

Evaluating the economic freedom of countries: An application of grey factor analysis

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ABSTRACT

Economic freedom is crucial in determining policies for economic performance of nations and monitoring changes in the international economic order. Evaluating economic freedom requires the use of multiple indicators related to each other. Traditional statistical analyses used as an evaluation tool are often constrained by the probability distribution of indicators or sample size. To overcome these shortcomings, this paper uses grey factor analysis (GFA) to evaluate the economic freedom of countries. GFA can be used with multiple interrelated indicators without requirements about the probability distributions or sample size. The absolute degree of grey incidence matrix is used instead of the correlation matrix in factor analysis and GFA integrates the advantages of grey system theory into factor analysis. The analysis covers data for 2010 and 2020 about 20 economic freedom indicators in 36 selected countries. Two factors explain a significant part of the variance for both years. The scores for countries were obtained using the explained variance ratio as a weight. Our results show that GFA provides more accurate results than traditional statistical analyses.

KEYWORDS

economic freedom, performance evaluation, grey factor analysis, absolute degree of grey incidence

JEL CLASSIFICATION INDICES

K20, E10, C44

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1. INTRODUCTION

Economic freedom has been studied in recent years as a theoretical structure that is positively related to the concepts such as economic growth, welfare and development (Bengoa – Sanchez-Robles 2003; Berggren 2003; De Haan – Sturm 2003). The idea of measuring economic freedom, with the fundamental principles of freedom of personal choice, freedom of voluntary transactions, and protection of private property, began with a group of economists and policymakers in 1996 using an index (Gwartney et al. 1996, 1997). High values for this index, which was designed to measure the extent to which the institutional principles of an economy are market-oriented, represent the existence of a stable monetary environment in countries, the presence of policies compatible with free trade, and the dependence on markets for the allocation of goods and resources (Gwartney et al. 1999). With these features, economic freedom attributes more importance and responsibility to governments for the safety of private property rights, the implementation of contracts, and the free movement of labour, capital and goods. Governments can reduce economic freedom through structural reforms or taxation (De Haan et al. 2006: 158). However, the fact that markets create trust through incentives or mechanisms can increase economic freedom (Berggren – Jordahl 2006: 147).

Economic freedom is constantly referred to as secure property rights and freedom of trade, and is associated with desired social and economic outcomes, such as growth, prosperity and development, which has been sufficient for its rapid adoption and spread in the literature (Hall – Lawson 2014). The discussions about the term economic freedom owe a great deal to Adam Smith's (1776/2007) "An Inquiry into the Nature and Causes of the Wealth of Nations". This work was the first to ask questions about what causes economic growth. It was stated that welfare can be enhanced with a free market, private property and minimal state intervention. An increasing volume of literature showed that economic freedom enhances welfare. Therefore, economic freedom can be accepted as a crucial component in the recipe for welfare (Stroup 2007: 63; Graafland 2020: 127). The effort to theorize economic freedom continued with the report entitled Economic Freedom of the World, published by the Fraser Institute in 1996. In the following years, the Fraser Institute published and continues to publish economic freedom reports for countries using various indicators in the main areas that show the multidimensional structure and legal and regulatory elements of economic freedom (Gwartney et al. 2022: 3).

The fundamental areas of economic freedom are the following:

- The size of the state, it measures the extent to which countries rely on individual choices and markets when allocating resources, goods and services.
- The legal system and property rights measure the existence of an independent judiciary and an impartial court system, the rule of law, and the implementation of contracts.
- Sound money, involves monetary growth, inflation indicators, and ensuring monetary stability.
- The freedom to trade internationally, measures the freedom of international trade.
- Regulation, economic freedom is measured through regulations of the credit and labour markets.

The data compiled from various sources, such as the World Bank, the International Monetary Fund, and the World Economic Forum, are translated into 0–10 scales in five main areas and sub-indicators in the report. The economic freedom score for the fundamental areas is



calculated by taking the arithmetic average of the sub-indicators, while the economic freedom score for the countries is calculated by taking the arithmetic average for the fundamental areas. However, this aggregation process using simple averages was criticized because it tends to overstate the real extent of economic freedom (Doucouliagos 2005: 369). The arithmetic average compensates between indicators that are not interchangeable; thereby causing misleading results (Mazziotta – Pareto 2013: 68).

In this study, a new economic freedom score for countries was calculated by using grey factor analysis and the indicators of economic freedom published by the Fraser Institute. These indicators do not have high statistical validity since they are related to one another and equal weight is given to all indicators (OECD – JRC 2008), all areas and all indicators in these areas are given the same weight. However, if indicators are grouped into areas and those areas are aggregated into the index, giving equal weight to the indicators may cause an unbalanced structure in the index.

The main reason why we employed the grey factor analysis that it creates a ranking model by considering interrelated multi-dimensional areas and broad-spectrum indicators of economic freedom. This paper aims to contribute to the literature by revealing the current situation of countries in terms of their transformation into economically free societies by using grey factor analysis, which involves no priori assumptions, such as statistical independence or probability distributions. A grey factor analysis model was created without rotation to test this aim. Then, the grey factor analysis model underwent a rotation process to make the meanings of the factors clearer.

The remainder of the paper is structured as follows. *Section 2* presents the literature review about economic freedom and its relations to other economic concepts. *Section 3* explains the methodological structure of the grey factor analysis. In *Section 4*, the data is presented, and solutions and findings obtained from grey factor analysis are given. This study concludes by making comments about evaluating economic freedom of the selected countries.

2. LITERATURE REVIEW

Economic freedom was defined as a concept to follow the change in economic order through structural reforms and regulations (Odugbesan et al. 2021). As a result of the tendency of free market ideology and financial stability to favour economic freedom, an increasing number of studies were conducted about the relationship between economic freedom and economic growth, social welfare and development. It was emphasized that economic freedom increases growth through the stimulation of physical capital, and innovation activities; hence, more economic freedom leads to more economic growth (De Haan – Sturm 2000; Saeedikiya et al. 2022: 59). Compton et al. (2014) stated that economic freedom improves economic welfare to different extents in different income brackets, by checking whether these benefits are distributed across the entire population. Stansel (2019) confirmed the positive relationship between economic freedom and economic welfare and stated that economic freedom had the same result for local economies. Prados de la Escosura (2016) presented an aggregate index for areas of economic freedom using data from pre-1994 for the OECD member countries. According to the aggregate index, each of the economic freedom areas had a genuine impact on the aggregate index, but their contributions changed over time. However, property rights have been a key area



in the long-term advancement of economic freedom. Kešeljević and Spruk (2013a, 2013b), criticizing the arbitrary assumption of the equivalent effect of indicators on the general index, used a non-parametric distribution to determine the effect of economic freedom areas on the index and per capita income. They found that a 10% increase in the overall economic freedom index will increase average income per capita by 1.51% (Kešeljević – Spruk 2013a: 3956). They stated that there are fundamental structural differences in the endogenous distribution of economic freedom between countries.

