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Determinants of Human Capital Development and Macroeconomic Freedoms: DEA Modelling

Yuliia Yehorova, https://orcid.org/0000-0002-8756-4073
PhD, Research Institute of Trade and Sustainable Business, Faculty of Commerce, University of Economics in Bratislava, Slovakia
Serhii Drozd, https://orcid.org/0000-0002-0716-3078
Department of Economic Cybernetics, Sumy State University, Ukraine
Corresponding author: Serhii Drozd, s.drozd@uabs.sumdu.edu.ua
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Abstract: *The purpose of the study is to identify countries with mechanisms to most effectively ensure that human capital losses do not become an obstacle to strengthening macroeconomic freedoms. The study is based on the hypothesis that a decrease in absence from work due to personal health problems, unemployment, and mortality leads to an increase in the level of six basic macroeconomic freedoms: business, labour, trade, investment, monetary, and financial freedoms. In this case, absence from work due to personal health problems, unemployment, and mortality serve as discouragers/inhibitors of human capital development, the growth of which reduces the chances of an employee obtaining the necessary knowledge and skills to effectively transform this employee's labour into an economic asset. To generalise the scientific opinion on the studied issue, a bibliometric analysis of the relationship between each of these factors and the totality of all macroeconomic freedoms was carried out using the R Bibliometrix package in RStudio software. The basis of this analysis was formed by the databases of publications indexed by Scopus for 1937–2024, consisting of 1618, 1578, and 1517 literature sources for each factor-destimulator. This analysis allowed us to form clouds of the most used keywords and analyse the dynamics of their use, see how the relevant research areas and the keywords used have evolved, build a topic map of the research interface, etc. The information base of the study is the statistical data of Europa and the Heritage Foundation; the object is 30 European countries; the time horizon is 2021; the main method is the non-parametric method of Data Envelopment Analysis (CCR and BCC models); the software package is the rDEA and Benchmarking package in the R programming language. Frontier graphs were constructed that clearly show the efficiency frontier in the CCR and BCC orientations. Six iterations of DEA modelling were carried out, each using only one of the 6 indicators of macroeconomic freedom as an output and three indicators of human capital as inputs. The countries with the most effective national mechanisms to ensure that human capital losses do not become an obstacle to strengthening macroeconomic freedoms are Cyprus, Czech Republic, Iceland, Ireland, Malta, and Romania. These countries demonstrate "benchmark" efficiency in 6 cases out of 6 calculated. There is also a group of countries that have never been included in the list of "benchmark" countries: Austria, Belgium, Croatia, Estonia, France, Hungary, Greece, Italy, Lithuania, Latvia, Portugal, Serbia, Slovakia, and Spain. We have also identified countries that are "benchmark" not by all parameters, but only by certain ones: Bulgaria – only in terms of the impact of the studied human capital determinants on monetary freedom; Luxembourg – only on investment freedom and financial freedom; Poland – only on investment freedom.*
Keywords: Data Envelopment Analysis, economic freedoms, efficiency, freedom of business, health, human capital, investment freedom, labour freedom, mortality, unemployment.
JEL Classification: O15, O16, O52.

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Introduction

Human Capital. Human capital plays an important role in the development of economic relations. A high level of its development is one of the most important factors in the growth of labour productivity and living standards, an important determinant of the country's competitiveness and the building of a fair and successful society. The scientific community most often interprets human capital as a set of all knowledge, skills, abilities, and experiences gained during a person's lifetime that can be used in the process of creating additional economic value. Thus, in particular, Samsudeen et al. (2020) define human capital as mastered knowledge, skills, and ability to generate and accept new ideas, and adapt to them; Becker (1993) – as a stock of knowledge and abilities formed by investing in a person; Law et al. (2008) – as general or special skills acquired during training and work experience; Merriam-Webster (2023) – as skills, knowledge, and qualifications considered as economic assets, etc.

Scientists in the fields of economics, medicine, social sciences, etc. have developed a significant number of studies that examine the impact of various factors on human capital development. For example, Benzoni et al. (2015) examine the impact of economic factors and their components (in particular, the employee's salary level during his/her life cycle) on human capital; Liu et al. (2023) – the impact of environmental factors on the human capital sustainability; Ruzikulov (2022) – the impact of socio-demographic, integration, socio-psychological, environmental, industrial, and demographic aspects on the human capital formation; Abdullayev (2023) – the impact of education, experience, health, and information environment on the human capital formation.

For this study, three important indicators were selected that are discouragers/inhibitors of human capital development, i.e. their growth reduces the chances of an employee acquiring the necessary knowledge and skills to effectively transform this employee's labour into an economic asset:

1) Absence from work due to personal health problems (according to Europa (2021) is calculated as the proportion of the employed population that is absent from work for a certain period due to non-work-related health problems). If an employee has health problems and is unable to work for these reasons, this has a significant impact on this employee's productivity, and if this process is prolonged, it reduces the competitiveness of this employee compared to others, losing important skills and time, which ultimately significantly reduces the potential for using the human capital of such an employee. The importance of the impact of public health on human capital development is highlighted in Ha et al. (2021); Gumbau (2021); Zheng et al. (2020); Gillard et al. (2023); Yang et al. (2022).

2) Unemployment (according to Europa (2021) is calculated as the share of the working-age population that, for reasons beyond their control, has no earnings or other income stipulated by the current legislation due to lack of employment). The impact of unemployment on human capital development is important because unemployment leads to a loss of skills, knowledge, and experience, as well as to a decrease in people's motivation and self-esteem. The impact of unemployment on human capital development has been studied by Nagasubramaniyan et al. (2023); Triatmanto et al. (2023); Majeed et al. (2023); Chukwu (2022); Butkus et al. (2023).

Mortality (according to Europa (2021) is calculated as the total number of deaths that occurred during the year within the country). The impact of population health on the potential for the formation and efficient use of human capital is significant, as health problems reduce the ability to work effectively, improve skills in a timely manner, hinder labour mobility and the acquisition of international work experience, etc. The impact of population health (through various indicators, including mortality rates) on human capital development has been studied by de Camargo Cancela et al. (2023); Hao et al. (2023); Rocco et al. (2021); Onyimadu et al. (2022); Murayama et al. (2021).

Macroeconomic Freedoms. The Index of Macroeconomic Freedom is calculated by The Heritage Foundation, a strategic research institute based in Washington, D.C., founded in 1973. This institution regularly conducts analytical research on many vital economic, foreign policy, and social issues, including assessing the level of basic macroeconomic freedoms in different countries. The data obtained (The Heritage Foundation, 2021) allow us to build macroeconomic freedom indices for 184 countries, which can serve as an assessment of political, investment, and legal risks and help to compare different countries by selected indicators and predict political changes in these countries.

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According to the methodology of the Heritage Foundation (2021), the level of macroeconomic freedom for each country is estimated in the range from 0 to 100, where 100 corresponds to the most favourable environment. The macroeconomic freedom index includes the following components:

1) Business Freedom – assesses the difficulty of starting, running, and closing a business, access to infrastructure, the level of inclusion of women in business, etc. This sub-index is based on four main factors that determine: 1) access to electricity, 2) business environment risks, 3) quality of business regulation, and 4) opportunities for women's economic integration.

2) Labor Freedom – assesses the level of labour market regulation by taking into account the following factors: (1) the level of minimum wage, (2) the rights of associations and trade unions, (3) the availability and duration of annual paid leave, (4) notice periods for redundancy, (5) the availability and amount of severance pay for redundancy, (6) labour productivity, (7) employment, (8) the availability and severity of overtime restrictions, and (9) the ability to dismiss staff in connection with redundancy.

