSSION

The discussion and Comments section, Theoretical Implications section, Managerial Implications section, Limitations of the Dissertation and Future Research Directions section, and Conclusion section are presented as follows.

5.1. Discussion and Comments

Being a new Operations Research/Operations Management sub-discipline, the Operations Research/Operations Management literature in healthcare management, also known as Healthcare Operations Management, is growing exponentially like the other new sub-disciplines (Langabeer & Helton, 2021; Tüzün & Topcu, 2018).

While operations management is responsible for making strategic decisions that affect the entire organization and should support the organization's mission and overall strategy (Kamauff, 2010), operations strategy aims to interpret the organization's overall strategy (Greasley, 2020).

As a novel performance measurement tool, the Operations Strategy Matrix is one method of checking the reconciliation between the inside-out (operations resources) and outside-in (market requirements) perspectives (Slack & Brandon-Jones, 2021).

The Operations Strategy Matrix was employed measurement tool in this dissertation. While there are four inputs used in the analysis; these are Decision Areas/Strategic Decision Areas in the Operations Strategy Matrix adapted from Slack and Lewis (2017) and Karuppan et al. (2016) as the primary input framework; there are four outputs two of which are undesirable, used in the analysis: these are Competitive Priorities or Performance Objectives in the Operations Strategy Matrix adapted from Slack and Lewis (2017) and Karuppan et al. (2016) as the main output framework (Karuppan et al., 2016; Slack & Lewis, 2017).

Extant literature review and increasing interest in the Operations Research/Operations Management studies in healthcare management have paved the way for this dissertation, which has three research questions below;

- (i) Are OECD (38) countries efficient in the healthcare system in terms of the Operations Strategy Matrix using Data Envelopment Analysis (DEA)?
- (ii) Are OECD (38) countries efficient in the healthcare system in terms of the Operations Strategy Matrix using the integration of Artificial Neural Network (ANN) and Data Envelopment Analysis (DEA-ANN Model)?
- (iii) How are OECD (38) countries classified according to their DEA scores and DEA-ANN Model scores based on Data Envelopment Analysis Matrix?

Within the scope of the first research question, upon validation of the dataset through “The Polarity of Input and Output Variables”, “Correlations Input and Output Variables”, and “Multicollinearity Input Variables” techniques, below five analysis steps were conducted using BCC (VRS)-Output Orientation Data Envelopment Analysis (DEA) model;

In the first analysis step of the first research question, Decision-Making Units (DMUs) were evaluated using pure technical efficiency scores.

According to results, Australia, Austria, Canada, Colombia, Costa Rica, Czech Republic, Denmark, Estonia, Germany, Greece, Hungary, Iceland, Ireland, Israel, Latvia, Lithuania, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Slovak Republic, Slovenia, Türkiye and United States have a score of 1, and they are relatively efficient.

However, Belgium, Chile, Finland, France, Italy, Japan, Korea, Poland, Portugal, Spain, Sweden, Switzerland and the United Kingdom have scores greater than 1; thus, they are identified as inefficient in the output-oriented model.

Since the healthcare system of the U.S. doesn’t fit into any of the recognized models (T. R. Reid, 2009), when these results are interpreted over 37 OECD countries, the average efficiency scores of four basic healthcare models as follows;

- ✓ The Beveridge Model: 4 countries are efficient of 10 OECD countries, and the average efficiency score of the model is 95.97%.
- ✓ The Bismarck Model: 14 countries are efficient of 19 OECD countries, and the average efficiency score of the model is 97.49%.

- ✓ The National Health Insurance Model: 3 countries are efficient of 4 OECD countries, and the average efficiency score of the model is 96.66%.
- ✓ The Out-of-Pocket Model: 3 countries are efficient of 4 OECD countries, and the average efficiency score of the model is 98.66%.

When the average efficiency scores of four basic healthcare models were ranked, the following ranking was reached;

The Out-of-Pocket Model (98.66%) > The Bismarck Model (97.49%) > The National Health Insurance Model (96.66%) > The Beveridge Model (95.97%)

The Out-of-Pocket Model has the highest average efficiency scores in the DEA-VRS model. It is followed by the Bismarck Model.

In the second analysis step of the first research question, a reference set was identified for each inefficient Decision-Making Unit (DMU).

According to the results, Türkiye is the most appeared Decision-Making Unit (DMU) in the reference sets with 9 (nine) peer counts. Türkiye is followed by New Zealand (6 peer counts) and Costa Rica (5 peer counts). Norway, Israel and Australia have the same peer counts with 4 (four), and Colombia has appeared 3 (three) times in the reference sets.

