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Foreign direct investment: robustness analysis of an attractiveness index

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Abstract

One of the most heavily employed tools to define countries' policies are the attractiveness indexes. The main purpose of our paper is to formally verify the capacity of an attractiveness index to describe the phenomenon of Foreign Direct Investment (FDI). Severe weaknesses were detected through the use of a framework (principal components analysis and *Cronbach*'s alpha reliability) to analyse indexes, regarding the theoretical background and the adequate selection of indicators, especially the ones from the bottom. Additionally, the study demonstrated that the analyzed FDI attractiveness index built to formally aggregate the factors that impacts foreign direct investment can hardly be applied to emerging economies.

Keywords: economics; factor analysis; investment analysis; location problems

1. Introduction

The study of Foreign Direct Investments (FDI) has been assuming a relevant role in the sustainable development of countries given that these are one of the least volatile, and most dependable, sources of international investment for host countries (Moosa and Cardak, 2006). Some knowledge aggregators, including composite indicators have been created to facilitate capital raising. One of these business aggregators, which was considered in the fuzzy approach done by Murat and Pirotti (2010), belongs to Groh and Wich (2009). This is an FDI attractiveness index that captures business attractiveness.

Our study is an appraisal of the robustness of Groh and Wich's (2009) index. Some of the benefits of the FDI's positive impact are technology transfer, the introduction of new production processes and productivity gains (Barro, 2009). Using the framework defined by Zambujal-Oliveira and Pinheiro-Alves (2012), the main purpose of our paper is to verify the capacity of the attractiveness

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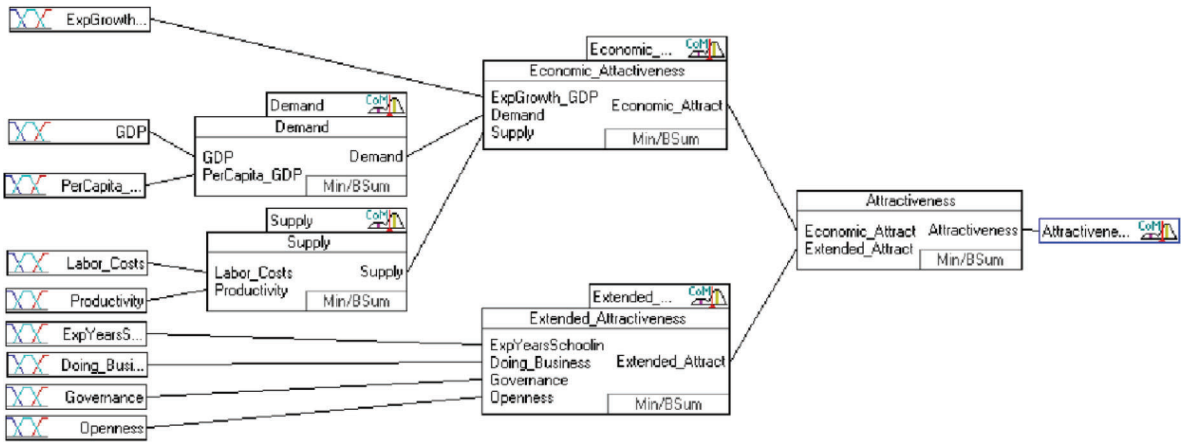

Fig. 1. Attractiveness Index Model (Murat and Pirotti, 2010).

index designed by Groh and Wich (2009), for modeling the economic phenomenon of the foreign direct investment (FDI). The examination of an attractiveness index comprehends the analysis of its underline theoretical framework and the selection and concordance appraisal of its quantitative indicators. Besides this analysis, the framework also verifies if the index might be adequately applied to all types of economies, independently of its level of development (Fig. 1).

Despite the profuse literature, the investment markets demand knowledge rationalization for FDI attraction factors. Thus, some authors have tried to answer the FDI question, as Groh and Wich (2009), who have developed an FDI attractiveness index, capable to rank 127 countries. Evaluating Groh and Wich (2009) index (GWI) robustness to formally describe the FDI attractiveness phenomenon becomes very useful in this context. Based on information collected, Teixeira and Tavares-Lehmann (2007) have realized an inability to determine the FDI attractiveness with accuracy.

Given its operational knowledge on how FDI should be measured, OECD (2008) contributes to defining FDI global standards, providing a single point of reference for FDI statisticians. FDI requires key international engagement and economic integration, providing resources to create direct, sustainable and long-lasting links among economies. The international political environment affects countries' local development, which improves competitiveness among origin and host countries of FDI. Particularly, FDI encourages the transfer of technology and know-how between economies, providing opportunities for the origin economies to promote their products in the international market (Roberts, 2000; Amaral, 2013). The global flow of FDI has grown over the last 30 years, continuing to play a crucial role in the production activities of developed countries, which capture approximately 75% (2008) of the global investment flows. UNCTAD (2014) has presented this percentage and revealed that the total FDI incoming flow captured by developing countries has improved since then (Fig. 2). Apart from confirming the considerable FDI growth in recent years, OECD (2008) shows an intensification of the number and value of transactions. Some authors interpret this growth as an entrepreneurial's determination to diversify businesses across economies and industrial sectors. As multinational enterprises (MNE) are traditionally major players in FDI

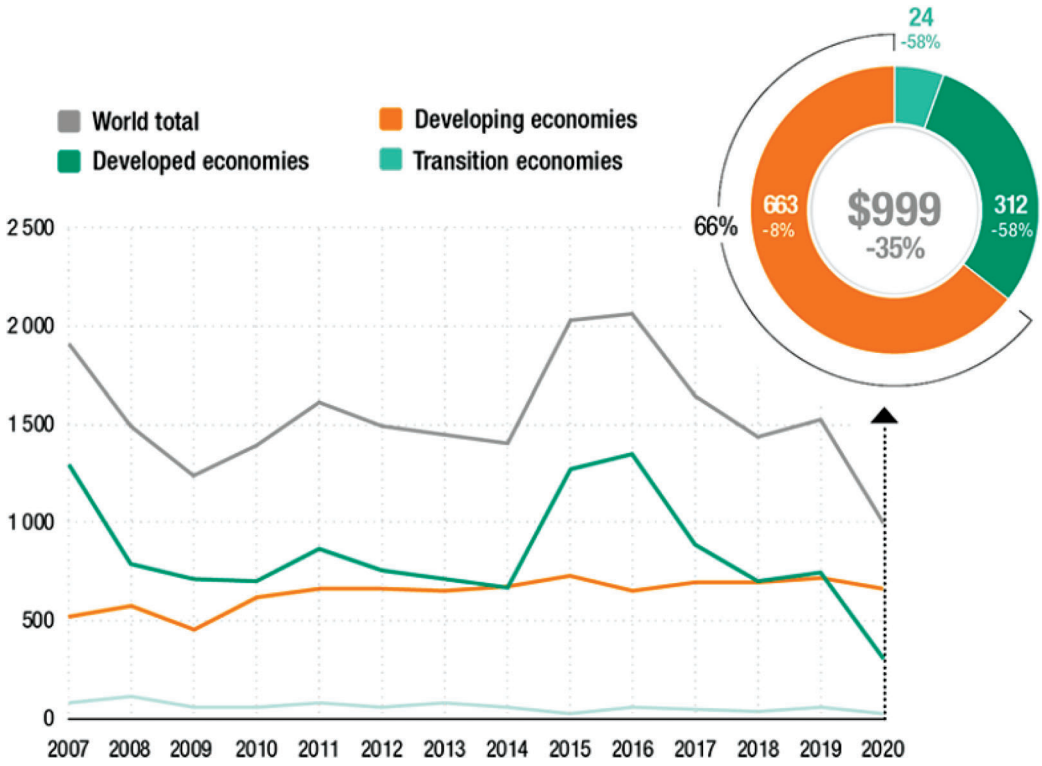

Fig. 2. Foreign direct investment inflows, global and by group of economies, 2007–2020 (Billions of dollars and percent) UNCTAD (2021).

transactions, Dunning (2002) considers that FDI progress complies with an increase in MNE's propensity to play a part in international markets and to act as global market players.