3) Monetary Freedom – assesses the risks of price distortion and price instability due to inflation (weighted average inflation rate over the last three years) and government actions (qualitative assessment of the level of government influence on prices through direct control or subsidies).

4) Trade Freedom – reflects the level of trade barriers to entry into the market of the respective country, based on two main components: an assessment of tariff barriers (weighted average trade tariff rate) and a qualitative assessment of non-tariff barriers.

5) Investment Freedom – determines the risks and restrictions on investment and withdrawal of investment capital in the market of the respective country and takes into account regulatory restrictions. The maximum score of 100 points corresponds to a situation where there are no restrictions (an ideal market). The score is reduced for each case of restrictions on the country's investment regime: unequal opportunities for domestic and foreign investment, restrictions on capital transfers, exchange rates, lack of transparency and bureaucracy, the possibility of expropriation, etc.

6) Financial Freedom – assesses the efficiency of the banking system and the degree of government intervention in the financial sector by taking into account the level of government regulation of financial services, the degree of government intervention in the activities of banks and financial corporations, including through ownership of banks and financial institutions, government influence on the granting and allocation of loans, the development of the financial market and its openness to foreign competition. This study is based on the understanding that a decrease in absence from work due to personal health problems, unemployment, and mortality (as discouragers to human capital formation) leads to an increase in macroeconomic freedoms.

Literature Review

The relationship between mortality and macroeconomic freedoms was studied by Marson et al. (2023). They empirically confirmed the impact of various macroeconomic freedoms on the mortality rate from seasonal influenza. Chen et al. (2020), based on their mathematical model, refuted the existence of a significant link between macroeconomic freedom and the mortality rate from COVID-19. Dempere (2021) studied the link between the levels of macroeconomic freedom and the success of countries in combating the first wave of COVID-19. Moga Rogoz et al. (2022) determined how macroeconomic freedom contributes to an increase in life expectancy in the new EU member states undergoing transformation.

The relationship between the level of unemployment and macroeconomic freedoms was studied by Cervelló-Royo et al. (2023). They used empirical data to argue for the need to take into account macroeconomic freedoms to develop effective mechanisms to reduce unemployment. Gouider (2022) determined which sub-index of macroeconomic freedoms has the strongest impact on youth unemployment. Man et al. (2021) built an econometric model of the dependence of the unemployment rate in a country on the levels of macroeconomic freedoms and the quality of public administration. Callais et al. (2023) determined the relationship between the level of macroeconomic freedoms, institutional quality, and economic growth during the 2002–2007 crisis.

The relationship between absence from work due to personal health problems and macroeconomic freedoms was studied by Nissan et al. (2008). They studied the relationship between labour productivity and macroeconomic freedoms. Zhang et al. (2018) studied the impact of macroeconomic freedom on labour productivity using a multistage semiparametric stochastic frontier estimation.

Bibliometric Analysis. For the bibliometric analysis of the literature on the research topic, we will use the R Bibliometrix package (Aria et al., 2017), in the RStudio software, which allows us to form clouds of the most used keywords and analyse the dynamics of their use, see how the relevant research areas and the keywords used have evolved, build a topic map of the research interface, etc. The basis of the bibliometric analysis is publications indexed by the Scopus scientometric database (for 1937–2024 period). The results of the bibliometric analysis for each human capital development discourager (absence from work due to personal health problems, unemployment, and mortality) and a set of macroeconomic freedoms (business freedom, labour freedom, monetary freedom, trade freedom, investment freedom, financial freedom) are presented in Figs. 1, 2, and 3.

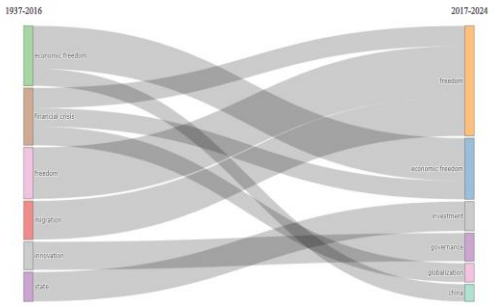
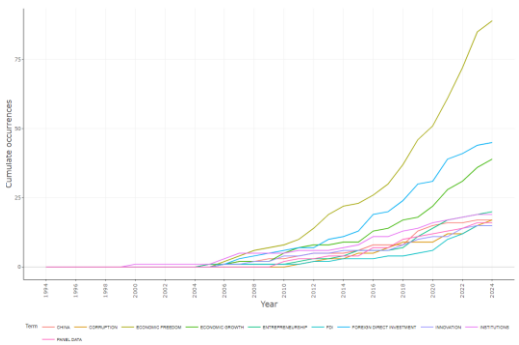
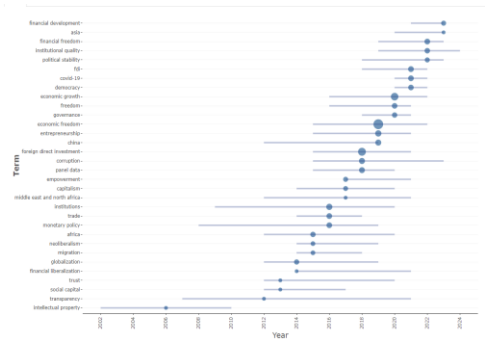
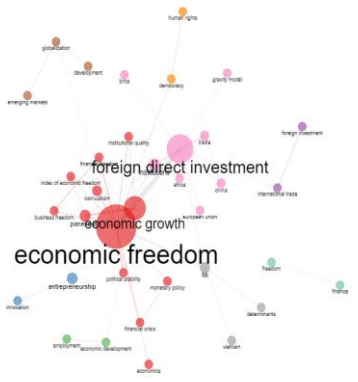
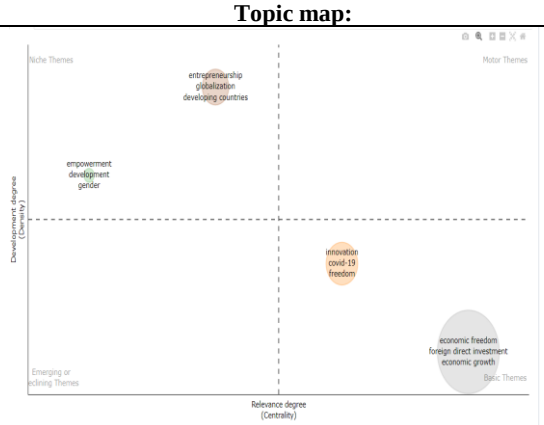
Software package	**Rstudio package and Bibliometrix software**	**Database**	**Scopus**
Keywords queries	(TITLE-ABS-KEY (deaths) OR TITLE-ABS-KEY (business AND freedom) OR TITLE-ABS-KEY (labor AND freedom) OR TITLE-ABS-KEY (monetary AND freedom) OR TITLE-ABS-KEY (trade AND freedom) AND TITLE-ABS-KEY (investment AND freedom) OR TITLE-ABS-KEY (financial AND freedom)		
Number of publications in the Scopus database by keywords	1618	**Period**	1937–2024
Cloud of the most used keywords:		**Evolution of the key research areas:**	
			
Dynamics of keyword usage:		**Evolution of keyword popularity:**	
			
Relationship of research areas:		**Topic map:**	
			

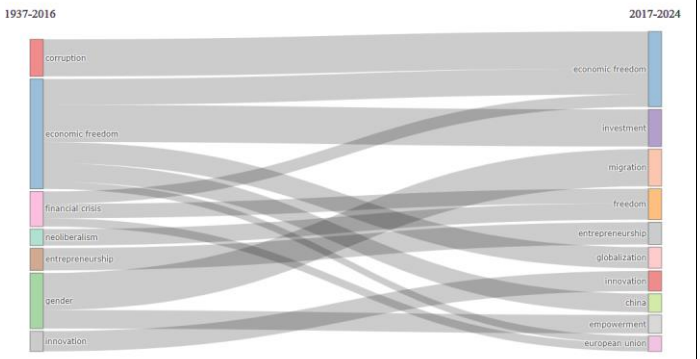
Figure 1. The results of Bibliometric Analysis for Such a Discourager of Human Capital Development as Mortality and a Set of Macroeconomic Freedoms (Business Freedom, Labour Freedom, Monetary Freedom, Trade Freedom, Investment Freedom, and Financial Freedom)