When these results are interpreted over 38 OECD countries, the most appeared Decision-Making Units (DMUs) in the reference sets are found to be evenly distributed across four basic healthcare models.

In the third analysis step of the first research question, a Robustness Analysis was conducted. According to the results, both Türkiye and New Zealand are not outliers. Besides, Switzerland became efficient after New Zealand was excluded from their reference sets. This reveals that Switzerland has a structure similar to New Zealand; it becomes inefficient due to the existence of New Zealand.

The Medical Council of New Zealand has confirmed this similarity, considering that Switzerland is one of the countries considered to have a health environment comparable to New Zealand (Medical Council of New Zealand, 2022).

According to Robustness Analysis results, the inefficient countries are classified as follows;

- ✓ Belgium is an *insensitive inefficient country*.
- ✓ Sweden is a *low-sensitive inefficient country*.
- ✓ Portugal, the United Kingdom, Chile, France, Finland, Italy and Switzerland are *medium-sensitive inefficient countries*.
- ✓ Spain, Korea, Japan and Poland are *highly sensitive inefficient countries*.

In the fourth analysis step of the first research question, improvement options for inefficient Decision-Making Units (DMUs) were calculated.

According to the results, Japan is the most improvement in terms of most input and output variables. These findings are in line with WHO Japan Health System Review (Sakamoto et al., 2018), which articulates recommendations those Japan should now find policies that balance universal insurance coverage, service quality and financial sustainability.

In the fifth analysis step of the first research question, fully efficient Decision-Making Units (DMUs) were determined based on efficiency scores and slack values.

According to results;

While Austria, Costa Rica, Germany, Greece and the United States are fully efficient DMU; Australia, Canada, Colombia, Czech Republic, Denmark, Estonia, Hungary, Iceland, Ireland, Israel, Latvia, Lithuania, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Slovak Republic, Slovenia and, Türkiye are weakly efficient DMU.

Since the healthcare system of the U.S. doesn't fit into any of the recognized models (T. R. Reid, 2009), when fully/weakly efficiency results are interpreted over 24 efficient OECD countries, the fully/weakly efficiency rate of four basic healthcare models as follows;

- ✓ The Beveridge Model: 0 (zero) country is fully efficient of 6 (three) efficient OECD countries.
- ✓ The Bismarck Model: 3 (three) countries are fully efficient of 14 efficient OECD countries.

- ✓ The National Health Insurance Model: 0 (zero) country is fully efficient of 3 (three) efficient OECD countries.
- ✓ The Out-of-Pocket Model: 1 (one) country is fully efficient of 3 (three) efficient OECD countries.

Within the scope of the second research question; the integrated DEA-ANN Model system is developed through the following steps; Variable Selection, Network Design, Network Application Process and, Prediction of ANN Efficiency Scores (Singh et al., 2018; Tsolas et al., 2020; N. Zhu et al., 2021).

There are strong pieces of evidence that the DEA-ANN model has high accuracy (*Average Accuracy= 98.70%, and Pearson Correlation between DEA scores and DEA-ANN scores= $r=0.940$, $p<0.01$ (two-tailed)*) and DEA-ANN model is capable of predicting Transformed DEA Efficiency Scores via maximum errors of lower than 10%; therefore, the results can be interpreted.

According to results, Canada, Lithuania, Mexico, Netherlands, Slovak Republic, and Türkiye have a score of 1 and are relatively efficient.

Since the healthcare system of the U.S. doesn't fit into any of the recognized models (T. R. Reid, 2009), when these results are interpreted over 37 OECD countries, the average DEA-ANN efficiency scores of four basic healthcare models are as follows;

- ✓ The Beveridge Model: 0 (zero) countries are efficient of 10 OECD countries, and the average DEA-ANN efficiency score of the model is 96.88%.
- ✓ The Bismarck Model: 4 (four) countries are efficient of 19 OECD countries, and the average DEA-ANN efficiency score of the model is 97.36%.
- ✓ The National Health Insurance Model: 1 (one) country is efficient of 4 (four) OECD countries, and the average DEA-ANN efficiency score of the model is 96.18%.
- ✓ The Out-of-Pocket Model: 1 (one) country is efficient of 4 OECD countries, and the average efficiency score of the model is 97.87%.