A compound indicator in the context of indexes, associates diverse nature factors and constitutes a frequent solution to integrate multi-environment dimensions. Cheveldayoff (1980) warns that one of the first problems related with weighted indexes comes from not clearly knowing its nature (current or fixed weighted). In a current-weighted index, the weighting factors are calculated and applied each year, reflecting the relative contribution made that same year by each component. Amaral (2013) points out additional problems related with the framework for the assembly of multi-indicators' indexes. These relate to the fact that the framework uses methodologies with weighted factors, meaning it adopts equal weights to the totality of the indicators. Even though these structural problems are well known, there are examples of extensively employed indexes such as the Global Competitiveness Index of World Economic Forum, the Ease of Doing Business Index (EDBI) and the Worldwide Governance Indicators.

Several steps were followed to analyze the multi-indicator index GWI (Appendix A) in this paper. The first one is the assortment of sub-indicators, followed by the statistical treatment of missing data, the selection of the integration model and the choice of the indicators' weights. The audit made by Zambujal-Oliveira and Pinheiro-Alves (2012) about the robustness of the Ease of Doing Business Index demonstrates that even the fulfilment of all Nardo's steps can originate distorted or

fragile policy conclusions. This also constitutes an excellent example of how the process of choosing data sets for sub-indicators and the index structures remains questionable.

Section 1 describes the concept of the study, with support from existing literature on theoretical pillars of attractiveness indexes. Section 2 includes a literature review and analyses relevant previous studies. Section 3 applies the methodology and analyses the proposed improvements. Finally, Section 4 presents the contributions.

2. Methodology

2.1. Foreign direct investment and attractiveness indexes

According to OECD (2008), the investment category that comprises FDI aims to establish long-term entrepreneurial interest in other economies and therefore implies a strong relationship between investors and host countries. Formally, OECD (2008) considers that a foreign direct investor, which has origin in one economy, should acquire (directly or indirectly) at least 10% of the voting rights in a company established in another economy. However, in practice, as stated by Bjorklund and Fortier (2014), the requirements can change widely from one economy to another.

For instance, sometimes FDI can assume odd forms such as the one described by Carr et al. (2001). In this case, a company domiciled in economy A can lend capital to owners that reside in economy B (and are experienced in industry Y) to enable them to buy out less capable owners from country A. In this scenario, no net movement of physical or financial capital is involved. Unusual FID forms, as the one just described, belong to what Carr et al. (2001) denominated as the knowledge capital model of MNEs.

OECD (2008) and IMF (2012) state that a foreign direct investor may come from any sector of the economy and can be one of the following entities (or any combination of them): an individual, a group of related individuals, a company incorporated or unincorporated, a public or private company, a group of related companies; organ government, a fund, or other social organization. In case two or more companies hold at least 10% of the voting rights of one over the other, each company can be considered, on its own, as a direct investor.

Although the IMF's (2012) categorization contributes to a delimitation of FDI nature, Portes and Smith (2010) have done several empirical tests on reputed indexes, using countries as the analysis units, which concluded there are conflicting definitions (on FDI literature) for the concept of different entities in the IMF (2012)'s categorization spectrum. This problem became evident when OECD (2008) requested a definition on a well-known concept that would identify the FDI direction and enable to classify it by type.

The arguments behind the OECD (2008) statement reside in the fact that FDI can be approached from multiple perspectives. One viable perspective considers bilateral flows among countries with the evolution of the internalization theory under the eclectic paradigm of Dunning (2000). Nee and Opper (2009) adopted an opposite perspective, centered on the nature of the economic legal regime. They collected evidence of a correlation between bureaucratic and progress levels associated with financial markets and the subsequent aptitude to persuade FDIs. Bénassy-Quéré et al. (2007) assembled cross-section estimations that confirmed institutions' performance is the main determinant of FDI attractiveness and bureaucracy correlation.

Table 1
Synthesis of the literature relating to FDI determinants (updated from Coy and Kathryn (2014))

Category + Factor	References
Government policy	
Proactive role of government	Lall (2002), Rios-Morales and Brennan (2007), and Wang et al. (2019)
Low corporate tax rates	Eicher et al. (2012) and Desbordes and Wei (2017)
Political environment	Blonigen (2005), Cieślik and Ryan (2004), and Koepke (2019)
High-quality government institutions	Kinoshita and Campos (2002), Blonigen (2005), and Navaretti and Venables (2020)
Industrial policies for knowledge clusters	Morisset (2003), Dimitropoulou et al. (2013), Nielsen et al. (2017)
International trade agreements on FDI	Kinoshita and Campos (2002) and Bermejo Carbonell and Werner (2018)
Economic activity	
Strong macroeconomic conditions	Kinoshita and Campos (2002), Cieślik and Ryan (2004), Razin et al. (2008), Piteli (2010), and Eicher et al. (2012)
Access to local capital within a stable banking system	Ozturk (2007), Piteli (2010),UNCTAD (2010), and Saini and Singhania (2018)
Low levels of corruption and risk	Wheeler and Mody (1992), Wei (2000), Kolstad and Villanger (2004), and Navaretti and Venables (2020)
Access to a strong export market	Cieślik and Ryan (2004) and Cieślik (2020)
Growing domestic and regional markets	Wheeler and Mody (1992), Cheng and Kwan (2000), Torrisi et al. (2008), Groh and Wich (2009), and UNCTAD (2010)
Competitive labor force costs and productivity	Barrell and Pain (1996); Cheng and Kwan (2000); Groh and Wich (2009); Hsu et al. (2019)
Access to high-skilled labor	Noorbakhsh et al. (2001); Gilmore et al. (2003); Bermejo Carbonell and Werner (2018); Dimitropoulou et al. (2013)
Clusters and agglomeration effects	Wheeler and Mody (1992); Kinoshita and Campos (2002)
Low-cost operations and high quality infrastructure	Cheng and Kwan (2000); Li and Clarke-Hill (2004); Pavlínek (2018)
Business enablement	
Access to progressive investment promotion incentives	Li and Clarke-Hill (2004), Baniak et al. (2005), Naudé and Krugell (2007), and Groh and Wich (2009)
Access to local amenities and high quality of life	Gunnigle and McGuine (2001), Li and Clarke-Hill (2004), and Annan-Diab and Filippaios (2017)
Previous investment or knowledge of country	Cieślik and Ryan (2004) and Cieślik (2020)

Besides clarifying the FDI perspective to be adopted in the index implementation, a substantive analysis requires knowledge gathering on theoretical relationships, and documenting the index phenomena in terms of investment, social factors and economic growth (Table 1). Nasser (2007) confirmed the relationship between investment, economic, and social factors (market size, GDP growth, macroeconomic stability, trade openness, education level, and infrastructure availability) through employing a set of panel data regression models. Similarly, Shatz and Venables (2000) concluded that market size and productivity are closely related to FDI development. Fung et al. (2000) verified these statements for developed countries, finding evidence of the relevance of the GDP as a decision variable for FDI. Helpman et al. (2004) and Brainard (1997) demonstrated that economic and political factors increase the bilateral FDI.