Gehring (2013), Graafland (2020) and Hadsell – Jones (2020) found that economic freedom was also associated with life satisfaction and well-being. It was emphasized that economic freedom is a prerequisite for life satisfaction and well-being in the long-run. Social capital, seen as a function of financial institutions and policies and interpreted as generalized trust, was also associated with economic freedom as it affects the market economy (Berggren – Jordahl 2006). The market economy, based on the rule of law, voluntary transactions and interactions, increases social capital while affecting economic freedom. On the other hand, while income inequality negatively affects economic freedom, this situation is reinforced by the low level of democracy in countries. For this reason, countries should ensure income equality and implement welfare-centred policies through democratization, structural reforms and market regulation (Islam 2018).

Numerous reports were published by institutions such as the Fraser Institute and Heritage Foundation on the technical definition of economic freedom and the identification of its fundamental areas and sub-indicators. There are various studies about developing a composite index by aggregating the economic freedom indicators in these reports. Balliew et al. (2020) ranked countries according to their level of economic freedom by taking the geometric average of the indicators in the report published by the Fraser Institute. In the literature, the most frequently used aggregation operators are arithmetic average and geometric average (Aull-Hyde et al. 2006). However, the averages are usually affected by the extreme values, and they may lead to misleading assessments (Huang et al. 2009: 448). Beaulier et al. (2016) used the values for the countries' fundamental areas of economic freedom within the scope of ordinal ranking methodology when ranking the economic institutions of the countries. However, this methodology was not seen as applicable as it creates numerous different rankings when repeated at the level of indicators rather than fundamental areas. Cabello et al. (2021) proposed an alternative aggregation procedure for the evaluation of economic freedom by using the values of 14 economic freedom indicators for 44 European countries with the multiple reference point method for 2019. Focusing on normalization and aggregation procedures, he used the multiple reference point method. This method, which tries to create composite indexes of economic freedom, is evaluated differently for countries at different reference levels. However, considering several composite indexes rather than a single index was seen as the drawback of the method. Miozzi and Powel (2023) used the quarantine regulatory freedom indicators in conjunction with the economic freedom indicators to determine the extent to which the Covid-19 pandemic regulations restricted countries' economic freedom. Taking the averages, they stated that there was a global decline in economic freedom from 2019 to 2020. Dialga and Vallée (2021) stated that the use of statistical tools such as, principal components analysis (PCA), benefit of the doubt (BOD) and country-specific weighting were more legitimate approaches for the evaluation of countries' economic freedom. They found that the country-specific weighting system should be used to obtain the correct economic freedom score of countries rather than equal weight. By using PCA



and BOD methods, they tried to overcome the methodological limitations of weighting and aggregation operators. All these economic freedom indices provide invaluable information for monitoring economic reforms and regulations, identifying market opportunities and encouraging investments.

3. RESEARCH METHODOLOGY

Developed by Deng in 1989, the grey system theory ensures a systematic analysis of the solution to decision-making processes in which uncertainty exists. As a part of grey system theory, grey incidence analysis is one of the analyses independent of sample size and probability distributions of the indicators in cases where statistical methods are not applicable (Hatami-Marbini et al. 2022). This analysis enables decisions by comparing the similarities of units whose performances will be evaluated, through a reference set, in problems with limited or noisy data (Liu – Lin 2010). This study uses grey factor analysis based on the combination of grey system theory and factor analysis developed by Tung and Lee (2010). When there are high correlations and extreme values, methods such as PCA or factor analysis (FA) are used to prevent deviations in performance evaluation (Huang et al. 2021: 11). However, these analyses are disadvantageous in terms of processing nonlinear data (Chen 2012: 676). This situation can be solved with grey factor analysis, which is structured on the ADGI matrix instead of the correlation matrix. Therefore, it is accepted that grey factor analysis is an evaluation model that integrates the benefits of grey system theory and PCA.

Assume that there are n countries and m indicators that need to be evaluated. Let the observation value of the indicators be considered as $Z = (Z_1, \dots, Z_i, \dots, Z_m)^t$ system behavioural sequence where $Z_i = (z_{i1}, z_{i2}, \dots, z_{in})$, $i = 1, 2, \dots, m$. The steps of grey factor analysis are presented below (Tung – Lee 2010; Hatami-Marbini et al. 2022):

Step 1. The sequences with different structures and scale units are normalized according to their characteristics, and $X = (X_1, \dots, X_i, \dots, X_m)^t$ normalized sequences are obtained where $X_i = (x_{i1}, x_{i2}, \dots, x_{in})$, $i = 1, 2, \dots, m$.

$$\text{The larger the value the better: } x_{ik} = \frac{z_{ik} - \min_k z_{ik}}{\max_k z_{ik} - \min_k z_{ik}}, i = 1, 2, \dots, m, k = 1, 2, \dots, n. \quad (1)$$

$$\text{The smaller the value the better: } x_{ik} = \frac{\max_k z_{ik} - z_{ik}}{\max_k z_{ik} - \min_k z_{ik}}, i = 1, 2, \dots, m, k = 1, 2, \dots, n. \quad (2)$$

$$\text{The optimal value the better: } x_{ik} = 1 - \frac{|z_{ik} - OT|}{\max_k \left(\max_k z_{ik} - OT, OT - \min_k z_{ik} \right)}, i = 1, 2, \dots, m, k = 1, 2, \dots, n. \quad (3)$$

where OT is the value of the optimal target.



Assume $\hat{X}_i, i = 1, 2, \dots, m$, is the i th continuous curve and $x_{ik}, k = 1, 2, \dots, n$, $\hat{X}_i$ is the k th observation value of the information curve. Figure 1 is provided when $x_{i1} = 0$.

Step 2. The corresponding polygonal path of X_i is converted to X_i^0 using $x_{ik}^0 = x_{ik} - x_{i1}$.

Step 3. The geometrical area, σ_i , between X_i^0 and x - axis is calculated using Equation (4) and Figure 1:

$$\sigma_i = \sum_{k=2}^n |x_{ik}^0| \quad (4)$$

Assume X_i^0 and X_j^0 are two sequences with equal length, the area between these two sequences is calculated using Equation (5):

$$\sigma_{ij} = \sum_{k=2}^n |x_{ik}^0 - x_{jk}^0|, i, j = 1, 2, \dots, m \quad (5)$$

where σ_{ij} is the absolute degree of grey incidence (ADGI). Since $\sigma_{ij} = 0$, it is assured that $x_{ik}^0 = x_{jk}^0, \forall k$.