When the average DEA-ANN efficiency scores of four basic healthcare models were ranked, the following ranking was reached;

The Out-of-Pocket Model (97.87%) > The Bismarck Model (97.36%) > The Beveridge Model (96.88%) > The National Health Insurance Model (96.18%)

The Out-of-Pocket Model has the highest average efficiency scores in the DEA model and DEA-ANN model. It follows The Bismarck Model.

Within the scope of the third research question, to classify OECD (38) countries according to their DEA scores and DEA-ANN Model scores, below two analysis steps were conducted.

In the first analysis step of the third research question, while the X (Horizontal) axis represents the relative efficiency score based on the DEA-ANN model, the Y (Vertical) axis represents the relative efficiency score based on Output Oriented DEA-VRS.

In the second analysis step of the third research question;

OECD (38) countries were divided into Super Stars, Potential Stars, Question Marks, and To Be Governed Effectively based on Data Envelopment Analysis Matrix (DEAM).

According to the results;

- ✓ *Super Stars Group* consists of Australia, Austria, Canada, Colombia, Costa Rica, Czech Republic, Denmark, Estonia, Germany, Greece, Hungary, Iceland, Ireland, Israel, Latvia, Lithuania, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Slovak Republic, Slovenia, Sweden, Switzerland, Türkiye and the United States.
- ✓ *Potential Stars Group* consists of the United Kingdom.
- ✓ *To Be Governed Effectively Group* consists of Belgium and Finland
- ✓ *Question Marks Group* consists of Chile, France, Italy, Japan, Korea, Poland, Portugal and Spain.

While all efficient countries based on DEA and DEA-ANN scores fall into the Super Stars Group, the inefficient countries, except the United Kingdom, Sweden and Switzerland, based on DEA scores fall into the To Be Governed Effectively Group and Question Marks Group.

It will make sense when Belgium falls into the “To Be Governed Effectively Group” of the Data Envelopment Analysis Matrix and corresponds to the “Insensitive Inefficient Country Group” of DEA Robustness Analysis are considered together.

It will make sense when Finland falls into the “To Be Governed Effectively Group” of the Data Envelopment Analysis Matrix and corresponds to the “Medium Sensitive Inefficient Country Group” of DEA Robustness Analysis are considered together.

It will make sense when the United Kingdom falls into the “Potential Stars Group” of the Data Envelopment Analysis Matrix and corresponds to the “Medium Sensitive Inefficient Country Group” of DEA Robustness Analysis are considered together.

It will make sense when Sweden falls into the “Super Stars Group” of the Data Envelopment Analysis Matrix and corresponds to the “Low-Sensitive Inefficient Country Group” of DEA Robustness Analysis are considered together.

It will make sense when Switzerland falls into the “Super Stars Group” of the Data Envelopment Analysis Matrix, corresponds to the “Medium-Sensitive Inefficient Country Group” of DEA Robustness Analysis and becomes efficient after New Zealand is excluded from their reference sets are considered together.

It will make sense when Poland corresponds to the “Highly Sensitive Inefficient Country Group” of DEA Robustness Analysis and has the highest error of the DEA-ANN model are considered together.

5.2. Theoretical Implications

(Tüzün & Topcu, 2018) have developed a taxonomy for Operations Research studies in Healthcare Management based on domains grouped into five classes as follows;

- (i) *Study Specifications* class shows how the study is specified.
- (ii) *Subject* class shows what is analysed.
- (iii) *Methodology* class shows the methodology used in the research.
- (iv) *Problem Specifications* class shows who and what the problem is analysed for.
- (v) *Location Specifications* class shows where the research was carried out.

The taxonomy of Operations Research works in healthcare management developed by (Tüzün & Topcu, 2018), and the theoretical implications of this dissertation, which is a part of Healthcare Operations Management, a discipline that integrates scientific principles of management for healthcare area (Langabeer & Helton, 2021), are presented in Table 5.1.