Borensztein et al. (1998) found that countries with high availability levels of human resources suffer a major impact on their economic process from the FDI inflows. Addison and Heshmati (2003) and Noorbakhsh et al. (2001) also confirmed the well-known positive connection between bilateral FDI flows and economic growth. Asiedu (2002) studied countries' openness to international trade in African environments and reached the same conclusion, that is, its positive influence on FDI flows. Makki and Somwaru (2004) and Borensztein et al. (1995) verified the impact of FDI on the economic process using a cross-country regression framework and found evidence of its role as the main channel for technology transfer. This is because it facilitates significative improvements in human capital and institutions of host countries. Reversely, Barrell and Pain (1997) isolated the negative impacts of abroad investments on exports from Germany, the UK, Sweden, and France, and also concluded FDI works as a diffusion tool for technologies among developed economies.

According to Alesina et al. (2005), the regulatory reform of product markets is strongly related to a level of increase in FDI. However, some authors are increasingly concerned about the shape of FDI as a special vehicle for importing intermediate products. The first key reason for concern is the disproportionate bargaining power the foreigner company can capture in the host country through the value created by its subsidiary company. The second reason for concern regards to decisions on nature resources transferred with lower benefits than the ones that would result from standard resource allocation Dunning (2002).

2.2. Previous studies

The definition of FDI remains as a challenging question and has been studied in diverse approaches, most of which are designed from the rationale of FDI. Groh and Wich (2009) tried to ground its index structure on a consistent set of literature that described the FDI attractiveness relationships with determinants. The main challenge of this study consisted of validating the quality of the relationship between determinants of FDI, considering relevant indicators may be missing. For that reason, our first methodological step was trying to reproduce the process of Groh and Wich (2009), employing databases that are equal or similar to the ones they have used, to understand the business attractiveness of the chosen set of countries (IMF, 2012).

Apart from evaluating the robustness of the relationship between FDI and its determinants in the Groh and Wich (2009) index (Fig. 3), this paper verifies its compliance with the general index purposes. Bandura (2008) studied several ways of classifying these purposes such as simplifying the analysis of complex issues and revealing position changes in rankings. Some authors (Saisana et al., 2002; Pellegrini, 2006) consider using FDI to assess progress of countries relative to their international commitments, converting FDI into a valuable instrument to enhance government policies and improve investors' knowledge. Assessment methods employed in the index construction include aggregation techniques, multiple linear regression analysis, principal component analysis and factor analysis, Cronbach's alpha, neutralizing the effect of correlation, expert's advise, target distance, public opinion, and the analytic hierarchy process.

Indexes have been analyzed by several authors. Pellegrini (2006) evaluated various competitiveness indexes, concluding they have weak adherence to underlying literature. Other authors, such as Cracolici et al. (2008) studied sectoral indexes and analyzed the competitiveness of tourist destinations. Pellegrini (2006) found that an index structure with equal weights conveys a meaningless

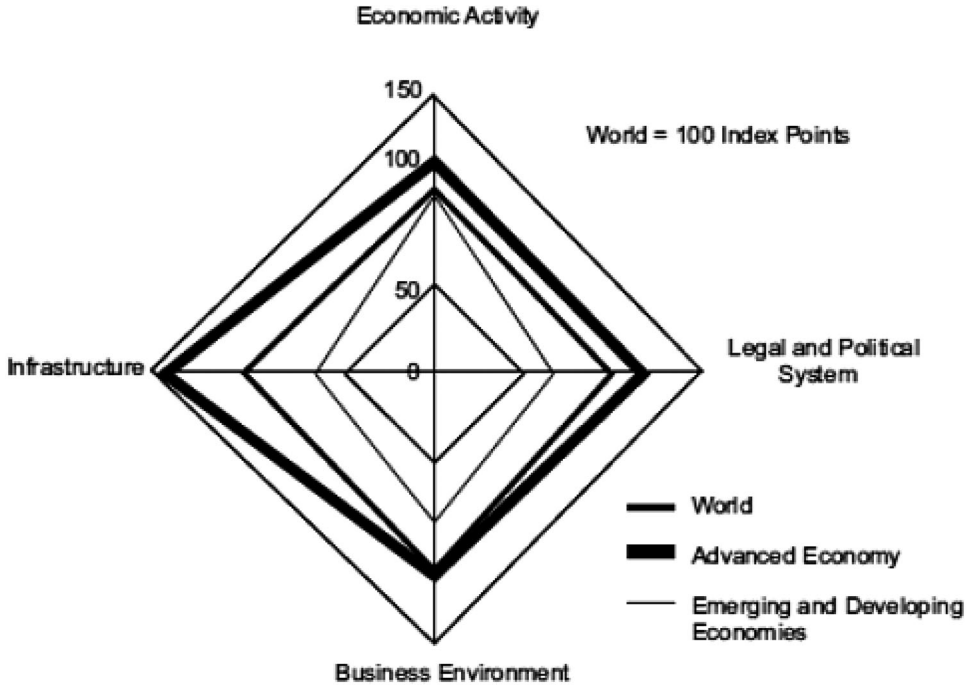

Fig. 3. Strengths and weaknesses (index four key drivers) (Groh and Wich, 2009).

perception of the indicators. Therefore, creating an index structure that attributes appropriate weights to all indicators is challenging for index creators. There are, however, examples of this practice, including Gwartney et al. (2010) and Schwab (2018).

The index structure used on the study is based on the work of Groh and Wich (2009) and Amaral (2013). This structure comprises three levels: a) the first level aggregates single indicators into four themes: *Economic Activity*, *Political and Legal System*, *Business Environment*, and *Infrastructure*; b) the second level contains compound indicators; and c); the third level constitutes the base of the pyramidal index structure, including lower level indicators (i.e. indicators with the lowest weight values in the overall compound indicators). According to the same authors mentioned above and Jacobs et al. (2005), the weight readjustment of compound indicators at the middle level improves the index robustness. Nonetheless, it is considered appropriate to reproduce compound indexes from underlying performance indicators and use Monte Carlo simulations to examine the robustness of the compound. Figure 4 depicts the process in three phases: (1) normalization and standardization; (2) weighting indicators; and (3) indicators' aggregation.

2.2.1. Normalization

Following the procedure described by Nardo et al. (2005) and complemented by Otoiu et al. (2021), the first step of an index study is examining, for each country, the relationship between global FDI dynamics and their progress during the time period being considered. This operation requires normalization techniques to fill in the data holes found in the numeric series of the FDI data. The

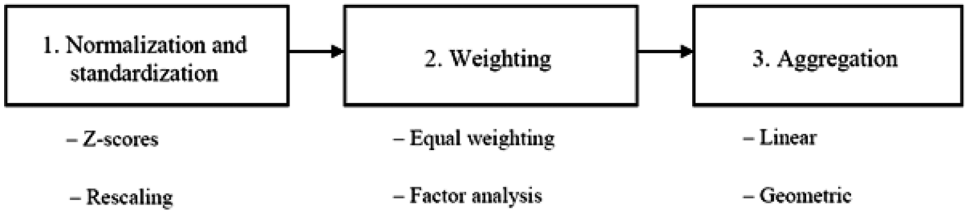

Fig. 4. Index structuring phases Groh and Wich (2009).

normalization process can employ techniques such as the ones described by Van Buuren (2012), sometimes even assuming variables with more than 5% of missing data. Little and Rubin (2014) also consider that the analysis of missing data is crucial for the process and have suggested a mechanism to treat missing-data indicators, in which they are considered as random variables and are assigned a distribution.