Source: Compiled by the authors using Rstudio package and Bibliometrix software

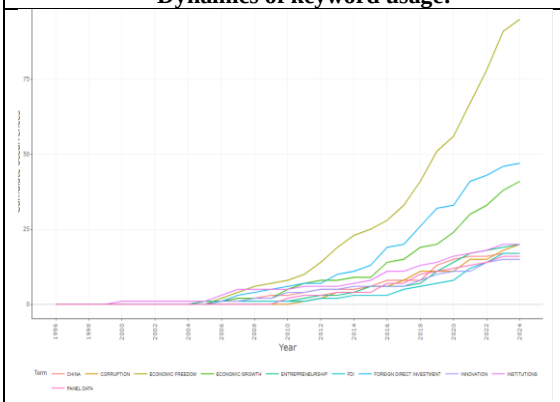
Software package	Rstudio package and Bibliometrix software	**Database**	Scopus
Keywords queries	(TITLE-ABS-KEY (unemployment) OR TITLE-ABS-KEY (business AND freedom) OR TITLE-ABS-KEY (labor AND freedom) OR TITLE-ABS-KEY (monetary AND freedom) OR TITLE-ABS-KEY (trade AND freedom) AND TITLE-ABS-KEY (investment AND freedom) OR TITLE-ABS-KEY (financial AND freedom)		
Number of publications in the Scopus database by keywords	1578	**Period**	1937–2024

Cloud of the most used keywords:

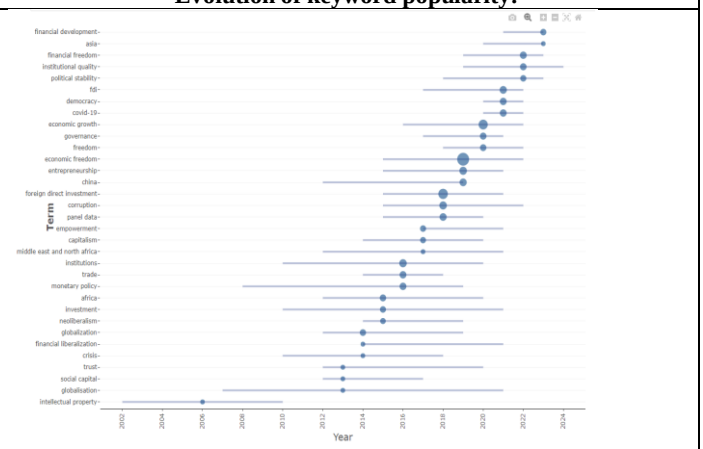
Evolution of the key research areas:



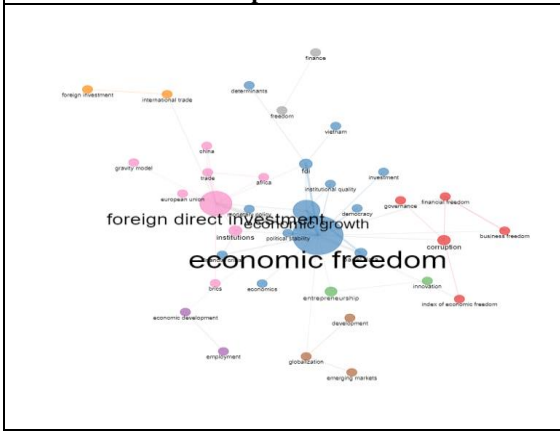
Dynamics of keyword usage:



Evolution of keyword popularity:



Relationship of research areas:



Topic map:

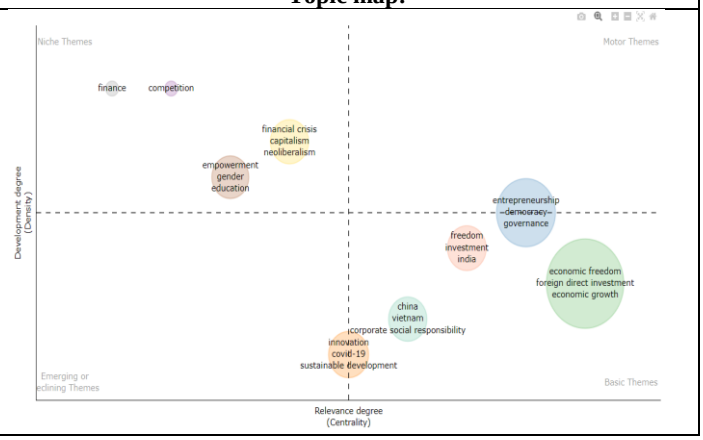


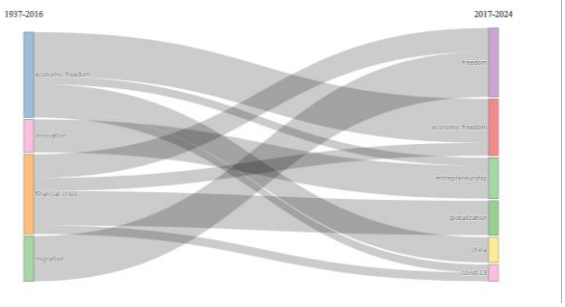
Figure 2. The Results of Bibliometric Analysis for Such a Discourager of Human Capital Development as Unemployment and a Set of Macroeconomic Freedoms (Business Freedom, Labour Freedom, Monetary Freedom, Trade Freedom, Investment Freedom, And Financial Freedom)

Source: Compiled by the authors using Rstudio package and Bibliometrix software

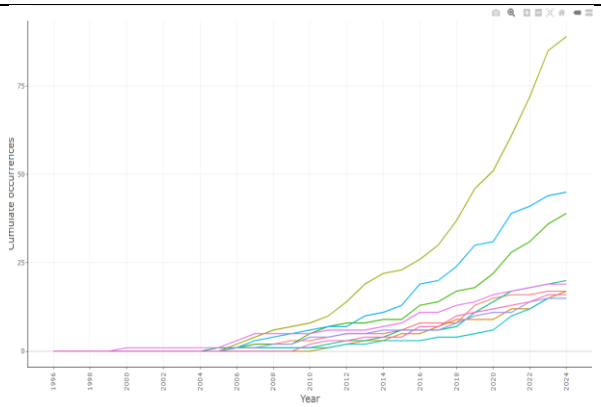
Software package	Rstudio package and Bibliometrix software	**Database**	Scopus
Keywords queries	(TITLE-ABS-KEY (absence AND from AND work AND due AND to AND personal AND health AND problem) OR TITLE-ABS-KEY (business AND freedom) OR TITLE-ABS-KEY (labor AND freedom) OR TITLE-ABS-KEY (monetary AND freedom) OR TITLE-ABS-KEY (trade AND freedom) AND TITLE-ABS-KEY (investment AND freedom) OR TITLE-ABS-KEY (financial AND freedom)		
Number of publications in the Scopus database by keywords	1517	**Period**	1937-2024

Cloud of the most used keywords:

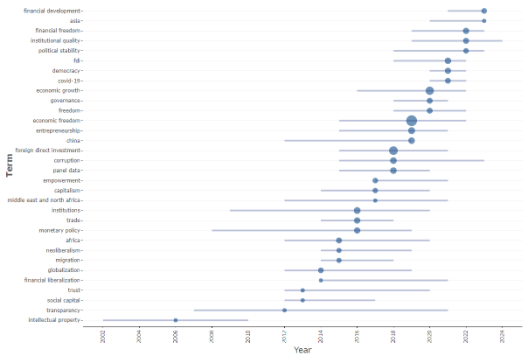
Evolution of the key research areas:



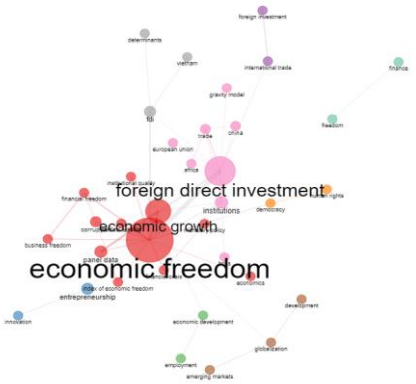
Dynamics of keyword usage:



Evolution of keyword popularity:



Relationship of research areas:



Topic map:

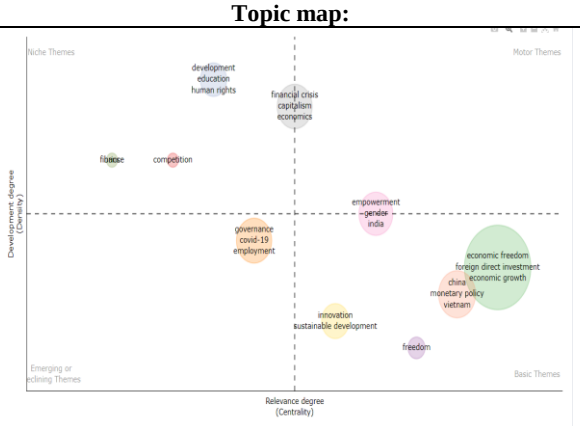


Figure 3. The Results of Bibliometric Analysis for Such a Discourager of Human Capital Development as Absence From Work Due to Personal Health Problems and A Set of Macroeconomic Freedoms (Business Freedom, Labour Freedom, Monetary Freedom, Trade Freedom, Investment Freedom, And Financial Freedom Together)

Source: Compiled by the authors using Rstudio package and Bibliometrix software

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The analysis of the results of the bibliometric analysis presented in Figs. 1, 2, and 3, allows us to draw several of interesting conclusions. When studying the relationship between mortality and the set of macroeconomic freedoms (Fig. 1), a significant increase in the number of articles occurred in 2006–2024, and an analysis of the evolution of the popularity of keywords showed that most of their peaks occurred in 2012–2022. The highest activity of authors studying the relationship between macroeconomic freedoms and unemployment (Fig. 2) was in 2013–2020. The highest activity of authors studying macroeconomic freedoms with regard to the factor of absence from work due to personal health problems is in 2012–2022.

The most used keywords (number of uses) are:

- in the study of the relationship between mortality and the set of macroeconomic freedoms: economic freedom (89), foreign direct investment (45), economic growth (39), entrepreneurship (20), institutions (19), china (17), corruption (17), panel data (16), fdi (15), innovation (15), covid-19 (14), european union (14), financial freedom (14), monetary policy (14), trade (14), democracy (13), financial crisis (13), freedom (13), institutional quality (12), africa (11);
- in the study of the relationship between unemployment and the set of macroeconomic freedoms: economic freedom (95), foreign direct investment (47), economic growth (41), corruption (20), entrepreneurship (20), institutions (20), china (17), fdi (17), panel data (16), innovation (15), covid-19 (14), democracy (14), european union (14), financial freedom (14), monetary policy (14), trade (14), financial crisis (13), governance (12), institutional quality (12), africa (11);
- in the study of the relationship between absence from work due to personal health problems and the set of macroeconomic freedoms: economic freedom (89), foreign direct investment (45), economic growth (39), entrepreneurship (20), institutions (19), china (17), corruption (17), panel data (16), fdi (15), innovation (15), financial freedom (14), monetary policy (14), trade (14), democracy (13), european union (13), financial crisis (13), institutional quality (12), africa (11), freedom (11), governance (11).

As we can see, the keywords found in these queries are multidirectional and describe a wide range of research areas. Most of them are logical and understandable, but the appearance of two geographical names in these lists, in particular, China and Africa, suggests that an interesting area for further research on the issues chosen in this article would be to conduct an in-depth analysis on the example of these regions and find out their specific features.

Thus, the analysis of the evolution of key research areas on the relationship between all the studied human capital factors and macroeconomic freedom, presented in Figs. 1, 2, and 3, shows that a separate area – "China" in 2017–2024 – has emerged from the "economic freedom" area, which was significant in science in 1937–2016. This indicates that the observance of macroeconomic freedoms in China is a significant problem that scholars from different countries are focusing their efforts on solving. On the one hand, since 1978, when China introduced economic reforms, the country has experienced impressive economic growth, which was achieved by strengthening the role of the market and attracting foreign investment. This has brought significant business and entrepreneurship development in China.

However, on the other hand, the Chinese economy remains heavily controlled by the state. The government retains significant influence over the economic sector through state ownership, regulation, and other control mechanisms. This may limit some aspects of economic freedom, such as property rights and freedom of market competition. The Heritage Foundation's Index of Economic Freedom generally reflects this dichotomous nature of the situation in China. Although the Chinese economy has made significant achievements, it may score low on the Heritage Foundation's macroeconomic freedom scores in categories related to government intervention and the level of regulation.

The research area "financial crisis", which is indicated in Figs. 1, 2, and 3, shows as being popular in 1937–2016, was split into several other areas in 2017–2024. In particular, Fig. 1 shows that such areas as "freedom", "economic freedom', and "globalization" have become derivatives of it. This indicates that in the context of financial crises and globalisation, economic freedoms can affect the stability of the financial system and the country's ability to adapt to changes in the global economy. Economic freedoms, financial crises, and globalisation are interrelated phenomena that affect the modern economy.

Financial crises can arise for a variety of reasons, including excessive risky lending, unstable financial markets, and inadequate regulation that reduces economic freedoms. Globalisation refers to the process of increasing economic, social, and political integration between countries and regions of the world. It facilitates the convergence of markets, increased international trade, foreign investment, and technology exchange. However,

globalisation also creates new challenges, such as greater competition in global markets and the risk of cross-border crises, which places new demands on effective regulation and economic policy and creates a need for common regulatory mechanisms across countries.

In the context of studying the impact of human capital characteristics and macroeconomic freedoms, it was interesting to combine the areas of "freedom"/"economic freedom" and "migration" in 1937–2016 into one area of "freedom" in 2017–2024 (Figs. 1 and 3). This suggests that economic freedoms can create incentives for migration, depending on individual goals and opportunities. The concepts of "freedom" and "migration" are interrelated through: (1) labour migration (traditionally, countries with free markets create more opportunities for earning money, which attracts migrants); (2) business migration (entrepreneurs may wish to move to countries with a higher level of economic freedom – with a favourable business environment, low taxes and minimal restrictions on starting or developing a business); (3) investment migration (investors may seek countries with a high level of economic freedom to invest their funds); (4) financial migration (to protect financial assets from political and economic risks).

An interesting fact is that the research for 1937–2016 on "corruption" evolved in 2017–2024 into the topic of "economic freedom" (Fig. 2). Developed economic freedoms can help reduce corruption: (1) the greater the economic freedoms and transparency, the less opportunities for corruption, as the actions of public officials become more visible and subject to greater public scrutiny; (2) economic freedoms promote the development of the legal system, which can be an obstacle to corrupt schemes; (3) healthy competition, which often occurs in the context of economic freedoms, can reduce corruption, as businesses and organisations prefer innovation and efficiency to mutual agreements. Therefore, fighting corruption and ensuring economic freedoms are interconnected and important for the stable development of society.