Table 5.1: The Taxonomy of OR Work in Healthcare Management and the Theoretical Implications of This Dissertation

The Taxonomy of Tüzün and Topcu (2018)		This Dissertation
1. Study Specifications	1.1. Type of Study	1.1.1. Model Construction using an Existing Method
		1.1.2. Model Construction using a Modified Method or Integration of Method ✓
		1.1.3. Method Comparison ✓
	1.2. Data Used	1.2.1. Real Data ✓
		1.2.2. Both Real and Synthetic Data
	1.3. Problem Treatment	1.3.1. Situation Analysis
		1.3.2. Decision-Making (Problem Solving) ✓
2. Subject	2.1. Planning and Design	
	2.2. Performance Measurement ✓	
	2.3. Capacity Management	
	2.4. Scheduling and Assignment	
	2.5. Resource/Budget Allocation	
	2.6. Patient Flow and Waitlist Management	
	2.7. Location	
	2.8. Other	

Table 5.1: (continued)

3. Methodology		3.1. Linear/Integer Programming	
		3.2. Multi-Objective Programming	
		3.3. Simulation	
		3.4. Data Envelopment Analysis	✓
		3.5. Queuing Theory	
		3.6. System Dynamics	
		3.7. Stochastic Methods	
		3.8. Multi-Attribute Decision Making	
		3.9. Game Theory	
		3.10. Bayesian Belief Network	
		3.11. Artificial Neural Network	✓
		3.12. Other	DEAM
4. Problem Specifications	4.1. Concerning People	4.1.1. Management	✓
		4.1.2. Doctor/Physician	
		4.1.3. Nurse or Non-Medical Staff	
		4.1.4. Patients	
	4.2. Concerning Area	4.2.1. Hospital/Clinic	
		4.2.2. Non-hospital Organizations	
		4.2.3. Public Health	✓
	4.3. Concerning Facility	4.3.1. Entire Clinic/Hospital	✓
		4.3.2. Emergency Room	
		4.3.3. Operating Room	
		4.3.4. Ambulance	
		4.3.5. Nursing Home	
4.3.6. Hospital Room			
4.3.7. Other			
5. Location Specifications	5.1. Large Scale	5.1.1. Worldwide	
		5.1.2. Continent Based	
	5.2. Medium Scale	5.2.1. Country Based	✓
		5.2.2. State Based	
	5.3. Small Scale	5.3.1. City/Town Based	
		5.3.2. Specific Location Based	
	5.4. No Location Specific		

Source: (Tüzün & Topcu, 2018)

When Table 5.1. is examined within the frame of taxonomy principles of (Tüzün & Topcu, 2018), the below considerations appeared.

- ✓ In terms of the *Type of Study (1.1.)* sub-domain, since the integration of Artificial Neural Network (ANN) and Data Envelopment Analysis (DEA-ANN Model) was used, *Model Construction using a Modified Method or Integration of Method (1.1.2.)* attribute was observed. Besides, since the

efficiency scores obtained through both Artificial Neural Network (ANN) and Data Envelopment Analysis (DEA) were compared, *Method Comparison (1.1.3.)* attribute was observed.

- ✓ In terms of the *Data Used (1.2.)* sub-domain, since data used for inputs and outputs were collected from OECD Health Databases, *Real Data (1.2.1.)* attribute was observed.
- ✓ In terms of the *Problem Treatment (1.3.)* sub-domain, since the methods of statistical inference like Data Envelopment Analysis (DEA) was used, *Decision Making (Problem Solving) (1.3.2.)* attribute was observed.
- ✓ In terms of the *Subject (2.)* domain, since healthcare systems of OECD (38) countries were evaluated, *Performance Measurement (2.2.)* attribute was observed.
- ✓ In terms of the *Methodology (3.)* domain, since an integrated method of Operations Research and Management Information Systems was used, *Data Envelopment Analysis (3.4.)*, *Artificial Neural Network (3.11.)* and Other (*Data Envelopment Analysis Matrix-DEAM) (3.4.)*, attributes were observed.
- ✓ In terms of the *Concerning People (4.1.)* sub-domain, since the people affected by the research questions of this dissertation were governments of OECD (38) countries, *Management (4.1.1.)* attribute was observed.
- ✓ In terms of the *Concerning Area (4.2.)* sub-domain, since the research questions of this dissertation occurred in healthcare systems of OECD (38) countries, *Public Health (4.2.3.)* attribute was observed.
- ✓ In terms of the *Concerning Facility (4.3.)* sub-domain, since the facilities affected by the research questions of this dissertation were all facilities within the OECD (38) countries, *Entire Clinic/Hospital (4.3.1.)* attribute was observed.
- ✓ In terms of the *Location Specifications (5.)* domain, since the research questions of this dissertation were applied to OECD (38) countries, *Medium Scale (5.2.)* sub-domain and *Country Based (5.2.1.)* attribute were observed.