Therefore, the challenge of the normalization process is the adequate selection of methods, which are capable of filling information gaps and following the approach of IAEA (1992) to the normalization and scaling process after indicators are defined and elementary data are collected. This includes a calculation of the indicators on a per component class basis. For such normalization, Ebert and Welsch (2004) recommend the employment of $z_s cores\ z = \frac{x-\bar{x}}{s}$ ($\bar{x}$: sample mean and s: sample standard deviation) and min–max methods. Besides from such standardization, the process requires the aggregation of basic compound indicators and item indexes, using weights to form the desired aggregate indicators and item indexes (USBLS, 1992).

2.2.2. Indicators's selection and weighting

Regarding the indicator selection, there are a set of multivariate techniques that are adequate to replicate the knowledge behind the data set structure of compound indicators. The principal component analysis (PCA) exposes the relationship among correlated indicators through transforming them into a new set of uncorrelated indicators using a covariance matrix. PCA produces indexes, in which each component is a linear weighted combination of variables.

$$PC_1 = a_{11}X_1 + a_{12}X_2 + \cdots + a_{1n}X_n, \tag{1}$$

$$PC_m = a_{m1}X_1 + a_{m2}X_2 + \cdots + a_{mn}X_n, \tag{2}$$

a_{mn} : weight for the mth principal component and the nth variable;

$X_1 \ldots X_n$: variables X_1 through to X_n

An interesting characteristic of the PCA is its capacity to reduce the data set dimensionality. Figure 5 shows the concept of PCA, in which two perpendicular components are represented, each one is measuring different data dimensions (Manly and Alberto, 2016).

Furthermore, the most common approach to analyze the index's internal robustness is the calculation of *Cronbach*'s alpha coefficient to explore the correlation among its variables (Nardo et al., 2005). However, Spiliotopoulou (2009) suggests caution when analyzing the metric for internal

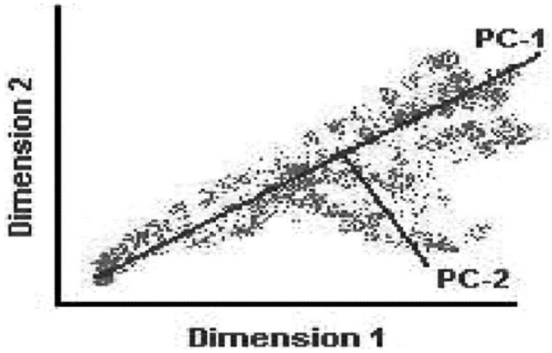

Fig. 5. Two sequential components in PCA (Vyas and Kumaranayake, 2006).

robustness because low levels of the coefficient alpha may not always be evidence of problems in index structure. Also, high levels of coefficient alpha may not always indicate appropriate reliability.

In Spiliotopoulou (2009), the author insists the analysts should consider the nature of data, the scale's length and width, the linearity and the normality of response distribution, the central response tendency, the sample response variability, and the sample size. This way, analysts take into account some characteristics of the response (sample size, normality of distribution, tendency, and variability) and some characteristics of the data (scale's length and width, and nature).

2.2.3. Aggregation

When trying to explain observed weaknesses in internal robustness of a inventory index, Wong and Yuen (2015) also checked the diversity of the involved factors. *Cronbach*'s alpha coefficient is therefore an estimation of the correlation among random samples of variables taken from a universe of variables. It is considered to be an appropriate coefficient of equivalence and of relevance for the first-factor concentration in the internal foundation tests (Cronbach, 1951; Management Association, I.R, 2020). Hence, the study reproduces the procedure described by Groh and Wich (2009), employing the *Cronbach*'s alpha coefficient to assess the inner robustness of compound indicators and single indicators of each theme.

$$\alpha_c = \frac{n\bar{\rho}}{1 + (1 - n)\bar{\rho}}. \tag{3}$$

However, reliability tests require go further, which includes applying *Cronbach* techniques and validating the suitable number of clusters, the index structure, and the weights associated to the compound indicators (Miller et al., 2010; Amaral, 2013). Our study considers a trivial linear model of y unobservable themes Φ_i that are functions of x indicators Ψ_j characterized by having theme loadings $\kappa_{i,j}$ associated with themes and residuals. Themes Ψ_j are not correlated and residuals ε_i have a null mean. The variance of themes is unitary and the variance of the residuals does not have any restrictions. Additionally, factor analysis estimates the common factors, which is useful to quantify the percentage of variance explained by the sub-indicators (Zambujal-Oliveira and

Pinheiro-Alves, 2012).

$$\Phi_i = \kappa_{i,1}\Psi_1 + \kappa_{i,2}\Psi_2 + \cdots + \kappa_{i,x}\Psi_x + \varepsilon_j, \quad i = 1..y;\ j = 1..x;\ \kappa_{i,j}:\ \text{factor loadings};\ \Psi_1:\ \text{factors}. \tag{4}$$

Our analysis assumes factors Ψ_j and residuals ε_j not correlated and residuals with null mean. Two tests can be applied to confirm the absence of correlation among the index variables and verify the applicability of the factor analysis approach: the Bartlett's test of sphericity (Snedecor and Cochran, 1967):

$$\chi^2 = \frac{(N-k)\ln(S_p^2) - \sum_{i=1}^{k}(n_i - 1)\ln(S_i^2)}{1 + \frac{1}{3(k-1)}\left(\sum_{i=1}^{k}\left(\frac{1}{n_i - 1}\right) - \frac{1}{N-k}\right)}, \quad N = \sum_{i=1}^{k} n_i;\ S_p^2 = \frac{1}{N-k}\sum_{i}(n_i - 1)S_i^2;$$

$$k\text{: sample number};\ n_i\text{: sample sizes};\ S_i^2\text{: sample variances}. \tag{5}$$

and the *Kaiser–Meyer–Olkin (KMO)* measure:

$$\kappa = \frac{\sum\sum_{j\neq k}\rho_{jk}^2}{\sum\sum_{j\neq k}\rho_{jk}^2 + \sum\sum_{j\neq k}\varrho_{jk}^2}, \quad \rho_{jk}\text{: correlation coefficient between variables } X_j \text{ and } X_k;$$

$$\varrho_{jk}\text{: partial correlation coefficient between } X_j \text{ and } X_k, \text{ given other } X_s \tag{6}$$

While Cronbach (1951) was trying to measure the correlation among answers included in a survey by profile analysis, Nunnally (1978) created an alpha coefficient to examine a survey's reliability. The *Cronbach's* coefficient evaluates on a scale from 0 to 1, how consistently the indicators abstain themselves from contributing to the weighted sum of the index (Goodboy and Martin, 2020). *Cronbach*'s coefficient may be viewed as the weighted-average of the robustness of all indicators if all possible scale divisions are known. Cortina (1993), apart from explaining that *Cronbach*'s alpha coefficient incorporates the dissimilarities between the indicator standard deviations and the standardized item alpha, refers to alpha as a measure of reliability, making evident its strong relationship with the robustness of indexes (Maroco and Garcia-Marques, 2013).

At this stage of the analysis, the expectation is to find evidence of process discrepancies, because the study considers a lower number of countries. A potential fundament of these discrepancies is the existence of different normalization scales, which results in the detection of severe deficiencies in the index structure. Dasgupta and Tam (2005) confirm the normalization procedures mentioned above, after comparing alternatives across a range of indicators with different orders of data magnitude. To verify this, the study analyses the paired sample *t-test* to draw tangible conclusions.

A high value of the *Cronbach*'s alpha coefficient would signalize that the underlying indicators constitute relevant proxies of the compound indicator (Amaral, 2013). Nardo et al. (2005) assume a benchmark of 0.7 to the *Cronbach*'s alpha, value suggested by Nunnally (1978), as a satisfactory cut-off limit of acceptance, which is widely recognized in the indexes literature. For instance, the completely diverse multidimensional living conditions index (*LCI*) designed by Krishnan (2015) also accepts it, as an adequate boundary assumption.

