Assessing e-commerce using composite indicators: The creation of European E-commerce Index

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Abstract: The Internet and information technologies dramatically changed business operations. Companies world-wide are shifting to e-commerce due to multiple benefits such as lower operational cost, around the clock availability, enabling deals and coupons, and easy access to global market. Therefore, the percentage of e-commerce in total retail and its importance for the country's economy is increasing year by year. Accordingly, e-commerce has, slowly but surely, became a topic on which companies or even countries should be ranked. Herein, we propose the creation of a composite indicator which will rank European countries based on the e-commerce activities of their companies. The proposed European E-commerce Index (EECI) consists of four pillars: Sale, Purchase, Presence on the Internet, and Software. The suggested framework is based on equal weights within pillar indicators and the Benefit-of-Doubt (BoD) weights within pillars. We believe our approach can act as a foundation for further academic research on composite indicators, their weighting schemes, e-commerce, and rankings based on the companies' e-commerce activities.

Keywords **- Benefit-of-Doubt, Composite Index, E-commerce, European Union.**

I. INTRODUCTION

E-commerce can be defined as business activities conducted over the Internet [1]. The business activities can be done among businesses or between businesses and consumers. Nowadays e-commerce is seen as an essential mean of commerce which can reduce the cost of management, grant access the international and internal market, and increase the competitiveness of company [2]. Although e-commerce has been praised, there are some drawbacks of this kind of trade. Namely, online trade leads to the creation of new types of cost such as parcel delivery and online payments systems [3]. Putting aside the possible negative consequences of e-commerce, the e-commerce has expanded at a very brisk pace [4]. Namely, now participants of the global market have to adapt their business activities to the ongoing changes [5].

Empirical evidence shows that information and communication technology (ICT) is an important factor of economic growth and company performance [6]. According to the OECD, it is believed that at the aggregate level, productivity and economic growth could rise due to increased e-commerce, at least for some time, as the result of more efficient management of supply and distribution, lower transaction costs, and improved access to information [4]. Also, e-commerce can enhance commercial efficiency and facilitate the convergence and unity of countries, mainly developing countries [7]. It can be observed that e-commerce potentially has significant impact on the national economy.

Researchers and practitioners are struggling to determine how to measure the Internet-based, e-commerce initiatives and activities [8]. Although it is not an easy task to determine the metrics of e-commerce, such metrics are necessary because they allow comparison and ranking of entities [9]. So far, different approaches have been suggested. [8] proposed a four-scale and 20-item instrument. [10] ranked B2C e-commerce websites using analytic hierarchy process (AHP) and fuzzy TOPSIS. United Nations Conference on Trade and Development (UNCTAD) publishes a composite indicator on business to consumer (B2C) e-commerce [11]. Therefore, we can observe that the topic of ranking entities based on e-commerce is a topic of interest for both academia and global organisations.

European e-commerce turnover increased by 15% to €530 billion in 2016. However, the pace of this growth varies regionally [12]. According to the 2017 European Ecommerce Report issued by the Ecommerce Foundation the internet penetration in Europe is steadily increasing, the number of companies offering an e-Commerce enabled experience is on the rise, cross-border purchases are becoming more and more, and the number of online shoppers varies from country to country [13]. It can be concluded that the European e-commerce market is still developing and that more research could be done on this issue.

The aim of this paper is to create a novel composite indicator which will rank countries based on the e-commerce activities of their companies. The proposed index will rank European countries and will have two levels: the level of indicators and the level of pillars. The proposed approach to weighting indicators is equal weights and data-driven weights within pillars. The multivariate statistical analysis used to devise the data-driven weights is the Benefit-of-Doubt model [14].

The following chapter sees the introduction of the proposed methodology of the European E-commerce Index (EECI) along with the basic concepts of the BoD model. The results are provided in Section 3 while the concluding remarks are given in the final chapter.

II. EUROPEAN E-COMMERCE INDEX (EECI)

We considered a broad set of indicators to quantify the e-commerce in Europe. Finally, 12 indicators were chosen and placed in four pillars: Sale, Purchase, Presence on the Internet, and Software. All indicator data was retrieved from Eurostat and is publicly available [15]. The data for the pillars Sale, Purchase and Presence on the Internet were acquired for the year 2015, while the data for the pillar Software was collected for the year 2014, as there was no data for 2015. Also, there were missing data for the indicators of the pillar Purchase. The mean values of indicators were imputed. The list of indicators which make the EECI and the proposed structure of the composite indicator are given in Table I.