Step 4. The absolute degree of grey incidence matrix, Γ , is obtained. This symmetric matrix consists of γ_{ij} where $0 < \gamma_{ij} \leq 1$. γ_{ij} is calculated for the sequences of X_i^0 and X_j^0 using Equation (7):

$$\Gamma = \begin{bmatrix} 1 & \gamma_{12} & \cdots & \gamma_{1m} \\ \gamma_{21} & 1 & \cdots & \gamma_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ \gamma_{m1} & \gamma_{m2} & \cdots & 1 \end{bmatrix} \quad (6)$$

$$\gamma_{ij} = \frac{1 + \sigma_i + \sigma_j}{1 + \sigma_i + \sigma_j + \sigma_{ij}} \quad (7)$$

It should be stated that γ_{ij} has the following characteristics (Liu et al. 2006; Tung – Lee 2010):

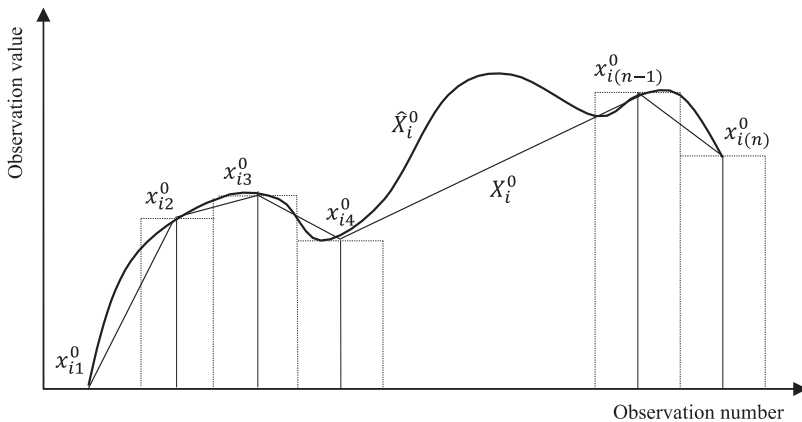


Fig. 1. Information curve ($\hat{X}_i^0$) and polygonal path (X_i^0) for information sequence (X_i)

Source: Tung – Lee (2010: 7846).



- (a) $0 < \gamma_{ij} \leq 1$.
 (b) $\gamma_{ij} = \gamma_{ji}$.
 (c) $\gamma_{ii} = 1$.
 (d) γ_{ij} depends on the geometrical shapes of X_i^0 and X_j^0 . The more geometrical the shapes of X_i^0 and X_j^0 are, the larger is γ_{ij} .
 (e) X_i^0 and X_j^0 are parallel if and only if $\gamma_{ij} = 1$.

Step 5. The eigenvalues and eigenvectors of Γ are calculated using $\epsilon_i(\Gamma - \lambda_i I) = 0$. It should be noted that $\epsilon_i = (e_{i1}, e_{i2}, \dots, e_{im})$, $i = 1, 2, \dots, m$ is the eigenvector, λ_i ($\lambda_1 \geq \lambda_2 \geq \dots \geq \lambda_m \geq 0$) is a scalar called eigenvalue corresponding to V_i ($\sum_{i=1}^m \lambda_i = m$), and I is an identity matrix of size m . The eigenvectors ϵ_i and ϵ_j ($i, j = 1, 2, \dots, m; i \neq j$) corresponding to a symmetric matrix are orthogonal. Therefore, $\epsilon_i \perp \epsilon_j$ and $\epsilon_i \epsilon_j^t = 0$.

Step 6. Assume $Y_i = (y_{i1}, y_{i2}, \dots, y_{im})$, $Y_i = y_i^t X$, $GVar(Y_i) = \lambda_i$ is the grey variance of Y_i , and $GCov(Y_i, Y_j) = 0$ is the grey covariance of Y_i and Y_j . Grey principal component analysis is the uncorrelated linear combination of Y_i , $i = 1, 2, \dots, m$ where grey variances are as large as possible. The i th grey component is the linear combination that maximizes $GVar(Y_i)$ subject to $y_i^t y_i = 1$. For the purpose of this definition, m grey principal component is defined using Equation (8):

$$Y_i = e_{i1}X_1 + e_{i2}X_2 + \dots + e_{im}X_m, i = 1, 2, \dots, m \quad (8)$$

where $GVar(X_i) = 1$ and $GCov(X_i, Y_j) = \sqrt{\lambda_j} e_{ji}$.

Step 7. Assume $l_{ij} = \sqrt{\lambda_j} e_{ji}$, $\Pi = [l_{ij}]_{m \times m}$, $F = (F_1, F_2, \dots, F_m)^t$ and $X = \Pi F$, l_{ij} is grey factor loading and Π is the grey factor loading matrix. It should be noted that $GVar(F_i) = 1$ and $GCov(F_i, F_j) = 0$. Therefore, the grey factor covariance matrix, $GCov(F) = I_m$ satisfies the requirements for factor analysis and $\sum_{i=1}^m GVar(F_i) = m$ is obtained. There is at least one eigenvalue of Γ matrix greater than one. Based on the Kaiser principle, the eigenvalues $\lambda_1 \geq \lambda_2 \geq \dots \geq \lambda_q \geq 1$, ($q \leq m$) larger than one and corresponding to the grey principal component Y_i , $i = 1, 2, \dots, q$ are selected. Therefore, q grey cofactor, $F_i = Y_i / \sqrt{\lambda_i}$, $i = 1, 2, \dots, q$ and $l_{i1}^2 + l_{i2}^2 + \dots + l_{mi}^2 = \lambda_i$ is obtained. The grey factor analysis model is constructed using Equation (9):

$$X = LF + \epsilon \quad (9)$$

where $\epsilon_i = l_{i,q+1}F_{q+1} + \dots + l_{im}F_m$.

- (a) Grey factor analysis model has q common factors extracted by grey principal component analysis. The explained variance of grey common factor F_i is λ_i , and the explained variance ratio is λ_i/m .
 (b) The accumulated explained variance ratio of r ($r \leq q$) grey common factors F_i ($i = 1, 2, \dots, r$) is $\sum_{i=1}^r \lambda_i/m$.
 (c) The grey communality of X_i is calculated using $h_i^2 = \sum_{j=1}^q l_{ij}^2$.
 (d) The grey uniqueness of X_i is calculated using $\Psi_i = 1 - h_i^2$.

Step 8. Factor rotation enabling factor loading close to zero or one is needed to make the meaning of the factors clearer and more significant. The new grey factor analysis model obtained using the varimax-normalized procedure is constructed using Equation (10) (Johnson – Wichern 1982; Tung – Lee 2010):



$$X = \overline{L}\overline{F} + \epsilon \quad (10)$$

where $\overline{L} = [\bar{l}_{ij}]_{m \times q}$ and $\overline{F} = (\overline{F}_1, \overline{F}_2, \dots, \overline{F}_q)^t$. Although the explained variance (λ_i and $\bar{\lambda}_i$) obtained before and after factor rotation are different, the sums remain unchanged ($\sum \lambda_i = \sum \bar{\lambda}_i$). Additionally, h^2 and Ψ remain unchanged before and after factor rotation.