Table 2
Cumulative variance

	Initial Eigenvalues		
Factors	Total	%Variance	$\sum$%
1	9.284	46.219	46.219
2	2.660	13.721	59.940
3	1.820	8.948	68.888
4	1.212	6.016	74.904
5	0.895	4.939	79.843
6	0.849	4.290	84.133
7	0.757	3.854	87.987
8	0.520	2.969	90.957

3. Results and enhancements

Following the steps described by Zambujal-Oliveira and Pinheiro-Alves (2012), the study compared the factors with the themes previously obtained by Groh and Wich (2009). First, the proportion of the overall variance associated with each eigenvalue was analyzed and the factors whose eigenvalues contributed proportionally more or were superior to 1.00 (Mingoti, 2007) were maintained. The latter's contribution to the explanation of the cumulative variance should exceed 75% (Nunnally, 1978; Nardo et al., 2005).

Second, the study determined the slope of the factor analysis through the identification of the eigenvalues distribution and the extraction of the factors at the point where the curve becomes flat (Hair and Kuppel, 2014).

Third, the study normalized the data series to obtain indicators with a unit variance. This enabled getting the correlation matrix and determining the eigenvalues of the nonfactors. The number of compound factors with significant explanatory power will come from applying the *Kaiser* criterion on the latent value (Kaiser, 1958; Slimane et al., 2016). This was successfully applied by Najmi et al. (2010) on a business intelligence project aimed at helping organizations to manage information through transforming into knowledge.

3.1. Descriptive statistics

As a first step, we performed the Bartlett's test of sphericity (Snedecor and Cochran, 1967; Chen et al., 2020) and obtained a highly significant p-value ($p < 0.003$), confirmed by the sampling adequacy (0.794) of KMO with a $\chi^2 = 2856.85$. Maza and Villaverde (2015) and Mukha et al. (2019) also detected a KMO's value considerably higher than the threshold of 0.5. They provided evidence that this limits the potential lack of correlation between indicators and ensures quality and adequacy of the sampling data, which should appropriately represent business attractiveness.

The GWI's analysis indicated four factors that capture 74.90% (Table 2) of the global cumulative variance, which is consistent with the theoretical structure of the index (Fig. 6). Mukha et al. (2019) confirmed and maintained the factors detected by Amaral (2013) to keep accuracy on the

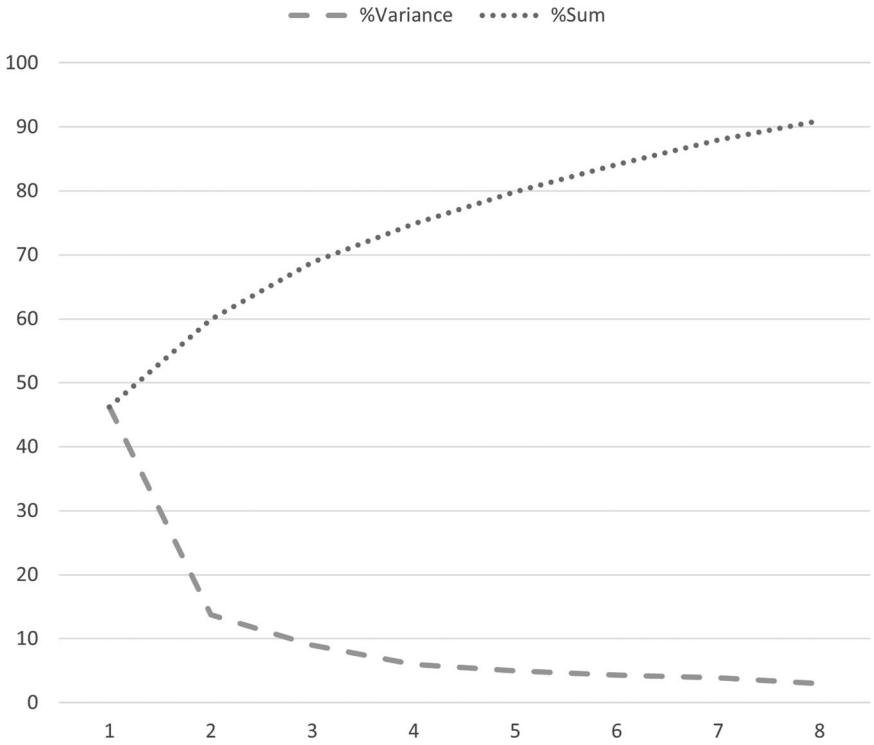

Fig. 6. Eigenvalue to main aggregate of the index.

representation of the business attractiveness phenomenon. This author found the two main components of the GWI that explain 86.1% of the variance of original indicators (subindexes). The method of principal components enables a correspondence between the factors and each one of the four themes (subindexes): *1. Attractiveness of the economy*, *2. Legal and political systems*, *3. Business environment*, and *4. Infrastructure and workforces*.

3.2. Evaluation of the measurement model

We established the correlation between factors and indicators (Table 3), to obtain the concordance levels between indicators and statistical factors. We then selected the most relevant values (gray shades) and aggregated them by theme.

The concordance levels were summed up for each theme (Table 4) to estimate the explanatory power of each factor (Rodriguez and Pallas (2008) measured it with an adjusted R^2). In parallel, we calculated the relative weights of each statistical factor to compare them with the theoretical weights (similar to the process used by Levary and Wan (1999), Zambujal-Oliveira and Pinheiro-Alves (2012), and Amaral (2013)).

Table 4 displays the concordance levels between themes belonging to the GWI and the four statistical factors. For example, theme *4. Infrastructure* has a concordance level of 42.1% with factor

Table 3
Indicators versus factors concordance

Themes/Indicators		Factors 1	2	3	4
1.	Economic Activity				
1.1.1	GDP PPP per capita	0.696	0.109	−0.451	−0.129
1.1.2	Real GDP Growth	0.066	0.140	0.113	0.612
1.2	Prevalence of Trade Barriers	−0.071	−0.157	0.981	0.017
1.3	Central Gross Government Surplus / Deficit	0.601	0.029	0.609	0.014
2.	Legal and Political System				
2.1.1	Rule of Law	0.864	0.448	0.081	0.364
2.1.2	Regulatory Quality	0.765	0.336	0.313	0.225
2.1.3	Legal Enforcement of Contracts	0.377	0.407	0.139	0.116
2.1.4	Business Impact on FDI	0.527	0.114	0.413	0.380
2.2.1	Stability and Absence of Violence / Terrorism	0.614	0.190	0.048	0.361
2.2.2	Government Effectiveness	0.858	0.656	0.176	0.241
3.	Business Environment				
3.1	Pay and Productivity	0.400	0.235	−0.259	0.671
3.2	Profit and Capital Gains Tax	0.865	−0.107	0.036	−0.054
3.3	Administrative Requirements	0.611	0.326	−0.220	0.513
3.4	Control of Corruption	0.672	0.456	0.126	0.400
4.	Infrastructure				
4.1.1	Quality of Roads	−0.071	0.831	0.005	0.306
4.1.2	Quality of Railroad Infrastructure	−0.119	0.931	−0.273	0.271
4.1.3	Quality of Port Infrastructure	0.255	0.816	0.245	−0.053
4.1.4	Quality of Air Transport Infrastructure	0.310	0.752	0.193	−0.064
4.2	Quality of Electricity Supply	0.350	0.896	−0.182	0.156
4.3	Fixed Line and Mobile Phone Subscribers	0.411	0.712	−0.194	−0.333
	Total per Theme	4.005	4.937	1.251	1.530

Table 4
Themes versus factors concordance

Themes	Factors 1	2	3	4
1. Economic Activity	1.294	0.121	1.251	0.514
2. Legal and Political System	4.005	3.061	0.855	1.688
3. Business Environment	2.548	0.91	−0.317	1.53
4. Infrastructure	1.136	4.937	−0.206	0.283
Weights	34.2%	42.1%	10.7%	13.1%

2, and theme *2. Legal and Political System* has a concordance level of 34.2% with factor 1. These two themes represent more than 75%(34.22% + 42.1%) of the dynamics of business attractiveness. Figure 7 illustrates this correspondence.