The first pillar, Sale, aims at measuring the percentage of companies who sell their products and services electronically. We took into account the internal market, but also the sales on the EU market and the global market. Such indicators have been used in a study on e-commerce and firm performance [16]. Next topic, Purchase, quantifies the percentage of companies who purchased products and services using computer. As in case with the pillar Sale, we took into account the internal market, but also the sales on the EU market and the global market.

Next pillar, Presence on the Internet, deals with the use of services through which the company can interact with potential consumers and transmit them marketing messages. Namely, solely opening an online shop is not enough anymore. The companies must be active on the Internet to attract potential customers to their website or online shop [17]. Also, a new trend of conducting e-commerce on social networking sites has been identified [18]. Therefore, companies should also be present on various social media. In our proposed framework, besides the Use of blog or microblog and Use of multimedia content sharing websites, we include the indicator Use of any social media. Finally, Software aims to quantify how much companies use advanced accounting, office and customer relationship software. If the company does not possess the adequate, up-to-date software and hardware, it might hinder firm ability to exploit the value of a new technology or to conduct everyday activities more efficiently [8]. Therefore, to operate on the Internet and to stay competitive on the e-market, the company should possess advanced software [19]. The chosen indicators and pillars aim to quantify different activities that a company conducts to perform e-commerce. We took into account activities which are done to strengthen online connections with customers (Presence on the Internet pillar), to facilitate transactions and improve customers service (Software), and of course the trade activities (Sale and Purchase).

One of the usually cited slippery steps in the process of creating a composite index is the weighting scheme [20]. When it comes to weighting in the EECI, indicators are weighted equally within pillars, while to determine weights within pillars we suggest the Benefit-of-Doubt model, which proposes data-driven weights.

Table I: Indicators and pillars of the proposed European E-commerce Index (EECI)

Pillar	Indicator
Sale	Enterprises having done electronic sales to the own country
	Enterprises having done electronic sales to other EU countries
	Enterprises having done electronic sales to the rest of the world
Purchase	Enterprises having purchased via computer networks from supplier located in the own country
	Enterprises having purchased via computer networks from supplier located in the other EU countries
	Enterprises having purchased via computer networks from supplier located in the rest of the world
Presence on the Internet	Use of blog or microblogs (e.g. Twitter, Present.ly, etc.)
	Use multimedia content sharing websites (e.g. YouTube, Flickr, Picasa, SlideShare, etc.)
	Use any social media (as of 2014)
Software	Buy finance or accounting software applications (as a CC service)
	Buy Customer Relationship Management software (as a CC service)
	Buy office software (e.g. word processors, spreadsheets, etc.) (as a CC service)

1) Benefit-of-the-Doubt model

Melyn and Moesen (1991) looked upon the essence of the Data Envelopment Analysis (DEA) [21] and proposed the Benefit-of-the-Doubt (BoD) model. The goal of the DEA model is to obtain the maximum efficiency of decision-making units (DMUs) taking into account the information on their inputs and outputs. The BoD model, similarly, aims at maximising the overall index value but without prior information on indicator weights. As it can be observed, there are conceptual similarities between DEA and BoD: between their goals and in the lack of available information on weights [22]

The BoD model has been used with a lot of success in the process of composite index creation as it assigns specific weights to each entity while maximizing the overall value of the index [20], [23], [24]. The original BoD model is a linear programming problem [25] in which the goal function is to maximise the value of the composite indicator taking into account the constraints that the weights should be above zero and that the overall value of the composite indicator should not be above 1.

The model as such has some shortcomings. One of them is that the original model has full freedom as it can assign weight to just one indicator and zero weight to all others so as to achieve the maximum value of the indicator [25]. This means that the model can take into account only one indicator [26]. Therefore, additional constraints are recommended [22], [27].