Step 9. The grey factor scores are used in the evaluation of n countries ($C_k, k = 1, 2, \dots, n$). Assume the values of m indicators of C_k are $\chi_k = (x_{1k}, x_{2k}, \dots, x_{mk})$ and i th grey factor score of C_k is $\hat{F}_{ik}$, it should be noted that $\hat{F}_k = (\hat{F}_{1k}, \hat{F}_{2k}, \dots, \hat{F}_{qk})$. $\hat{F}_k$ is calculated using the weighted least square method:

$$\hat{F}_k = (\overline{L}^t \Psi^{-1} \overline{L})^{-1} \overline{L}^t \Psi^{-1} \chi_k \quad (11)$$

where Ψ is a matrix in which the elements of the prime diagonal are Ψ_i ($i = 1, 2, \dots, m$) and the other elements are zero.

Step 10. The total performance score of C_k is calculated using the explained variance ratio ($\bar{\lambda}_i$) as weight:

$$GF_k = \sum_{i=1}^q \bar{\lambda}_i \hat{F}_{ik}. \quad (12)$$

4. DATA AND APPLICATION

4.1. Data

We used the data for 2020 from “Economic Freedom of the World: 2022 Annual Report” (Fraser Institute 2022). Additionally, the data for countries in 2010 were also considered in our study to monitor the transformation in economic freedom scores. To effectively solve the economic freedom and to obtain objective assessments for the countries, 20 indicators were used in the five areas of economic freedom presented in Table 1. Many studies showed that the economic freedom areas and indicators given in Table 1 and presented by the Fraser Institute are related (e.g., Ott 2018).

The countries to be evaluated in our study are Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Netherlands, North Macedonia, Norway, Spain, Sweden, Switzerland, Montenegro, Latvia, Lithuania, Luxembourg, Malta, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Türkiye and United Kingdom. Within this study, the European Union (EU) member states, the EU candidate countries, the United Kingdom, and the countries that are members of the European Free Trade Association (EFTA) were selected. Member countries of the EFTA, which refers to a regional trade organization, are Norway, Switzerland, Iceland and Liechtenstein.¹ The descriptive statistics of the indicators used to measure the economic freedom of these countries in 2020 are presented in Table 2.

¹However, Liechtenstein is not included in the dataset due to the lack of data.



Table 1. Fundamental areas and indicators used in the measurement of economic freedom

Area	Indicator	Symbol
Size of the government	Government consumption (% total consumption)	X_1
	Transfers and subsidies (% GDP)	X_2
	Government enterprises and investment (% total investment)	X_3
	Top marginal tax rate (0-10 scale)	X_4
	State ownership of assets (0-10 scale)	X_5
Legal system and property rights	Judicial independence (0-10 scale)	X_6
	Impartial courts (0-10 scale)	X_7
	Protection of property rights (0-10 scale)	X_8
	Military interference in rule of law and politics (0-10 scale)	X_9
	Integrity of the legal system (0-10 scale)	X_{10}
	Legal enforcement of contracts (0-10 scale)	X_{11}
	Regulatory costs of the sale of real property (0-10 scale)	X_{12}
	Reliability of police (0-10 scale)	X_{13}
Sound money	Money growth (average annual growth of GDP)	X_{14}
	Standard deviation of inflation (0-10 scale)	X_{15}
	Inflation: Most recent year (ratio)	X_{16}
Freedom to trade internationally	Freedom to trade internationally (0-10 scale)	X_{17}
Regulation	Credit market regulations (0-10 scale)	X_{18}
	Labour market regulations (0-10 scale)	X_{19}
	Business regulations (0-10 scale)	X_{20}

Source: Authors' compilation based on the Fraser Institute dataset.

4.2. Economic freedom scores of the countries

Before using the grey factor analysis, the normalization process in Equations (1–3) was carried out with the intent of comparability of indicators with different structures and scale units. By obtaining sequences with zero starting points, the absolute degree of grey incidence was calculated between the sequences. The ADGI matrix was obtained using the absolute degree of grey incidence in Equation (6).² The details of the analysis for 2020 data are presented following. The

²The ADGI matrixes for 2020 and 2010 will be made available upon request.



Table 2. Descriptive statistics of indicators for 2020

Indicator	Minimum	Maximum	Mean	Standard deviation
X ₁	12.71 (12.50)	38.25 (38.56)	28.18 (26.20)	6.01 (5.75)
X ₂	0.00 [*] (0.00 [*])	34.89 (29.78)	20.38 (19.42)	6.59 (5.95)
X ₃	6.10 (10.38)	31.88 (36.97)	18.34 (19.91)	5.83 (5.34)
X ₄	1.00 (1.00)	8.50 (8.50)	4.99 (5.11)	2.19 (2.18)
X ₅	5.35 (6.69)	9.04 (9.13)	7.55 (7.90)	0.77 (0.62)
X ₆	3.64 (4.26)	8.59 (8.78)	6.76 (6.95)	1.38 (1.30)
X ₇	3.80 (3.86)	8.67 (8.86)	6.43 (6.66)	1.45 (1.48)
X ₈	3.84 (3.54)	9.34 (9.08)	6.60 (6.41)	1.45 (1.56)
X ₉	0.00 [*] (3.33)	10.00 (10.00)	8.61 (9.10)	2.50 (1.38)
X ₁₀	4.41 (4.54)	9.64 (9.22)	7.69 (7.46)	1.37 (1.18)
X ₁₁	3.07 (3.78)	7.46 (8.13)	5.29 (5.83)	1.22 (1.15)
X ₁₂	4.90 (4.62)	9.73 (9.68)	8.04 (7.91)	1.16 (1.29)
X ₁₃	3.91 (3.99)	9.54 (9.51)	6.83 (6.75)	1.49 (1.62)
X ₁₄	1.08 (−3.86)	16.11 (13.12)	9.55 (4.34)	4.93 (3.16)
X ₁₅	0.16 (0.32)	3.85 (8.20)	1.21 (2.07)	0.86 (1.67)
X ₁₆	−1.25 (−1.09)	12.28 (8.57)	1.18 (2.34)	2.23 (1.96)
X ₁₇	6.73 (6.29)	8.60 (8.95)	7.94 (8.06)	0.43 (0.57)
X ₁₈	5.65 (4.67)	9.94 (10.00)	8.21 (8.52)	1.16 (1.33)
X ₁₉	5.04 (4.34)	8.25 (8.25)	6.79 (6.55)	0.84 (1.10)
X ₂₀	6.45 (5.56)	8.71 (8.50)	7.41 (7.30)	0.66 (0.85)

Source: Authors’ calculations based on the Fraser Institute dataset.
Notes: The data in parentheses are descriptive statistics for economic freedom indicators for 2010.
*: Montenegro does not have data for some indicators, it is included in the data set as 0.00.

eigenvalues and eigenvectors for the ADGI 2020 matrix were calculated and the corresponding grey principal components were obtained. Factor loadings were calculated using the grey principal components with eigenvalues greater than one (Table 3), and the grey factor analysis model was constructed using Equation (9).