In the context of the study of the relationship between unemployment and macroeconomic freedoms, it was interesting, in the set of studies for 1937–2016 (Fig. 2) in the area of "economic freedom" and "unemployment", to identify separate areas from 2017–2024: "economic freedom", "investment", "globalisation", "China", and "European union". Countries with a high level of economic freedom, such as Western democracies, usually have a more stable legal system that protects property rights and contracts and, in turn, encourages investors to invest in these countries. China's economy is increasingly becoming a separate area of research, as political and social factors play a key role in determining economic policy and regulating markets in China. Despite the large labour force in China, sectors and regions of the country can experience large differences in unemployment rates due to economic fluctuations and transitions in the Chinese economy.

The European Union is a complex economic and political structure whose common policies have a significant impact on unemployment and economic freedoms of its member states (this is an interesting area for further research). In the context of the study of the relationship between unemployment and macroeconomic freedoms, it is interesting to note that research conducted in the period 1937–2016 with the keyword "gender" changed its focus in 2017–2024 to "empowerment" and "migration". The expansion of human rights, including the rights of women, migrants, and other groups, has an impact on broader social and economic justice, as it can include access to jobs, education, and health services, which facilitates their integration and contributes to social and economic development. It is not for nothing that women's inclusion in the labour market is measured in the Labour Freedom Index.

The research conducted in the period 1937–2016 in the area of "economic freedom", taking into account the factor of absence from work due to personal health problems (Fig. 3), was divided into four separate areas in 2017–2024: "economic freedom", "entrepreneurship", "China", and "covid-19". The impact of the COVID-19 pandemic, during which many countries imposed travel restrictions and introduced remote workplace regimes, gained popularity during this period. Economic freedoms, such as freedom of establishment, freedom of competition, freedom of ownership and low levels of regulation, encourage "entrepreneurship" and the creation of new businesses. Entrepreneurship is one of the main sources of job creation in society, given that entrepreneurship is based on the development of small and medium-sized enterprises, which are the basis of economic activity and provide a significant number of jobs. The research conducted in the period 1937–2016 (Fig. 3) with the keyword "financial crisis" is divided into 4 areas in 2017–2024: "economic freedom", "freedom", "globalisation", and "covid-19". The emergence of crises due to restrictions imposed during the COVID-19 pandemic and restrictions on freedoms attracted the attention of scholars during this period.

The analysis of the closeness of the keywords and topic maps (Figs. 1, 2, and 3) shows that such keywords as "economic freedom", "economic growth", and "foreign direct investment" are strongly related to each other, and they are also closely related to other keywords. It should be noted that these keywords are basic in the

chosen research topic. Other basic keywords include “innovation”, “covid-19”, and “freedom”. The group of popular keywords that define the sub-topics of the research includes the following: “entrepreneurship”, “globalisation”, “developing countries”, “empowerment”, “development”, and “gender”.

Methodology

The choice of research method directly depends on the type of input data of the indicator (quantitative or qualitative indicators) and the availability of these data. Quantitative indicators require the use of objective research methods, while qualitative input data require subjective methods. All input data in this study are quantitative, so the objective method of Data Envelopment Analysis (DEA) was chosen for further calculations. This statistical method searches for efficiency values in a group of objects and identifies reference objects in the group. DEA analysis does not make any assumptions about the distribution of data, as it is a non-parametric method (Charnes et al., 1978). Let us consider some examples of the use of data envelopment analysis (DEA) in modern economic research.

Flegl et al. (2023) applied a two-stage data envelopment analysis (DEA) to find indicators of the technical efficiency of public safety systems in Mexico. See et al. (2023) developed a mixed-integer generalised DEA model to assess the level of efficiency of regional university technology transfer in China. Vaseei et al. (2023) presented a network data coverage analysis model to evaluate the effectiveness of a sustainable supply chain process through initial modelling. Jiakui et al. (2023), together with colleagues, conducted an efficiency analysis using the data envelopment analysis and directional distance function (DEA-DFF) method for indicators of green finance, financial development, and green innovative technologies in terms of their impact on the aggregate environmental productivity of production factors in China.

Lotfi et al. (2010) in their study developed a model of employee performance and identified the factors that influence it (performance was measured only using the CCR model). Tasnim et al. (2018) used DEA analysis and the Tobit model to study the impact of national entrepreneurship systems on country-level efficiency, which allowed them to identify the most relevant macro determinants that determine this efficiency. Monika et al. (2015) used the CCR method based on qualitative indicators (based on the data from the company’s employee survey) to assess the effectiveness of the human resource management system.

The main idea of the DEA method is to find a combination of inputs that will maximise outputs or a combination of outputs that will minimise costs. For this purpose, DEA uses a set of linear programmes to limit the use of resources and ensure that the desired results are achieved. DEA has a number of advantages over other efficiency assessment methods. Firstly, it is non-parametric, which allows it to be used to assess the efficiency of facilities with different data distributions. Secondly, DEA is flexible, which allows it to be used to assess the efficiency of facilities with different objectives. Thirdly, DEA is efficient, which allows it to be used to evaluate the efficiency of large data sets. Thus, the Data Envelopment Analysis (DEA) method of finding efficiency indicators meets the main objective of the study – to identify countries with mechanisms to most effectively ensure that human capital losses do not become an obstacle to strengthening macroeconomic freedoms.

The DEA methodology allows for efficiency analysis using two types of models:

- CCR model (Charnes-Cooper-Rhodes model) is an efficiency evaluation model used to compare the performance of several decision-making units (DMUs). A DMU is any organisation that makes products (outputs) (e.g. goods or services) using resources (inputs). CCR models are based on the assumption that production technologies have constant scales. This means that an increase in production inputs leads to a proportional increase in output (Yarovenko et al., 2020);
- BCC model (Banker-Charnes-Cooper model) is a model based on the concept of the production frontier, which is the set of all production combinations for a given set of inputs and outputs. In the Banker-Charnes-Cooper model, a DMU is considered efficient if its actual combination of outputs and inputs is in the production frontier. To determine whether a DMU is efficient, the BCC model uses optimisation software to find the best use of resources for a given set of outputs. If the actual resource use of the DMU is equal to the best use, the DMU is considered efficient (Havlíček et al., 2020).

In addition to the two models of efficiency search (CCR and BCC), the DEA methodology separates each model by using two different orientations of input resources. There is an input orientation and an output orientation, each of which is used to identify efficient and inefficient units, but they are suitable for different situations of efficiency search. The choice between the two depends on which aspect of efficiency needs to be investigated more: maximising outputs with fixed inputs or minimising inputs while achieving specified output

goals. The input-oriented approach analyses how companies (or other objects of study, such as countries) use their inputs to generate outputs. The goal is to maximise output with fixed inputs.

In the output-oriented approach, the analysis is conducted in terms of how companies generate output products or services using fixed inputs. The goal is to minimise inputs for a given output (Babalola et al., 2020). In this study, we use the output-oriented model using the BCC and CCR methods. It is assumed that the optimal combinations will be those in which maintaining the existing level of output data (level of macroeconomic freedoms) is achieved by reducing input indicators (input indicators in our study are discouragers/inhibitors of human capital development (health-related absence, unemployment, and mortality rates), so their level should be reduced).