5.3. Managerial Implications

Although the use of Data Envelopment Analysis (DEA) within healthcare efficiency analysis is worldwide for research publications, healthcare managers have not yet fully adopted Data Envelopment Analysis (DEA) as a standard performance measurement tool (Gök, 2012).

Thus, for healthcare managers of OECD countries, several managerial implications based on the findings of this dissertation are presented as follows;

- ✓ There is a negative correlation ($r=-0.630$, $p<0.01$, (two-tailed)) between the Capacity (i1), represented by the “Total Hospital Beds (Per 1 000 Population)” indicator and Data Envelopment Analysis (DEA) Transformed Efficiency Scores. Also, there is a negative correlation ($r=-0.706$, $p<0.01$, (two-tailed)) between the Capacity (i1), represented by the “Total Hospital Beds (Per 1 000 Population)” indicator and DEA-ANN Efficiency Scores. For these reasons, in particular, inefficient 13 OECD countries should balance between Total Hospital Beds number and Efficiency Scores, considering demand, resource and budget constraints.
- ✓ There is a negative correlation ($r=-0.383$, $p<0.01$, (two-tailed)) between the Process Technology (i3), represented by the “Medical Technology (Total per 1M Pop)” indicator and Data Envelopment Analysis (DEA) Transformed Efficiency Scores. Also, there is a negative correlation ($r=-0.439$, $p<0.01$, (two-tailed)) between the Process Technology (i3), represented by the “Medical Technology (Total per 1M Pop)” indicator and DEA-ANN Efficiency Scores. For these reasons, in particular, inefficient 13 OECD countries should balance between Medical Technology Devices number and Efficiency Scores, considering demand, resource and budget constraints.
- ✓ There is a positive correlation ($r=0.567$, $p<0.01$, (two-tailed)) between the Quality (o1), represented by the “Perceived Health Status (Good/very good, total aged 15+) (% of the population) (crude rate)” indicator and Data Envelopment Analysis (DEA) Transformed Efficiency Scores. Also, there is a positive correlation ($r=0.635$, $p<0.01$, (two-tailed)) between Quality (o1), represented by the “Perceived Health Status (Good/very good, total aged 15+) (% of the population) (crude rate)” indicator and DEA-ANN Efficiency

Scores. For these reasons, in particular, inefficient 13 OECD countries should increase the Perceived Health Status of their citizens, considering resource and budget constraints.

- ✓ There is a negative correlation ($r=-0.758$, $p<0.01$, (two-tailed)) between the Delivery (undesirable) (i3), represented by the “Hospital average length of stay by diagnostic categories (All Causes -Days)” indicator and Data Envelopment Analysis (DEA) Transformed Efficiency Scores. Also, there is a negative correlation ($r=-0.876$, $p<0.01$, (two-tailed)) between the Delivery (undesirable) (i3), represented by the “Hospital average length of stay by diagnostic categories (All Causes -Days)” indicator and DEA-ANN Efficiency Scores. For these reasons, in particular, inefficient 13 OECD countries should balance between Hospital Average Length of Stay rate and Efficiency Scores, considering demand, resource and budget constraints.
- ✓ The healthcare managers of the United Kingdom, which falls into the Potential Stars Group of Data Envelopment Analysis Matrix, should strive to become a member of the Super Stars Group of Data Envelopment Analysis Matrix.
- ✓ The healthcare managers of Belgium and Finland, which falls into the To Be Governed Effectively Group of Data Envelopment Analysis Matrix, should govern their healthcare systems effectively to become a member of the Super Stars Group of Data Envelopment Analysis Matrix.
- ✓ The healthcare managers of Chile, France, Italy, Japan, Korea, Poland, Portugal and Spain, which fall into the Question Marks Group of Data Envelopment Analysis Matrix, should revise their healthcare systems parameters to become a member of the Super Stars Group of Data Envelopment Analysis Matrix.

5.4. Limitations of the Dissertation and Future Research Directions

Although this dissertation reported numerous insights by using Data Envelopment Analysis (DEA), the integration of Artificial Neural Network (ANN) and Data Envelopment Analysis (DEA-ANN Model), and Data Envelopment Analysis Matrix (DEAM) methods to understand healthcare operations management, like all empirical research, there are some limitations in this dissertation that open up avenues for future studies;

Firstly, the inputs and outputs data were collected from OECD Health Databases mentioned above. As such, these databases were considered to be correct. Furthermore, the data period consists of 2021 or the nearest year, and this period corresponds to amid COVID-19, which is a global pandemic. Therefore, it is difficult to assess its effect on health systems. Further researchers can analyse based on pre-and post-COVID-19 conditions using Data Envelopment Analysis (DEA)-Malmquist methods within the framework of experimental design.