The most relevant concordance levels of Table 4 come only from the first two factors (4.005($F1$); 4.937($F2$)). The remaining factors captured concordance levels of only 1.251($F3$) and 1.688($F4$). This seems to evidence a statistical inconsistency on the GWI's structure. Consequently,

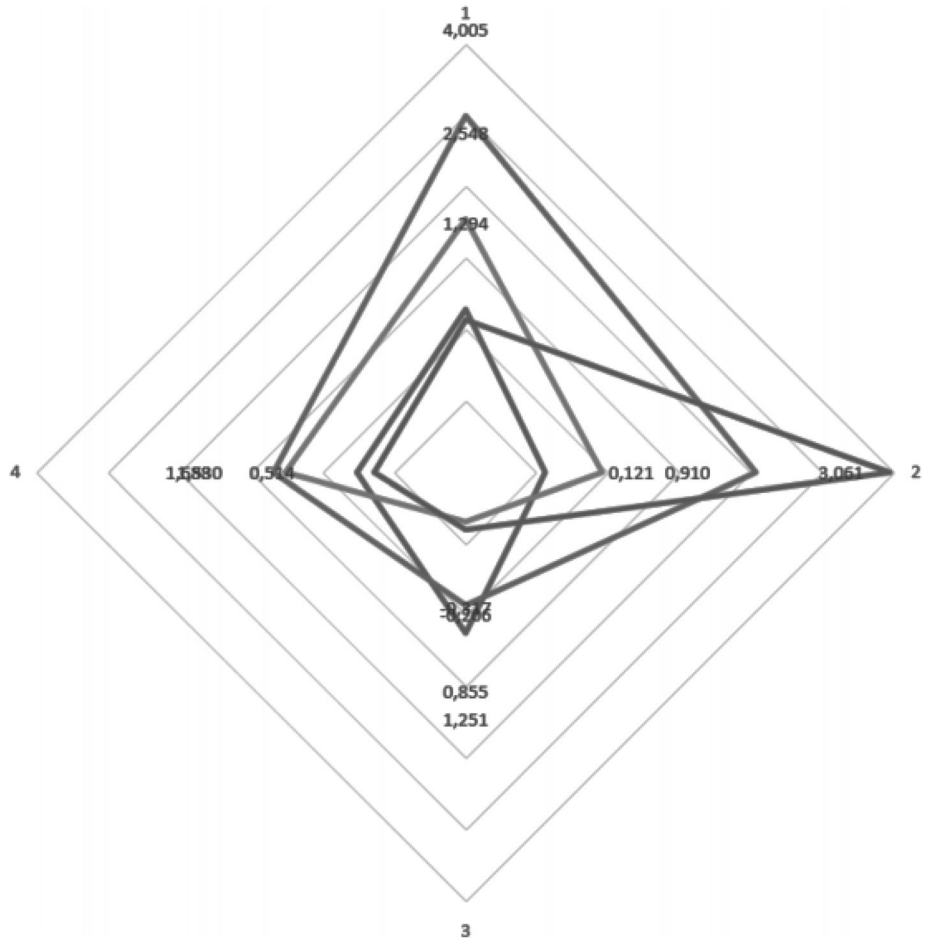

Fig. 7. Themes versus factors correspondence [(BY+6)..(BY+11)].

this indicates an urgent need to update the regression process between themes and indicators (compound and single).

Besides the deficient theoretical framework and an inadequate selection of indicators, we also detected a weak correlation (0.1461) among the indicators that compose the theme *1. Economic activity*. This demonstrates a poor selection of indicators, which are incapable of reproducing the phenomena represented by this theme. Amaral (2013) consequently examined two samples of countries with a paired sample *t-test*, which revealed that only 9 of the 21 sampled countries have values of two-tail significance (higher than 0.05), corroborating the weakness of the application of the GWI on less mature economies (Table B1, Appendix B).

The results obtained in this analysis may affect the accuracy of previous studies. This includes the work done by Joynt (2019), who employed transport infrastructure indicators to study the impact of the quality of transport infrastructure on global competitiveness ranking. Another example is the study from Gozgor et al. (2019) that examined the effects of legal system and property rights

Table 5
Cronbach's alpha with updated weights' configuration

Theme\Year	BY	+1	+2	+3	+4	+5	avg.
1. Economic activity	0.772	0.819	0.833	0.842	0.870	0.882	0.836
Theme\Year	+6	+7	+8	+9	+10	+11	avg.
1. Economic activity	0.718	0.857	0.753	0.842	0.917	0.743	0.805

Table 6
Cronbach's alpha of themes' indicators

Themes\Period	BY+6	+7	+8	+9	+10	+11
1. Economic Activity	0.389	0.075	0.416	0.190	0.346	0.284
2. Legal and Political System	0.907	0.903	0.907	0.904	0.905	0.897
3. Business Environment	0.841	0.785	0.829	0.823	0.836	0.810
4. Infrastructures	0.922	0.901	0.941	0.918	0.939	0.894

protection on inbound tourism, including multiple indicators from the theme *2. Legal and Political System*. This also relates to the paper from Wang and Xi (2022), which presents an approach to the design of China's Tax System Structure, using the indicator *3.2 Profit and Capital Gains Tax*, which may be incoherent for theme 4.

3.3. Index structure evaluation and improvements

After concluding the statistical examination on the internal consistency between the four themes of GWI and their internal compound and single indicators (different from the process employed by Schmitt (1996)), several measures were tested to increase the robustness of the index.

A successful measure was the update of the weights' configuration to the one defined in Table 4. The results were encouraging, showing a significant increase in internal robustness. After examining the internal consistency of the four themes and their internal indicators, we compared our results with the ones obtained by Groh and Wich (2009), as shown in Table 5. For this, we applied the new weights model to the theme *1. Economic Activity*, considering the same period [BY(2006)..(BY+5)] as Groh and Wich (2009).

Consequently, as described in Table 5, *Cronbach*'s alphas are above the boundary established by Nunnally (1978) for the entire study period, specifically in base year, and perfectly compatible with similar work (Rokhmawati, 2021). For example, Mihaylova et al. (2019) calculated average *Cronbach*'s alphas in the range of 0.860 and 0.660 in the consistency analysis. Hence, this configuration with unequal weights ensures a better correlation between themes and consequently helps enhancing their internal consistency. In this context, *Cronbach*'s alphas of each theme would increase well above the acceptable consistency boundary (0.7), namely *1. Economic Activity*: 0.805; *2. Legal and Political System*: 0.894; *3. Business Environment*: 0.979; and *4. Infrastructures*: 0.893.

The next step of the process was to determine the *Cronbach*'s alpha associated with the indicators that compose each theme. Table 6 illustrates the results of the internal consistency test for the indicators of the four themes, during the considered period.