To conduct the study, a statistical database of the following indicators was formed:

- Business Freedom (K1) (the Heritage Foundation, 2021),
- Labor Freedom (K2) (the Heritage Foundation, 2021),
- Monetary Freedom (K3) (the Heritage Foundation, 2021),
- Trade Freedom (K4) (the Heritage Foundation, 2021),
- Investment Freedom (K5) (the Heritage Foundation, 2021),
- Financial Freedom (K6) (the Heritage Foundation, 2021),
- Absence from work due to personal health problems (K7) (Europa, 2021),
- Unemployment (K8) (Europa, 2021),
- Deaths (K9) (Europa, 2021).

To solve this optimisation problem, the data normalisation procedure is not mandatory, so the original data is used in the calculations in its own units of measurement. The DEA method was implemented in the study using the rDEA package in the R programming language (Simm et al., 2022). The code for this analysis is presented below (Fig. 4). The implementation of the construction of efficiency graphs in the study was performed using the Benchmarking package in the R programming language (Bogetoft et al., 2011).

```
library(rDEA)
data<- read.csv("C:/Econometrics/data.csv")
View(data)
attach(data)
data1=data[,-1]
row.names(data1)=data[,1]
View(data1)
X = (data1[,1])
Y = (data1[,7:9])
bcc= dea(XREF=Y, YREF=X, X=Y, Y=X,  W=NULL, model="input", RTS="variable")
data$bcc_input <- factor(bcc$thetaOpt)
bcc1= dea(XREF=Y, YREF=X, X=Y, Y=X,  W=NULL, model="output", RTS="variable")
data$bcc_output <- factor(bcc1$thetaOpt)
ccr= dea(XREF=Y, YREF=X, X=Y, Y=X,  W=NULL, model="input", RTS="constant")
data$ccr_input <- factor(ccr$thetaOpt)
ccr1= dea(XREF=Y, YREF=X, X=Y, Y=X,  W=NULL, model="output", RTS="constant")
data$ccr_output <- factor(ccr1$thetaOpt)
View(data)
clipr::write_clip(data)
library(Benchmarking)
dea.plot(Y, X, RTS="vrs", ORIENTATION="out",txt=TRUE,lwd=4,cex=1.5,col="red", main="BCC(vrs) out")
dea.plot(Y, X, RTS="crs", ORIENTATION="out",txt=TRUE,lwd=4,cex=1.5,col="red", main="CCR(crs) out")
```

Figure 4. Code to Implement the Search for Optimal Efficiency Values Using the DEA Method

Source: Compiled by the authors in RStudio

Using the code described above, six iterations are needed to identify the countries that have the most effective national mechanisms to ensure that human capital losses do not become an obstacle to the strengthening of macroeconomic freedoms. Each iteration of the modelling uses only one indicator of economic freedom as an

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output and three indicators of human capital as inputs. In other words, the output (X) is one indicator for each of the six models that characterise macroeconomic freedom (K1, K2, K3, K4, K5, K6), and the input (Y) in all six models is K7, K8, and K9, which are used simultaneously. The desired trend for the input indicators should be to minimise their values; for the output indicators – to maximise them.

Results

The input sample of indicators for 30 countries is presented in Table 1. The input sample consists of 30 European countries, all of which have fairly high levels of human capital and macroeconomic freedom. Therefore, the search for countries that are optimal in terms of resource efficiency will provide the best information base for development and reform in countries with much lower indicators.

Table 1. Input Indicators for the 30 Countries in the Study Sample

Country	K1	K2	K3	K4	K5	K6	K7	K8	K9
Austria	72.6	68.4	81.7	84.0	90.00	70.00	53.1	6.2	91962.00
Belgium	80.1	61.1	82.0	84.0	85.00	70.00	41.3	6.3	112331.00
Bulgaria	62.9	68.5	85.2	84.0	70.00	60.00	15.8	5.3	148995.00
Croatia	56.2	43.6	78.7	84.0	75.00	60.00	21.8	7.6	62712.00
Cyprus	76.1	60.5	85.0	84.0	75.00	60.00	20.4	7.5	7202.00
Czechia	68.8	77.1	79.7	84.0	70.00	80.00	21.1	2.8	139891.00
Denmark	88.8	73.8	84.5	84.0	90.00	80.00	51.1	5.1	57152.00
Estonia	72.7	57.8	79.7	84.0	90.00	70.00	33.4	6.2	18587.00
Finland	85.8	50.5	83.3	84.0	85.00	80.00	57.9	7.7	57659.00
France	80.2	44.8	77.3	84.0	75.00	70.00	31.8	7.9	661779.00
Germany	82.4	53.0	77.2	84.0	80.00	70.00	58.6	3.7	1023687.00
Greece	75.8	49.8	80.0	84.0	55.00	50.00	16.2	14.7	143923.00
Hungary	59.9	64.8	78.8	84.0	80.00	70.00	29.7	4.1	156131.00
Iceland	83.6	62.0	79.4	86.8	80.00	70.00	53.7	6.1	2333.00
Ireland	81.5	76.1	84.4	84.0	90.00	70.00	20.0	6.2	34292.00
Italy	68,1	50.5	84.2	84.0	80.00	50.00	30.3	9.5	701346.00
Latvia	76.5	73.8	79.6	84.0	85.00	60.00	31.7	7.6	34600.00
Lithuania	73.1	74.4	80.1	84.0	70.00	70.00	27.9	7.1	47746.00
Luxembourg	66.1	45.9	76.5	84.0	95.00	80.00	47.1	5.3	4489.00
Malta	67.6	61.8	77.1	84.0	85.00	60.00	41.2	3.4	4163.00
Netherlands	80.5	60.1	80.4	84.0	90.00	80.00	48.0	4.2	170972.00
Norway	85.5	57.8	75.4	84.0	75.00	60.00	46.1	4.4	42002.00
Poland	61.6	66.1	80.8	84.0	80.00	70.00	23.3	3.4	519517.00
Portugal	75.9	44.1	85.0	84.0	70.00	60.00	29.7	6.6	124802.00
Romania	59.7	63.6	77.7	84.0	70.00	50.00	3.5	5.6	335527.00
Serbia	71.0	67.3	81.1	77.2	70.00	50.00	16.4	11.1	136622.00
Slovakia	55.6	52.2	74.8	84.0	75.00	70.00	23.1	6.8	73461.00
Slovenia	78.8	61.5	81.9	84.0	70.00	50.00	36.5	4.8	23261.00
Spain	66.3	57.9	83.5	84.0	85.00	70.00	22.8	14.8	449149.00
Sweden	83.2	53.9	81.5	84.0	85.00	80.00	41.0	8.8	91958.00

Note: Business Freedom (K1), Labor Freedom (K2), Monetary Freedom (K3), Trade Freedom (K4), Investment Freedom (K5), Financial Freedom (K6), Absence from work due to personal health problems (K7), Unemployment (K8), Deaths (K9)

Sources: Compiled by the authors based on (The Heritage Foundation, 2021; Europa, 2021)

Based on these data, six iterations of DEA modelling were conducted, each using only one indicator of economic freedom (K1, K2, K3, K4, K5, K6) as an output and three indicators of human capital (K7, K8 and K9) as inputs. The results of the DEA model (specifications − CCR and BCC; orientation − output) for the 30 countries in the study sample are presented in Table 2.