Varimax rotation was applied to make the meaning of the factors more significant. The factor loadings were calculated (Table 4), and the new grey factor analysis model was constructed using Equation (10).

As depicted in Tables 3–4, the explained variances are different, but the sums remain unchanged (0.86). The fact that the accumulated explained variance ratio is 86% indicates that the economic freedom performance status of the countries is reflected quite well. The



Table 3. Factor loadings (No rotation)

Explained variance			14.74				2.40			
Accumulation			0.74				0.86			
	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
F_1	0.85	0.86	0.83	0.83	0.88	0.91	0.89	0.86	0.89	0.91
F_2	0.36	0.37	0.41	0.36	0.29	0.31	0.35	0.39	0.1	0.31
h^2	0.85	0.87	0.86	0.82	0.86	0.92	0.92	0.90	0.81	0.92
ψ	0.15	0.13	0.14	0.18	0.14	0.08	0.08	0.10	0.19	0.08
	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}	X_{19}	X_{20}
F_1	0.83	0.86	0.88	0.85	0.82	0.76	0.89	0.87	0.87	0.82
F_2	0.4	0.31	−0.35	0.33	0.45	0.47	−0.26	−0.26	−0.26	−0.4
h^2	0.85	0.83	0.90	0.83	0.87	0.81	0.85	0.83	0.82	0.83
ψ	0.15	0.17	0.10	0.17	0.13	0.19	0.15	0.17	0.18	0.17

Source: Authors' calculations based on the Fraser Institute dataset.

Table 4. Factor loadings (Rotation with varimax-normalized)

Explained variance			9.26				7.87			
Accumulation			0.46				0.86			
	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
F_1	0.4	0.39	0.35	0.37	0.85**	0.88**	0.9**	0.9**	0.73**	0.88**
F_2	0.83**	0.85**	0.86**	0.82**	0.37	0.37	0.34	0.28	0.52	0.37
h^2	0.85	0.87	0.86**	0.82**	0.86**	0.92**	0.92**	0.90**	0.81**	0.92**
ψ	0.15	0.13	0.14	0.18	0.14	0.08	0.08	0.10	0.19	0.08
	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}	X_{19}	X_{20}
F_1	0.35	0.43	0.89**	0.42	0.31	0.25	0.83**	0.83**	0.82**	0.88**
F_2	0.85**	0.8**	0.33	0.81**	0.88**	0.86**	0.4	0.39	0.39	0.25
h^2	0.85	0.83	0.90	0.83	0.87	0.81	0.85	0.83	0.82	0.83
ψ	0.15	0.17	0.10	0.17	0.13	0.19	0.15	0.17	0.18	0.17

Source: Authors' calculations based on the Fraser Institute dataset.

Notes: **: Greater value than 0.70.

communalities of all sequences are greater than 0.70. This means that the extracted factors explain the variances of the sequences well. In calculating the efficiency of the selected countries



whose performance is evaluated, the factor score coefficient was calculated using the following equation: $(\bar{L}^t \Psi^{-1} \bar{L})^{-1} \bar{L}^t \Psi^{-1}$. Table 5 shows the factor scores coefficient.

Finally, the grey factor scores related to the economic freedom of the countries were calculated using Equation (12). The 2020 rankings of the countries were acquired by ordering the relevant scores from the largest to the smallest (Table 6). The concept of economic freedom, constructed by the Fraser Institute, is based on measuring the coherence of countries' institutions and policies in protecting individuals, their property and the freedom of economic decision-making. According to this accepted definition, the high economic freedom scores for countries express confidence in the institutions and policies of the countries in allocating resources, goods and services, the security of the private property of individuals, the existence of a stable monetary environment, the impartial and effective implementation of the legal system, and the presence of national and international trade freedom. A remarkable finding is that such countries as Switzerland, Denmark, Finland and Ireland had high scores, and therefore, institutional qualities and policies of these countries encourage economic freedom.

Table 7 presents a comparison of the country scores obtained using grey factor analysis and economic freedom scores constructed by the Fraser Institute for 2020. The analysis performed for 2020 was repeated and Table 8 was obtained. Table 8 presents the comparison of the economic freedom scores of the countries for 2010. The Fraser Institute classifies countries into four categories, from the least free to the freest, based on the countries' economic freedom scores. When considering this classification, the overlap between this study and the Fraser Institute is given in Tables 7 and 8 (countries in italics). Country scores obtained by the Fraser Institute are ranked from the smallest to the largest.

Although there is no perfect overlap for 2020, the correlation between rankings with grey factor analysis and the Fraser Institute was significant (Spearman's $\rho = 0.67$, $P < 0.01$), similarly for 2010 (Spearman's $\rho = 0.79$, $P < 0.01$). Considering 2020, Switzerland, Denmark, Ireland, Sweden and Netherlands, were considered the most economically free countries, overlap in both assessments. Considering 2010, these countries overlap in both assessments, except for the Netherlands. For example, Switzerland had the highest score in the grey factor analysis ranking for both years because it is the most economically free country in terms of having a rising economy with industrialization, protecting the property rights of individuals, and a local taxation system (Dutta 2021). Conversely, Murphy (2019) defined economic freedom as the degree of liberalization to which countries are exposed. He stated that the economic institutions of countries reached a consensus concerning liberalization and state-building with the term "getting to Denmark". Therefore, Denmark is accepted as a key actor in the transformation into an economically free society that has brought its institutions and policies to a position that

Table 5. Factor scores coefficient (Rotation with varimax-normalized)

F_1	−0.06	−0.07	−0.07	−0.05	0.10	0.18	0.20	0.17	0.04	0.18
F_2	0.15	0.19	0.18	0.13	−0.04	−0.07	−0.10	−0.10	0.02	−0.07
F_1	−0.07	−0.04	0.16	−0.04	−0.10	−0.07	0.09	0.08	0.07	0.10
F_2	0.16	0.12	−0.08	0.13	0.21	0.14	−0.02	−0.02	−0.02	−0.06

Source: Authors' calculations based on the Fraser Institute dataset.