Table 7
Average Cronbach's alphas

Themes\Authors	Groh and Wich (2009)	Amaral (2013)	2022
1. Economic Activity	0.617	0.299	0.355
2. Legal and Political System	0.908	0.903	0.893
3. Business Environment	0.522	0.821	0.837
4. Infrastructures	0.894	0.920	0.908

The *Cronbach*'s test we applied to the chosen countries' set confirmed the results obtained by Amaral (2013), revealing three themes with robust correlation values and one (*1. Economic activity*), composed by internal indicators, that are weakly correlated (0.389). Thus, the indicators seem poorly correlated for advanced economies. Table 7 summarizes the alpha levels obtained by Groh and Wich (2009) (over a sample of 127 countries), comparing them to other works.

We noticed in the results from Groh and Wich (2009), which was confirmed by our own results (Table 7), that the themes *1. Economic Activity* and *3. Business Environment* present levels below the minimal cut-off value suggested by Nunnally (1978). To respond to this, the authors performed a more detailed analysis and concluded they should discard the indicator *1.1.1 Growth rate of GDP* to increase the *Cronbach*'s alpha of the theme *1. Economic Activity*. For theme *3. Business Environment*, the authors state that the indicator *3.2 Taxation* has a low correlation to the remaining internal indicators and therefore it should be discarded to increase the statistical consistency of the theme.

Despite their knowledge, Groh and Wich (2009) unexpectedly decided to keep these low correlated indicators in the index. The reason for this was that literature on these topics considers them relevant for the phenomenon of FDI attractiveness. Consequently, our results on internal consistency were very different from the results presented above. One of the reasons behind the discrepancy may be the fact that the scale boundaries for normalizing the indicator data sets are not homogeneous due to the smaller size of countries' sample, which seems to be confirmed by Groh and Wich (2012) and Kayalvizhi and Thenmozhi (2018).

In summary, the enhancements applied to the GWI's structure, described in the previous paragraphs, increased the significance of all themes, particularly theme *3. Business Environment*, decreasing significantly Nunnally's (1978) level to 0.329. The proposal considered by Groh and Wich (2009) for discarding the indicator of *1.1.1 Growth rate of GDP* and removing the indicator *3.2 Taxation* from the theme *Business Environment*, seems to be in complete disconformity with the general FDI literature. Moreover, the proposal from Amaral (2013), which includes different scale boundaries and considers the existence of nonidentical sample sizes and different processes of normalization, may also underlined divergences in themes. Considering the GDP (PPP) values per country and taking into account their distribution (Fig. 8), we concluded that excluding indicators as *1.1.1 GDP PPP per capita* or *1.1.2 Real GDP Growth y-o-y* from the theme *1. Economic Activity*' produced a positive average benefit (79%) on the GWI internal robustness, measured with the *Cronbach*'s alpha, which reached an average value of 0.549 during the considered time period [(BY+6)..(BY+11)]. The average increase is in line with the one (86%) obtained by Amaral (2013).

Although Pavlopoulou-Lelaki (2022) considered *1.1.2 Real GDP Growth y-o-y* a main explanatory variable of interest, the exclusion of the two internal indicators with lower eigenvalues (*1.1.1 GDP PPP per capita* and *1.1.2 Real GDP Growth y-o-y*) from the theme *1. Economic Activity*,

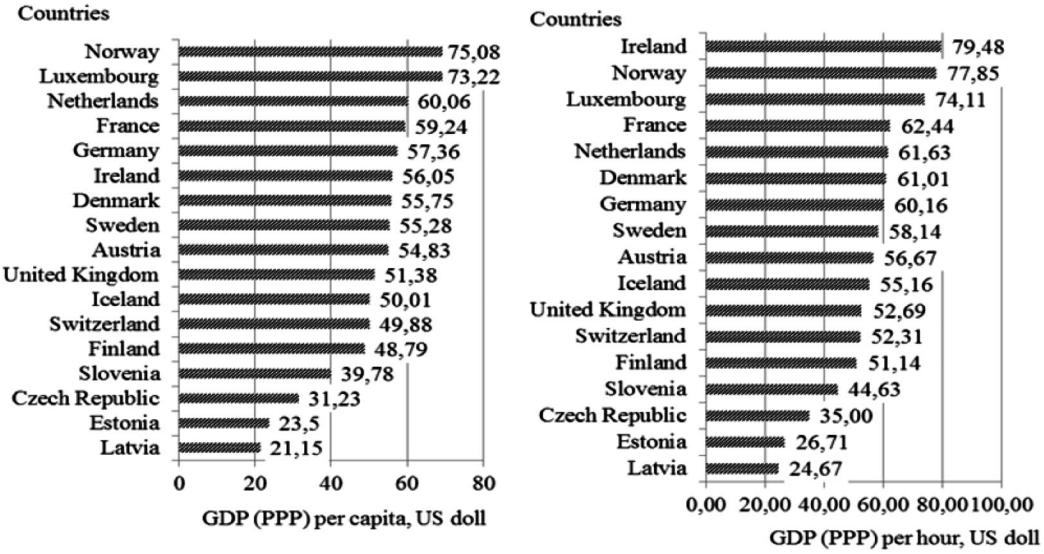

Fig. 8. GDP (PPP) per capita Grigoryev and Pavlyushina (2019).

Table 8
Variation of *Cronbach*'s alphas

Theme\Year	BY	+1	+2	+3	+4	+5	avg.
1. Economic activity	0.148	0.338	0.289	0.299	0.263	0.538	0.3125
1. Economic activity (exc. 1.1.1 and 1.1.2)	0.561	0.604	0.651	0.619	0.504	0.565	0.584
%var	279%	79%	125%	107%	92%	5%	87%
Theme\Year	+6	+7	+8	+9	+10	+11	avg.
1. Economic activity	0.313	0.313	0.382	0.232	0.207	0.395	0.307
1. Economic activity (exc. 1.1.1 and 1.1.2)	0.568	0.675	0.497	0.484	0.567	0.503	0.549
%var	81%	116%	30%	109%	174%	27%	79%

caused an increase in *Cronbach*'s alpha of the indicators associated with the theme, presenting a enhancement (max: 174%, min: 30%; average: 79%) in the explanatory variance power (Table 8). Therefore, after analyzing the experiments carried out by Groh and Wich (2009) over the themes *1. Economic Activity* and *3. Business Environment*, our results confirmed the conclusions of Amaral (2013) about the evidence of existing different versions of the GWI, according the evolution level (advanced or emerging) of the countries.

The first six years [(BY)..(BY+5)] of Table 9 show a very discrete increase in the Cronbach's alpha over the years, with the exclusion of indicator 3.2. The subsequent years [(BY+6)..(BY+11)] maintain a similar behavior, underlining the inability of the indicator of theme *3. Business Environment* to add variance explanatory power to the GWI. On this basis, we considered this indicator should be removed from the theme.

Beyond the previously referred indicators, we also observed a weak contribution of the indicator *3.2 Profit and Capital Gains Tax* to the robustness of theme *3. Business Environment*. However, its removal from the GWI contributes with a very discrete increase of 1% of the average *Cronbach*'s

Table 9
Variation of *Cronbach*'s alphas

Theme\Year	BY	+1	+2	+3	+4	+5	avg.
3. Business Environment	0.805	0.819	0.809	0.821	0.845	0.857	0.826
3. Business Environment (excluding 3.2)	0.776	0.822	0.828	0.853	0.854	0.852	0.831
%var	−4%	0%	2%	4%	1%	−1%	1%
Theme\Year	+6	+7	+8	+9	+10	+11	avg.
3. Business Environment	0.834	0.812	0.824	0.785	0.824	0.846	0.820
3. Business Environment (excluding 3.2)	0.875	0.848	0.875	0.813	0.808	0.838	0.844
%var	5%	4%	6%	4%	−2%	−1%	1%

alpha to 0.844. We consider this increase to be of low relevance and, therefore, we believe there is no significant value in further progressing the process. On the other hand, Sadayuki et al. (2019) found this indicator to be particularly useful, when they used it to measure the transparency of the real estate market. Merz et al. (2013) proposed indexes with industry-specific determinants for situations with weak indicators. They also developed a two-stage methodology to explain the underlying regional industrial vulnerability, combining a compound indicator model (to evaluate sector-specific indicators) with a new regionalization method.