Table 2. Results of the DEA Model (Specifications − CCR and BCC; Orientation − Output) for the 30 Countries in the Study Sample

Country	Input: K7, K8, K9 Output: K1		Input: K7, K8, K9 Output: K2		Input: K7, K8, K9 Output: K3		Input: K7, K8, K9 Output: K4		Input: K7, K8, K9 Output: K5		Input: K7, K8, K9 Output: K6	
	BCC	CCR	BCC	CCR	BCC	CCR	BCC	CCR	BCC	CCR	BCC	CCR
Austria	0.820	0.607	0.892	0.581	0.960	0.606	0.971	0.587	0.947	0.654	0.875	0.595
Belgium	0.930	0.702	0.795	0.533	0.963	0.646	0.976	0.634	0.905	0.673	0.875	0.616
Bulgaria	0.863	0.856	0.939	0.925	1.000	1.000	0.999	0.982	0.871	0.866	0.888	0.884
Croatia	0.686	0.609	0.571	0.502	0.925	0.802	0.996	0.855	0.830	0.733	0.817	0.758
Cyprus	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Czechia	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table 2 (cont.). Results of the DEA Model (Specifications − CCR and BCC; Orientation − Output) for the 30 Countries in the Study Sample

Denmark	1,000	0.876	0.984	0.755	1.000	0.735	0.977	0.681	0.957	0.749	1.000	0.825
Estonia	0,894	0.839	0.839	0.745	0.952	0.842	0.988	0.861	0.979	0.916	0.939	0.918
Finland	0.966	0.651	0.662	0.405	0.979	0.572	0.969	0.548	0.895	0.551	1.000	0.656
France	0.952	0.580	0.581	0.294	0.907	0.465	0.982	0.475	0.814	0.511	0.875	0.477
Germany	1.000	0.906	0.687	0.520	0.945	0.733	0.991	0.757	0.921	0.865	0.875	0.662
Greece	0.991	0.924	0.680	0.627	0.939	0.855	0.997	0.880	0.644	0.598	0.733	0.714
Hungary	0.773	0.657	0.840	0.655	0.954	0.755	0.990	0.765	0.951	0.839	0.875	0.690
Iceland	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Ireland	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Italy	0.812	0.453	0.655	0.306	0.988	0.459	0.983	0.430	0.871	0.493	0.625	0.325
Latvia	0.917	0.741	0.970	0.778	0.936	0.728	0.987	0.760	0.922	0.735	0.795	0.669
Lithuania	0.878	0.738	0.976	0.797	0.942	0.769	0.990	0.800	0.765	0.635	0.935	0.802
Luxembourg	0.845	0.805	0.734	0.665	0.957	0.869	0.980	0.887	1.000	1.000	1.000	1.000
Malta	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Netherlands	0.959	0.809	0.780	0.556	0.971	0.700	0.986	0.690	1.000	0.857	1.000	0.719
Norway	1.000	0.974	0.821	0.688	0.923	0.755	0.986	0.781	0.829	0.712	0.771	0.723
Poland	0.855	0.781	0.857	0.750	0.997	0.879	0.996	0.866	1.000	1.000	0.875	0.773
Portugal	0.912	0.695	0.573	0.397	0.998	0.714	0.985	0.690	0.763	0.602	0.750	0.554
Romania	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Serbia	0.925	0.868	0.917	0.852	0.952	0.872	0.917	0.815	0.817	0.764	0.734	0.716
Slovakia	0.676	0.593	0.683	0.580	0.879	0.750	0.994	0.841	0.828	0.730	0.934	0.835
Slovenia	1.000	0.982	0.885	0.823	1.000	0.927	0.992	0.903	0.783	0.735	0.694	0.689
Spain	0.807	0.444	0.751	0.388	0.980	0.468	0.987	0.452	0.939	0.500	0.875	0.552
Sweden	0.966	0.621	0.703	0.416	0.957	0.567	0.976	0.572	0.905	0.573	1.000	0.646

Note: Business Freedom (K1), Labor Freedom (K2), Monetary Freedom (K3), Trade Freedom (K4), Investment Freedom (K5), Financial Freedom (K6), Absence from work due to personal health problems (K7), Unemployment (K8), Deaths (K9)

Source: Compiled by the author using the rDEA package

In input and output models, efficiency is measured by the ratio of weighted outputs to weighted inputs. The efficiency score is expressed as a percentage, with 100% representing perfect efficiency. An efficiency score of 100% means that a country uses its inputs in the most productive way possible to produce its outputs, and there is no better combination of inputs and outputs given a given set of inputs. A visual representation of the efficiency frontier is shown in Figure 5.

The following notation is used in Figure 5:

1) Indicators: *Business Freedom (K1), Labor Freedom (K2), Monetary Freedom (K3), Trade Freedom (K4), Investment Freedom (K5), Financial Freedom (K6), Absence from work due to personal health problems (K7), Unemployment (K8), Deaths (K9);*

2) Countries: *Austria (AUT), Belgium (BEL), Bulgaria (BUL), Croatia (HRV), Cyprus (CYP), Czechia (CZE), Denmark (DNK), Estonia (EST), Finland (FIN), France (FRA), Germany (GER), Greece (GRC), Hungary (HUN), Iceland (ISL), Ireland (IRL), Italy (ITA), Latvia (LVA), Lithuania (LTU), Luxembourg (LUX), Malta (MLT), Netherlands (NLD), Norway (NOR), Poland (POL), Portugal (PRT), Romania (ROU), Serbia (SRB), Slovakia (SVK), Slovenia (SVN), Spain (ESP), Sweden (SWE).*

As can be seen (Fig. 5), the position of the efficiency frontier differs slightly when using different specifications of the DEA model (CCR or BCC).

Table 3 summarises the results of the study. The numbers 0, 1, and 2 in Table 3 indicate the number of times the country was the best among the others in the sample (the country with the most effective national mechanisms that prevent the loss of human capital from slowing down the strengthening of macroeconomic freedoms):

- The number 1 is an indicator that the country in the modelling process has acquired the status of a "benchmark" (most efficient) country using one of the two model specifications (BCC and CCR);
- The number 2 is an indicator that the country in the modelling process has acquired the status of a "benchmark" (most efficient) country using each of the two model specifications (BCC and CCR);
- The number 0 is an indicator that the country has never achieved the status of "benchmark" (most efficient) in the modelling process using either of the two model specifications (BCC and CCR).

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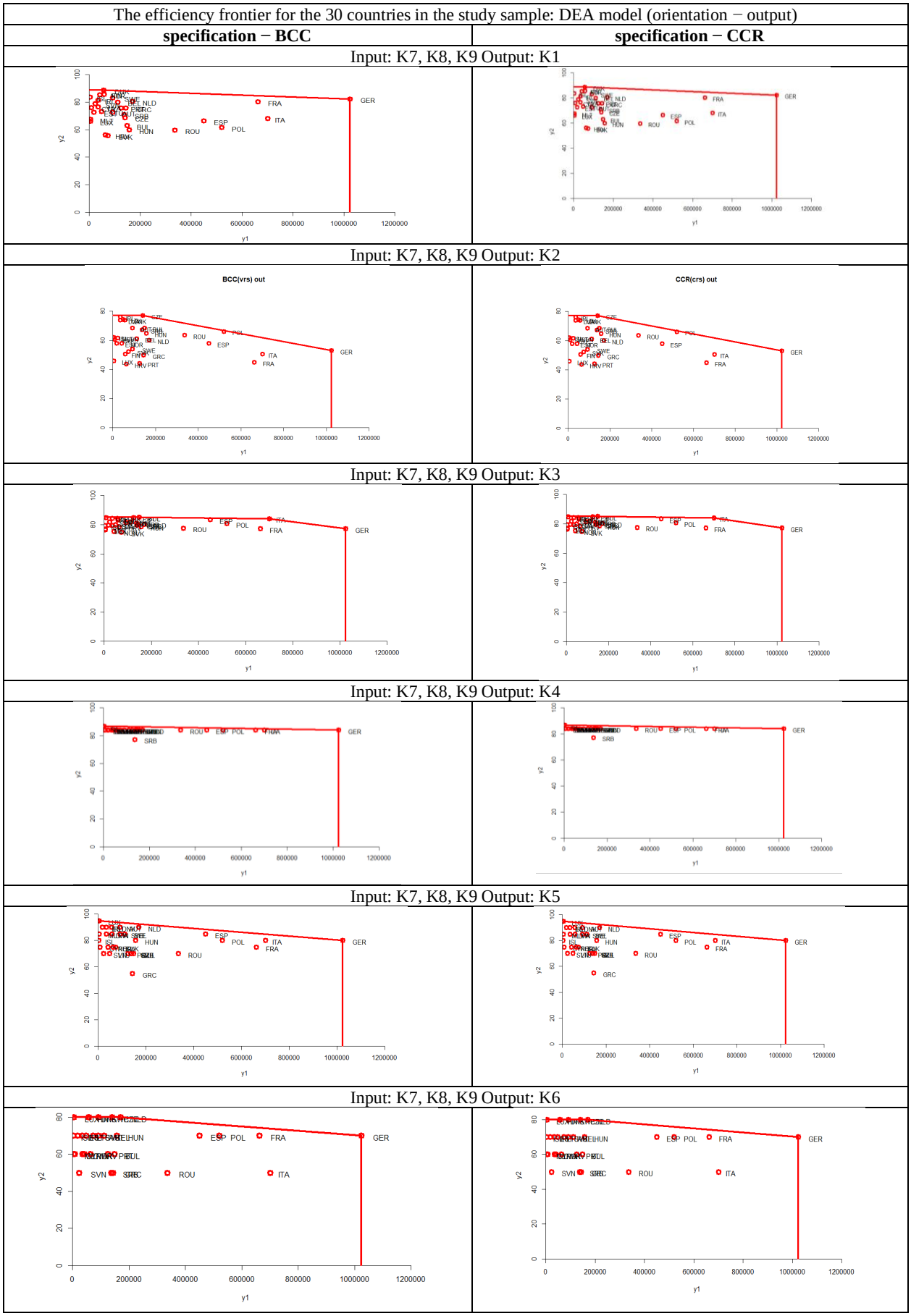