Table 6. GFA scores and ranking (2020)

	F_1	F_2	GF_k	Ranking		F_1	F_2	GF_k	Ranking
Switzerland	0.85	0.36	10.72	1	Czechia	0.52	0.42	8.09	19
Denmark	0.88	0.26	10.16	2	Cyprus	0.44	0.5	8.00	20
Finland	0.91	0.18	9.86	3	Latvia	0.57	0.32	7.8	21
Ireland	0.69	0.43	9.78	4	Italy	0.31	0.61	7.62	22
Iceland	0.76	0.29	9.28	5	Lithuania	0.56	0.3	7.57	23
Sweden	0.71	0.34	9.25	6	Slovenia	0.28	0.57	7.12	24
Belgium	0.65	0.40	9.22	7	Romania	0.33	0.5	6.97	25
Netherlands	0.89	0.13	9.21	8	Montenegro	0.27	0.57	6.94	26
United Kingdom	0.65	0.37	8.95	9	Albania	0.00	0.85	6.67	27
Germany	0.70	0.29	8.8	10	Croatia	0.15	0.65	6.46	28
Austria	0.73	0.25	8.73	11	Bulgaria	0.19	0.59	6.32	29
Portugal	0.42	0.61	8.67	12	Greece	0.16	0.61	6.32	30
Luxembourg	0.91	0.03	8.66	13	Slovakia	0.21	0.55	6.22	31
Spain	0.55	0.45	8.6	14	Poland	0.21	0.53	6.14	32
Malta	0.43	0.56	8.41	15	Hungary	0.2	0.49	5.72	33
Estonia	0.77	0.16	8.39	16	Serbia	0.04	0.67	5.63	34
Norway	0.89	−0.02	8.13	17	North Macedonia	0.02	0.62	5.09	35
France	0.57	0.37	8.11	18	Türkiye	−0.07	0.50	3.28	36

Source: Authors' calculations based on the Fraser Institute dataset.

supports economic freedom. This also raised the economic freedom score compared to 10 years before.

As can be seen in the third column of Table 7, Malta, Spain and Germany overlapped, and these countries are considered economically free. Malta is expected to be economically free because its economy strengthened with sectoral improvements and structural changes (Grech et al. 2016: 24). Similarly, Germany has a free market economy, and its government protects citizens with various regulations (Amadeo 2021). Italy, Cyprus and Montenegro overlapped in the second column of the table. Italy had low performance in the area of state size and is below average in the area of the legal system and property rights. As a founding member of the EU, although Italy has a well-established democracy, it lagged in economic freedom due to the decline in regulatory efficiency and the open market (Molnár – Urbanovics 2020). Conversely, the “bi-communal, bi-regional” structure of Cyprus required the country be included in the category of countries with relatively less economic freedom in both assessments, as it created limitations on individual freedom and various restrictions on the economy (Georgiou 2010: 422).



Table 7. Country scores according to grey factor analysis and the Fraser Institute (2020)

GFA							
Least free		>>>				Most free	
Türkiye	3.28	Albania	6.67	France	8.11	United Kingdom	8.95
North Macedonia	5.09	Montenegro	6.94	Norway	8.13	Netherlands	9.21
Serbia	5.63	Romania	6.97	Estonia	8.39	Belgium	9.22
Hungary	5.72	Slovenia	7.12	Malta	8.41	Sweden	9.25
Poland	6.14	Lithuania	7.57	Spain	8.60	Iceland	9.28
Slovakia	6.22	Italy	7.62	Luxembourg	8.66	Ireland	9.78
Greece	6.32	Latvia	7.80	Portugal	8.67	Finland	9.86
Bulgaria	6.32	Cyprus	8.00	Austria	8.73	Denmark	10.16
Croatia	6.46	Czechia	8.09	Germany	8.80	Switzerland	10.72
Fraser Institute							
Least free		>>>				Most free	
Türkiye	6.48	Belgium	7.37	Spain	7.63	Czechia, Netherlands	7.75
Greece	6.81	Italy	7.40	Albania, Finland	7.64	Latvia	7.77
Serbia	6.82	Portugal	7.43	Germany	7.65	Lithuania	7.82
Poland	6.93	Montenegro	7.46	Bulgaria	7.69	Ireland	7.86
Slovenia	7.00	Cyprus	7.49	United Kingdom	7.71	Estonia	7.95
North Macedonia, Croatia	7.16	Luxemburg	7.54	Malta	7.72	Denmark	8.09
Hungary	7.24	Austria	7.56	Iceland	7.73	Switzerland	8.37
Slovakia, France	7.33	Norway	7.58	Romania	7.74	Sweden	9.54

Source: Authors' calculations based on the Fraser Institute dataset.

According to Table 8, the economic freedom of Cyprus was better 10 years ago because the bi-communal bi-zonal structure caused a decrease in the economic freedom score over time.

When looking at countries that were least free in the first column of Table 8, Croatia, Greece, Slovakia, Poland, Hungary, Serbia, North Macedonia and Türkiye overlapped in both measurement categories. Türkiye had a value below the average in all areas except the size of government, the country is an example of the least free country, and ranks at the bottom. The lack of financial stability with high inflation and income inequality, and the lack of a secure institutional environment in an environment where political freedom and democracy satisfaction are low are the reasons of this ranking (Ekici – Koydemir 2014: 1044). Similarly, although the legal framework protecting property rights in Serbia is well defined, the country is in this category due



Table 8. Country scores based on grey factor analysis and the Fraser Institute (2010)

GFA							
Least free		>>>				Most free	
<i>Serbia</i>	3.98	Montenegro	7.25	<i>Malta</i>	8.27	<i>Germany</i>	9.52
<i>Türkiye</i>	4.67	Poland	7.31	<i>Spain</i>	8.54	Netherlands	9.68
Bulgaria	5.65	Slovenia	7.32	Iceland	8.58	Belgium	9.84
Albania	5.74	<i>Hungary</i>	7.34	<i>Norway</i>	8.69	<i>United Kingdom</i>	9.93
Romania	5.87	Croatia	7.36	Estonia	8.73	<i>Denmark</i>	9.98
North Macedonia	5.94	Czechia	7.48	Luxemburg	8.90	<i>Ireland</i>	10.10
Lithuania	6.85	Portugal	7.68	<i>France</i>	9.10	<i>Finland</i>	10.17
Greece	6.91	<i>Italy</i>	7.90	<i>Cyprus</i>	9.16	<i>Sweden</i>	10.60
Slovakia	7.03	Latvia	8.01	Austria	9.51	<i>Switzerland</i>	10.61
Fraser Institute							
Least free		>>>				Most free	
<i>Serbia</i>	6.60	Albania	7.33	Slovakia	7.65	<i>Germany</i>	7.84
Iceland	6.73	North Macedonia	7.34	<i>Norway</i>	7.66	Austria	7.85
Poland	6.91	Romania	7.49	Czechia	7.67	<i>Sweden</i>	7.89
<i>Türkiye</i>	6.97	Lithuania	7.54	<i>Spain</i>	7.69	<i>Ireland</i>	7.93
Croatia	7.00	Luxemburg	7.54	Latvia	7.73	<i>Denmark</i>	7.99
Greece	7.12	<i>Italy</i>	7.56	<i>France</i>	7.74	<i>Finland</i>	7.99
Slovenia	7.12	<i>Hungary</i>	7.58	Malta	7.77	Estonia	8.05
Montenegro	7.26	Bulgaria	7.60	Netherlands	7.79	<i>United Kingdom</i>	8.10
Portugal	7.28	Belgium	7.62	<i>Cyprus</i>	7.83	<i>Switzerland</i>	8.52

Source: Authors' calculations based on the Fraser Institute dataset.

to the problems with implementation and the low efficiency of its regulatory agencies (Golubović – Golubović 2020: 206). The economic freedom categories of these countries have not changed compared to 10 years before. With the provision of secure property rights, freedom of personal choice, real rule of law, and more open markets in these countries, which are considered the least economically free, they can become more economically free. The fact that countries have an institutional environment that supports economic freedom also helps them achieve higher economic growth and development (Spruk – Kešeljević 2018).