4. Conclusions

This analysis presents relevant weaknesses on the FDI attractiveness index of Groh and Wich (2009) with a study process that incorporates well known methodologies. First, the literature review detected serious deficiencies on the theoretical framework of the main determinants, mainly due to the integration of indicators with weak theoretical support. Second, the GWI includes a poor selection of indicators, and its accuracy is compromised for countries with lower levels of economic development. Third, the GWI does not differentiate between horizontal and vertical FDI. Fourth, some of the indicators are actually aggregations of others, based on surveys and built with ordinal scales. The mentioned aggregation problems were also addressed by Filippone et al. (2001) and Stiblarova (2021). The index analysis reveals a fragile relationship between the behavior of the FDI phenomenon and the progress of the GWI, for each one of the 12 economies included in the GWI (Nardo et al., 2005; Zambujal-Oliveira and Pinheiro-Alves, 2012; Amaral, 2013).

In terms of contributions, the paper demonstrates deficiencies on the internal robustness of the GWI, which prevents the adequate representation of the FDI phenomenon. The implications of this are that defining public politic strategies and monitoring them through the GWI can cause severe distortions in terms of public budget definition. The study also considers that an unbiased FDI attractiveness index should be configured according to the economic development level of each country, including different sets of indicators. However, this not mean that specific indicators cannot be allocated to different development environments, for example, the framework proposed by Archibugi and Coco (2004), developed to represent countries' technological capabilities (Radosevic and Yoruk, 2018).

The work of some authors such as Noorbakhsh et al. (2001) and Sadeghi et al. (2020), (technology spillovers, physical capital inflows, economic complexity, human capital, and FDI attraction),

Makki and Somwaru (2004) (group of 16 Arab economies), Borensztein et al. (1998), and Benacek et al. (2000) seems to justify the robust evidence of relevant disparities between determinants of FDI's attractiveness depending on the country economic stage of development (mature economies and developing economies) (Makhavikova, 2018). Therefore, the study proposes improvements on the GWI structure that contribute to more appropriate GWI fitness levels when reproducing inflow FDIs, especially, those associated to mature economies.

We recognize some limitations on the present study. The first limitation is associated with the constant change of data that leads to contingent contributions for the data periods. The second is related to the fact that the GW index is not being constantly updated, which decreases its utility and capacity of becoming widely accepted. Nonetheless, the applied methodology seems robust and prepared for future appraisal research in other attractiveness indexes. Additionally, themes such as *1. Economic activity* and *3. Business Environment* need further study on indicators that can improve their ability to represent the underlying phenomena.

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Appendix A

Identifier	Key Drivers, Construct, Data Series	Unit	Source
Denom. 1	Population	[millions]	IMF, UNFPA State of World Population 2008 for values in 2008, UNFPA State of World Population 2007 for values in 2007
Denom. 2	Total GDP	[US$ millions]	Euromonitor International from International Monetary Fund (IMF), International Financial Statistics
1. Economic Activity			
1.1	Market Size and Potential		
1.1.1	*Economic Size per Capita (GDP PPP per capita)*	[per capita]	IMF, World Economic Outlook Database (October 2008)
1.1.2	*Real GDP y-o-y Growth*	[% rate]	Euromonitor International from International Monetary Fund (IMF), International Financial Statistics and World Economic Outlook/UN/national statistics
1.2	Economic Openness (Prevalence of Trade Barriers)	[#]	World Economic Forum, The Global Competitiveness Report 2008-2009 from Executive Opinion Survey 2007, 2008
1.3	Economic Stability (Central Government Gross Surplus/Deficit)	[% of GDP]	World Economic Forum, The Global Competitiveness Report 2008-2009 from IMF, World Economic Outlook Database (April 2008); IMF country reports; European Central Bank; European Bank for Reconstruction and Development; African Development Bank; Economist Intelligence Unit, Country Data Database (June 2008); national sources
2. Legal and Political System			
2.1	Legal System		
2.1.1	*Rule of Law*	[#]	World Bank, WGI (Worldwide Governance Indicator)
2.1.2	*Regulatory Quality*	[#]	World Bank, WGI (Worldwide Governance Indicator)
2.1.3	*Legal Enforcement of Contracts*	[#]	Fraser Institute
2.1.4	*Business Impact on FDI*	[#]	World Economic Forum, The Global Competitiveness Report 2008-2009 from Executive Opinion Survey 2007, 2008
2.2	Political System		
2.2.1	*Political Stability and Absence of Violence/Terrorism*	[#]	World Bank, WGI (Worldwide Governance Indicator)
2.2.2	*Government Effectiveness*	[#]	World Bank, WGI (Worldwide Governance Indicator)
3. Business Environment			
3.1	Labor Costs (Pay and Productivity)	[#]	World Economic Forum, The Global Competitiveness Report 2008-2009 from Executive Opinion Survey 2007, 2008
3.2	Taxation (Profit and Capital Gains Tax)	[% rate]	Doing Business
3.3	Bureaucracy (Administrative Requirements)	[#]	Fraser Institute
3.4	Corruption (Control of Corruption)	[#]	World Bank, WGI (Worldwide Governance Indicator)
4. Infrastructure			
4.1	Transportation		
4.1.1	*Quality of Roads*	[#]	World Economic Forum, The Global Competitiveness Report 2008-2009 from Executive Opinion Survey 2007, 2008
4.1.2	*Quality of Railroad Infrastructure*	[#]	World Economic Forum, The Global Competitiveness Report 2008-2009 from Executive Opinion Survey 2007, 2008
4.1.3	*Quality of Port Infrastructure*	[#]	World Economic Forum, The Global Competitiveness Report 2008-2009 from Executive Opinion Survey 2007, 2008
4.1.4	*Quality of Air Transport Infrastructure*	[#]	World Economic Forum, The Global Competitiveness Report 2008–2009 from Executive Opinion Survey 2007, 2008
4.2	Energy (Quality of Electricity Supply)	[#]	World Economic Forum, The Global Competitiveness Report 2008–2009 from Executive Opinion Survey 2007, 2008
4.3	ICT Infrastructure (Fixed Line and Mobile Phone Subscribers)	[per capita]	World Bank, World Development Indicator

Appendix B: factor versus indicator concordance

Table B1
Countries paired sample *t-test* (Amaral, 2013)

Country	*t*	Sig. (2-tailed)
Netherlands	0.046	0.965
Switzerland	−0.445	0.675
Austria	0.648	0.546
Sweden	−0.723	0.502
Canada	0.798	0.461
Norway	1.323	0.243
New Zealand	−1.810	0.130
United States	1.984	0.104
United Kingdom	2.323	0.068
France	2.834	0.036
Australia	3.298	0.022
Finland	−3.790	0.013
Germany	−4.826	0.005
Japan	5.382	0.003
Belgium	9.539	0.000
Denmark	−14.957	0.000
Greece	19.456	0.000
Ireland	8.095	0.000
Italy	79.203	0.000
Portugal	16.502	0.000
Spain	18.088	0.000