Secondly, although this dissertation conducts a new and novel trilogy hybrid analysis design, since healthcare systems, like other business research problems, have gradually become complex, further studies can be developed new hybrid models applying different Data Envelopment Analysis approaches, such as Fuzzy Data Envelopment Analysis, Two-Stage Data Envelopment Analysis, Network Data Envelopment Analysis. Also, it is recommended that integrating Data Envelopment Analysis and Artificial Neural Networks (ANN) with other prominent quantitative methods, such as Cluster Analysis, Principal Component Analysis, Tobit Regression, AHP, TOPSIS, to prioritize issues, challenges, drivers, and barriers related to healthcare systems.

Thirdly, a number of particular circumstances in the health systems of the United Kingdom, Sweden, Switzerland and Poland have been determined. However, due to the lack of space and scope in this dissertation, an in-depth analysis of these circumstances is left to future researchers.

5.5. Conclusion

This dissertation has three research objectives;

- (i) to evaluate the efficiency of the operations strategy matrix in healthcare systems of OECD (38) countries using Data Envelopment Analysis (DEA);
- (ii) to evaluate the efficiency of the operations strategy matrix in healthcare systems of OECD (38) countries using the integration of Artificial Neural Network (ANN) and Data Envelopment Analysis (DEA-ANN Model) and,
- (iii) to classify OECD (38) countries divided into four groups; Super Stars, Potential Stars, Question Marks and To Be Governed Effectively based on Data Envelopment Analysis Matrix (DEAM).

In the context of the mentioned objectives, the evaluation of Operations Strategy Matrix, a novel and objective evaluation tool with both desirable and undesirable output, was evaluated using a hybrid methodology which includes Data Envelopment Analysis (DEA), the integration of Artificial Neural Network (ANN) and Data Envelopment Analysis (DEA-ANN Model), and Data Envelopment Analysis Matrix (DEAM).

Future researchers may consider the recommendations for research fields and analysis techniques *in section 5.4*.

According to the results of the Data Envelopment Analysis (DEA) stage, Australia, Austria, Canada, Colombia, Costa Rica, Czech Republic, Denmark, Estonia, Germany, Greece, Hungary, Iceland, Ireland, Israel, Latvia, Lithuania, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Slovak Republic, Slovenia, Türkiye and United States have a score of 1, and they are relatively efficient.

According to the results of the DEA-ANN Model stage, Canada, Lithuania, Mexico, Netherlands, Slovak Republic, and Türkiye have a score of 1 and are relatively efficient.

According to the results of the Data Envelopment Analysis Matrix (DEAM) stage;

- ✓ Australia, Austria, Canada, Colombia, Costa Rica, Czech Republic, Denmark, Estonia, Germany, Greece, Hungary, Iceland, Ireland, Israel, Latvia, Lithuania, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Slovak Republic, Slovenia, Sweden, Switzerland, Türkiye and the United States fall into in the *Super Stars Group*,
- ✓ The United Kingdom fall into the *Potential Stars Group*,
- ✓ Belgium and Finland fall into the *To Be Governed Effectively Group*,
- ✓ Chile, France, Italy, Japan, Korea, Poland, Portugal and Spain fall into the *Question Marks Group*.

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BIOGRAPHY

After graduating from Gaziantep High School in 2002, he graduated from Selcuk University Faculty of Economics and Administrative Sciences Department of Business Administration in 2009. After his undergraduate education, he studied Business Administration at the Institute of Social Sciences of Kilis 7 Aralik University and received his master's degree (MBA) in 2015. After his master's degree (MBA) education, he studied Business Administration at the Institute of Social Sciences of Gebze Technical University and received his doctorate degree in 2022. He is a Lecturer at Adiyaman University Besni Ali Erdemoğlu Vocational High School.



ANNEX

A. Articles Published / (To Be Published) Within the Scope of This Dissertation

1-Özdemir, A., Kitapçı, H., Gök, M. Ş., Ciğerim, E. (2021). “Efficiency Assessment of Operations Strategy Matrix in Healthcare Systems of US States Amid COVID-19: Implications for Sustainable Development Goals”. Sustainability, 13(21), 11934. <https://doi.org/10.3390/su132111934> (SSCI, SCI-E)