Economic growth and development are desired goals for all developed and developing countries alike. However, while developed countries try to achieve these goals by restructuring their financial arrangements and institutions to maintain their current situation, developing countries must ensure their growth and development.



In summary, [Tables 7 and 8](#) provide a very insightful comparative picture of the situation in countries regarding different categories of economic freedom in different years.

5. CONCLUSION

Economic freedom plays an important role in issues such as realizing economic development, stimulating labour and capital markets ([Aarhus – Jakobsen 2019](#)), and increasing competitiveness, flexibility and sensitivity to shocks ([De Grauwe – Ji 2020](#); [Bjørnskov 2016](#)). There are various reports and indexes that aim to find a reasonable measure of economic freedom that has international applicability considers national differences and uses multiple indicators. Among these reports and indexes, the Fraser Institute measurement is frequently preferred by researchers when considering the multidimensional nature of economic freedom. The reports evaluate the economic freedom of countries by using indicators related to each other, but no weighting is made at the level of indicators and whether the indicators are independent or not. To overcome these shortcomings, our study evaluated the economic freedom of countries using grey factor analysis, which can deal with multiple interrelated indicators without requirements about the probability distributions or sample size. Using the data from 20 economic freedom indicators in 36 selected countries, two factors were extracted after factor rotation for both the years 2020 and 2010, and country total scores were calculated using the explained variance ratio as weight. These findings are consistent with the the Fraser Institute's evaluation, [Cabello et al. \(2021\)](#), and [Graafland \(2020\)](#).

This study contributes to the literature in terms of integrating the concepts from the grey system theory with factor analysis and using a new methodological approach, which is an alternative to classical statistical methods with restrictive assumptions, for economic freedom measurement. When methodological matters arising from the assumption of the equal weight of indicators on the overall assessment of economic freedom are tackled with grey factor analysis, the economic freedom scores change significantly over time.

The results suggest that the economic freedom performances of the EU member countries differ from the candidate countries for both analysed years. The West European countries such as, Switzerland, Netherlands and Belgium achieved higher performance, and thus are among the economically free countries. Italy and France, among the founding members of the EU, are less economically free than the newer members. Grey factor analysis and the Fraser Institute classify Greece as the least economically free EU country for both years. The categories for some countries (Lithuania and Latvia) differ in these two evaluations in 2020. In 2010, the categories of countries such as, Iceland and Belgium were quite different.

A remarkable finding is that Türkiye, as a candidate EU country, is the least economically free country and ranks at the bottom. Switzerland, not an EU member country, is the most economically free country and ranks at the top. Similarly, Iceland and Norway, are among the countries that performed well in the performance ranking. Moreover, the density of countries in the least free category increased in 2020 compared to 2010.

Successes in the economic freedom evaluation contribute to the actualization of economic development by stimulating labour and capital markets of countries and increasing competitiveness. Therefore, the performance evaluation described by grey factor analysis can be used as a guiding principle to determine the current status for economic freedom in countries. This



analysis based on the integration of grey theory and factor analysis allowed for the incorporation of multiple indicators in determining economic freedom efficiency. The general conclusion is that the analysis provided a measure and benchmark for determining economically free and non-free countries, and the findings can be useful for policymakers, economists and market researchers to develop policies and plans.

REFERENCES

- Aarhus, J. H. – Jakobsen, T. G. (2019): Rewards of Reforms: Can Economic Freedom and Reforms in Developing Countries Reduce the Brain Drain? *International Area Studies Review*, 22(4): 327–347.
- Amadeo, K. (2021): Germany's Economy, Its Successes and Challenges. *The Balance*. <https://www.thebalancemoney.com/germany-s-economy-3306346>.
- Aull-Hyde, R. – Erdogan, S. – Duke, J. M. (2006): An Experiment on the Consistency of Aggregated Comparison Matrices in AHP. *European Journal of Operational Research*, 171(1): 290–295.
- Balliew, S. – Mathews, T. – Hall, J. C. (2020): Measuring Economic Freedom: An Alternative Functional Specification and Subsequent Ranking. *Applied Economics*, 52(14): 1582–1591.
- Beaulier, S. – Elder, R. – Han, C. – Hall, J. C. (2016): An Ordinal Ranking of Economic Institutions. *Applied Economics*, 48(26): 2482–2490.
- Bengoa, M. – Sanchez-Robles, B. (2003): Foreign Direct Investment, Economic Freedom and Growth: New Evidence from Latin America. *European Journal of Political Economy*, 19(3): 529–545.
- Berggren, N. (2003): The Benefits of Economic Freedom: A Survey. *The Independent Review*, 8(2): 193–211.
- Berggren, N. – Jordahl, H. (2006): Free to Trust: Economic Freedom and Social Capital. *Kyklos*, 59(2): 141–169.
- Bjørnskov, C. (2016): Economic Freedom and Economic Crises. *European Journal of Political Economy*, 45: 11–23.
- Cabello, J. M. – Ruiz, F. – Pérez-Gladish, B. (2021): An Alternative Aggregation Process for Composite Indexes: An Application to the Heritage Foundation Economic Freedom Index. *Social Indicators Research*, 153(2): 443–467.
- Chen, B. (2012): The Application of the Grey Correlation Method in the Principal Component Analysis. *Advanced Engineering Forum*, 6–7: 676–681.
- Compton, R. A. – Giedeman, D. C. – Hoover, G. A. (2014): A Distributional Analysis of the Benefits of Economic Freedom. *European Journal of Political Economy*, 33: 121–133.
- De Grauwe, P. – Ji, Y. (2020): Structural Reforms, Animal Spirits, and Monetary Policies. *European Economic Review*, 124: 1–29.
- De Haan, J. – Lundström, S. – Sturm, J.E. (2006): Market-Oriented Institutions and Policies and Economic Growth: A Critical Survey. *Journal of Economic Surveys*, 20(2): 157–191.
- De Haan, J. – Sturm, J. E. (2000): On the Relationship between Economic Freedom and Economic Growth. *European Journal of Political Economy*, 16(2): 215–241.
- De Haan, J. – Sturm, J. E. (2003): Does More Democracy Lead to Greater Economic Freedom? New Evidence for Developing Countries. *European Journal of Political Economy*, 19: 547–563.
- Deng, J. (1989): Introduction to Grey Theory System. *The Journal of Grey System*, 1(1): 1–24.
- Dialga, I. – Vallée, T. (2021): The Index of Economic Freedom: Methodological Matters. *Studies in Economics and Finance*, 38(3): 529–561.