Figure 5. Efficiency Frontier for the 30 Countries in the Study Sample: DEA Model (Specification − BCC and CCR; Orientation − Output)

Source: Compiled by the authors using the Benchmarking package

Table 3. Summarised Results of the DEA Analysis

Country	Input: K7, K8, K9 Output: K1	Input: K7, K8, K9 Output: K2	Input: K7, K8, K9 Output: K3	Input: K7, K8, K9 Output: K4	Input: K7, K8, K9 Output: K5	Input: K7, K8, K9 Output: K6
AUT	0	0	0	0	0	0
BEL	0	0	0	0	0	0
BUL	0	0	2	0	0	0
HRV	0	0	0	0	0	0
CYP	2	2	2	2	2	2
CZE	2	2	2	2	2	2
DNK	1	0	1	0	0	1
EST	0	0	0	0	0	0
FIN	0	0	0	0	0	1
FRA	0	0	0	0	0	0
GER	1	0	0	0	0	0
GRC	0	0	0	0	0	0
HUN	0	0	0	0	0	0
ISL	2	2	2	2	2	2
IRL	2	2	2	2	2	2
ITA	0	0	0	0	0	0
LVA	0	0	0	0	0	0
LTU	0	0	0	0	0	0
LUX	0	0	0	0	2	2
MLT	2	2	2	2	2	2
NLD	0	0	0	0	1	1
NOR	1	0	0	0	0	0
POL	0	0	0	0	2	0
PRT	0	0	0	0	0	0
ROU	2	2	2	2	2	2
SRB	0	0	0	0	0	0
SVK	0	0	0	0	0	0
SVN	1	0	1	0	0	0
ESP	0	0	0	0	0	0
SWE	0	0	0	0	0	1

Note: Business Freedom (K1), Labor Freedom (K2), Monetary Freedom (K3), Trade Freedom (K4), Investment Freedom (K5), Financial Freedom (K6), Absence from work due to personal health problems (K7), Unemployment (K8), Deaths (K9)

Sources: Calculated by the authors using MS Excel

The analysis of Table 3 shows that the most effective national mechanisms to ensure that human capital losses do not slow down the strengthening of macroeconomic freedoms are in the following countries: Cyprus, Czech Republic, Iceland, Ireland, Malta, Romania. These countries demonstrate "benchmark" efficiency (marked "2" in Table 3) in 6 cases out of 6 calculated.

There are also 3 countries that are not "benchmarks" in all the parameters studied, but only in 1 or 2:

1) Bulgaria − only in terms of the impact of the studied human capital determinants on Monetary Freedom (K3);

2) Luxembourg – in terms of the impact of the human capital determinants on Investment Freedom (K5) and Financial Freedom (K6);

3) Poland − only for the impact of the studied human capital determinants on Investment Freedom (K5).

There are countries that turned out to be "benchmarks" not according to both model specifications (BCC and CCR), but according to one of them (marked "1" in Table 3):

1) Denmark − regarding the impact of the studied human capital determinants on Business Freedom (K1), Monetary Freedom (K3) and Financial Freedom (K6);

2) Finland – in terms of the impact of the studied human capital determinants on Financial Freedom (K6);

3) Germany – in terms of the impact of the studied human capital determinants on Business Freedom (K1);

4) the Netherlands – in terms of the impact of the studied human capital determinants on Investment Freedom (K5) and Financial Freedom (K6);

5) Norway – in terms of the impact of the studied human capital determinants on Business Freedom (K1);

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6) Slovenia – in terms of the impact of the studied human capital determinants on Business Freedom (K1) and Monetary Freedom (K3);

7) Sweden – in terms of the impact of the studied human capital determinants on Financial Freedom (K6).

There is also a group of countries that have never been included in the list of "benchmark" countries (marked "0" in Table 3): Austria, Belgium, Croatia, Estonia, France, Hungary, Greece, Italy, Lithuania, Latvia, Portugal, Serbia, Slovakia, Spain, and the United Kingdom.

Conclusions

The study identified the countries with the most effective mechanisms for preventing human capital losses, which are obstacles to the development of macroeconomic freedoms. It also tested the hypothesis that a reduction in incapacity for work, unemployment, and mortality (factors that impede the human capital development) leads to an increase in macroeconomic freedoms such as business, labour, trade, investment, monetary, and financial freedoms. For this purpose, a bibliometric analysis was conducted to analyse about five thousand publications indexed by the Scopus scientometric database on the impact of incapacity for work, unemployment, and mortality on macroeconomic freedoms, to identify the most used keywords and the dynamics of their use, and to build topic maps of the research interface.

The most effective mechanisms for preventing human capital loss were identified in 6 out of the 30 countries that formed the information base of the study based on the Heritage Foundation's 2021 statistics and the use of the non-parametric data coverage method (Data Envelopment Analysis). These countries are Cyprus, the Czech Republic, Iceland, Ireland, Malta, and Romania. It was also found that 15 countries (Austria, Belgium, Croatia, Estonia, France, Hungary, Greece, Italy, Lithuania, Latvia, Portugal, Serbia, Slovakia, and Spain) have never been included in the "benchmark" list. Three countries are effective in certain macro-freedom indicators: Bulgaria –in terms of monetary freedom; Luxembourg – investment freedom and financial freedom; and Poland – investment freedom.

To assess the efficiency, we used output-oriented models with CCR and BCC specifications, which aim to minimise indicators that impede the development of macroeconomic freedoms (reduction of incapacity for work, unemployment, and mortality). The frontier graphs show the efficiency frontiers of the countries under study. The study has shown that there are countries where mechanisms for preventing the human capital loss effectively contribute to the development of macroeconomic freedoms, and, accordingly, other countries participating in the study are recommended to conduct additional research to identify factors that contribute to preventing the loss of human capital and to develop and implement regulatory measures to improve macroeconomic freedoms.

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