- Doucouliaqos, C. (2005): Publication bias in the Economic Freedom and Economic Growth Literature. *Journal of Economic Surveys*, 19(3): 367–387.
- Dutta, B. (2021): Understanding the Economy of Switzerland. <https://www.analyticssteps.com/blogs/understanding-economy-switzerland>.
- Ekici, T. – Koydemir, S. (2014): Social Capital, Government and Democracy Satisfaction, and Happiness in Turkey: A Comparison of Surveys in 1999 and 2008. *Social Indicators Research*, 118(3): 1031–1053.
- Fraser Institute (2022): Economic Freedom. <https://www.fraserinstitute.org/economic-freedom/dataset>.
- Gehring, K. (2013): Who Benefits from Economic Freedom? Unraveling the Effect of Economic Freedom on Subjective Well-Being. *World Development*, 50: 74–90.
- Georgiou, G. C. (2010): Cyprus: Economic Consequences of the Christofias–Talat/Eroglu Plan. *Southeast European and Black Sea Studies*, 10(4): 411–424.
- Golubović, N. – Golubović, S. (2020): Rule of Law and Democratic Consolidation in Serbia. *Law and Politics*, 17(3): 197–208.
- Graafland, J. (2020): When Does Economic Freedom Promote Well Being? On the Moderating Role of Long-Term Orientation. *Social Indicators Research*, 149(1): 127–153.
- Grech, A. G. – Micallef, B. – Zerafa, S. – Grech, A. G. (2016): Diversification and Structural Changes in the Maltese Economy. In: Grech, A. G. (ed.): *Understanding the Maltese Economy*. Valletta: Central Bank of Malta, pp. 15–25.
- Gwartney, J. – Lawson, R. (1997): *Economic Freedom of the World: 1997 Report*. Fraser Institute.
- Gwartney, J. – Lawson, R. – Block, W. (1996): *Economic Freedom of the World: 1975–1995*. Fraser Institute.
- Gwartney, J. – Lawson, R. – Hall, J. – Murphy, R. (2022): *Economic Freedom of the World: 2022 Annual Report*. Fraser Institute.
- Gwartney, J. D. – Lawson, R. A. – Holcombe, R. G. (1999): Economic Freedom and the Environment for Economic Growth. *Journal of Institutional and Theoretical Economics*, 155(4): 643–663.
- Hadsell, L. – Jones, A. T. (2020): The Company You Keep: Satisfaction with Life, Economic Freedom, and Preference-Policy Mismatch. *Journal of Comparative Economics*, 48(3): 642–657.
- Hall, J. C. – Lawson, R. A. (2014): Economic Freedom of the World: An Accounting of the Literature. *Contemporary Economic Policy*, 32(1): 1–19.
- Hatami-Marbini, A. – Hekmat, S. – Agrell, P. J. (2022): A Strategy-Based Framework for Supplier Selection: A Grey PCA–DEA Approach. *Operational Research*, 22: 263–297.
- Huang, Y. S. – Liao, J. T. – Lin, Z. L. (2009): A Study on Aggregation of Group Decisions. *Systems Research and Behavioral Science: The Official Journal of the International Federation for Systems Research*, 26(4): 445–454.
- Huang, M. – Xia, T. – Chen, Z. – Pan, E. – Xi, L. (2021): A DEA Integrated Grey Factor Analysis Approach for Efficiency Evaluation and Ranking in Uncertain Systems. *Computers – Industrial Engineering*, 162: 107681, 1–13.
- Islam, M. R. (2018): Wealth Inequality, Democracy and Economic Freedom. *Journal of Comparative Economics*, 46(4): 920–935.
- Johnson, R. A. – Wichern, D. W. (1982): *Applied Multivariate Statistical Analysis*. Prentice Hall, New Jersey.
- Kešeljević, A. – Spruk, R. (2013a): Endogenous Economic Freedom and the Wealth of Nations: Evidence from a Panel of Countries, 1996–2011. *Applied Economics*, 45(28): 3952–3962.
- Kešeljević, A. – Spruk, R. (2013b): Global Distribution and Dynamics of Economic Freedom: Non-Parametric Approach. *Economic Modelling*, 33: 560–571.
- Liu, S.-F. – Fang, Z.-G. – Lin, Y. (2006): Study on a New Definition of Degree of Grey Incidence. *Journal of Grey System*, 9(2): 112–115.



- Liu, S. – Lin, Y. (2010): *Grey Systems: Theory and Applications*. Springer Science – Business Media.
- Mazziotta, M. – Pareto, A. (2013): Methods for Constructing Composite Indices: One for All or All for One? *Rivista Italiana di Economia Demografia e Statistica*, 67(2): 67–80.
- Miozzi, V. J. – Powell, B. (2023): Measuring Economic Freedom during the Covid-19 Pandemic. *Journal of Institutional Economics*, 19(2): 229–250.
- Molnár, A. – Urbanovics, A. (2020): The Role of e-Democracy in Italy and Hungary. *Transforming Government: People, Process and Policy*, 14(3): 545–560.
- Murphy, R. H. (2019): Liberalizing, State Building, and Getting to Denmark: Analyzing 21st-Century Institutional Change. *Journal of Institutional Economics*, 15: 933–950.
- Odugbesan, J. A. – Rjoub, H. – Ifediora, C. U. – Iloka, C. B. (2021): Do Financial Regulations Matters for Sustainable Green Economy: Evidence from Turkey. *Environmental Science and Pollution Research*, 28(40): 56642–56657.
- OECD – JRC (2008): *Handbook on Constructing Composite Indicators: Methodology and User Guide*. Paris.
- Ott, J. (2018): Measuring Economic Freedom: Better without Size of Government. *Social Indicators Research*, 135(2): 479–498.
- Prados de la Escosura, L. (2016): Economic Freedom in the Long Run: Evidence from OECD Countries (1850–2007). *The Economic History Review*, 69(2): 435–468.
- Saeedikiya, M. – Li, J. – Ashourizadeh, S. – Temiz, S. (2022): Innovation Affecting Growth Aspirations of Early-Stage Entrepreneurs: Culture and Economic Freedom Matter. *Journal of Entrepreneurship in Emerging Economies*, 14(1): 45–64.
- Smith, A. (1776/2007): *An Inquiry into the Nature and Causes of the Wealth of Nations*. Harriman House Ltd.
- Spruk, R. – Kešeljević, A. (2018): Economic Freedom and Growth across German Districts. *Journal of Institutional Economics*, 14(4): 739–765.
- Stansel, D. (2019): An Economic Freedom Index for US Metropolitan Areas. *Journal of Regional Analysis and Policy*, 49(1): 40–48.
- Stroup, M. D. (2007): Economic Freedom, Democracy, and Quality of Life. *World Development*, 35(1): 52–66.
- Tung, C. T. – Lee, Y. J. (2010): The Innovative Performance Evaluation Model of Grey Factor Analysis: A Case Study of Listed Biotechnology Corporations in Taiwan. *Expert Systems with Applications*, 37(12): 7844–7851.