In our research we propose a slight modification of the BoD model constrained using the results of the Composite I-distance Indicator (CIDI) methodology, the BoD-CIDI model devised by [26]. Namely, to constraint the BoD model, they used a ±25% interval around CIDI weights. Herein, we propose the same interval, but around equal weights. The model can be formulised as:

$$CI_c = \max_{w_{c,i}} \sum_{i=1}^{q} w_{c,i} y_{c,i} \quad (1)$$

s.t

$$\sum_{i=1}^{q} w_{c,i} = 1 \quad i = 1,...,q \quad j = 1,...,c,...n \quad (2)$$

$$w_{c,i} \geq 0.75 \cdot w_{equal} \quad (3)$$

$$w_{c,i} \leq 1.25 \cdot w_{equal} \quad (4)$$

In the proposed BoD model, equation (1) is the objective function which computes the composite indicator. Equation (2) constraints the sum of weights assigned to indicators to be 1. The equations (3) and (4) ensure that the new weights will be within the interval of ±25% of the equal weights. The chosen interval around the equal weights ensures a wide enough interval to have robustness checks [26], [28]. The suggested constraints guarantee that all indicators will be taken into account and that no indicator will be marked as completely insignificant for the weighting process. The proposed model, as the BoD-CIDI model, overcomes the problem of full freedom. However, the model has a drawback. Namely, before solving it, the indicator values should be normalised to the range between 0 and 1. Accordingly, the question of the type of normalisation arises.

III. RESULTS

The dataset on which the analysis was performed contained all 16 indicator values for 29 European countries. As all indicators in the data set are given in percentages, the first step in our analysis was to calculate the values of pillars using equal weighting. The results per pillar are not presented in the paper but are available on demand.

Next, the modified BoD model was applied. As there are four indicators, they would have been weighted 0.25 each if equal weights are applied. The ±25% interval around equal weights is between 0.1875 and 0.3125. After calculating the upper and lower constraints, the modified BoD model was utilized on each country using Excel Solver. The model was run on each of the 29 observed countries to obtain entity-specific weights. The obtained weights were later employed to calculate the value of EECI. The EECI index results for the top and bottom ten countries are presented in Table II.

As it can be observed Ireland and Netherlands lead the way. Ireland is now established as a leading jurisdiction for social media and other technology companies and is headquarter to many of the world's leading computer hardware, software and social media businesses. One of the reasons for this is very competitive tax regime and the Knowledge Development Box which should support e-commerce [29]. Interestingly, United Kingdom is ranked fourth although the UK e-market is the largest in Europe [12]. Romania, Bulgaria and Poland found their place at the bottom on the list. Ecommerce in Poland accounted for approximately 4% of all retail sales in the country [30]. It is obvious there is place for improvement of this share of e-commerce. The same accounts for Romania and Bulgaria.

Table II: Values and ranks of top and bottom ten countries according to the EECI

Country	*EECI* value	*EECI* rank
Ireland	26.38	1
Netherlands	24.42	2
Finland	22.17	3
United Kingdom	19.04	4
Denmark	18.85	5
Malta	18.77	6
Norway	18.46	7
Cyprus	16.88	8
Czech Republic	16.17	9
Belgium	16.06	10
…	…	…
France	12.23	20
Slovakia	12.04	21
Latvia	12.00	22
Hungary	10.50	23
Greece	9.42	24
Estonia	9.40	25
FYROM	9.17	26
Romania	8.94	27
Bulgaria	7.90	28
Poland	6.73	29

It would also be interesting to observe the weights assigned to top and bottom five countries (Table III). It can be observed that the top countries have high values of pillars Purchase and Presence on the Internet. While at the bottom of the ranking countries have low values of indicator Software. These conclusions are made based on the assigned weights. Namely, the model assigns the upper constraint to indicators which have high values, and bottom constraint to indicators whose values are lower.

Table III: Assigned weights to top and bottom five countries using the proposed BoD model

Country	*Sale*	*Purchase*	*Presence on the Internet*	*Software*	*EECI* rank
Ireland	0.1875*	0.3125**	0.3125**	0.1875*	1
Netherlands	0.1875*	0.3125**	0.3125**	0.1875*	2
Finland	0.1875*	0.3125**	0.3125**	0.1875*	3
United Kingdom	0.1875*	0.3125**	0.3125**	0.1875*	4
Denmark	0.1875*	0.1875*	0.3125**	0.3125**	5
…	…	…	…	…	…
Estonia	0.3125**	0.1875*	0.3125**	0.1875*	25
FYROM	0.1875*	0.1875*	0.3125**	0.3125**	26
Romania	0.1875*	0.3125**	0.3125**	0.1875*	27
Bulgaria	0.1875*	0.3125**	0.3125**	0.1875*	28
Poland	0.3125**	0.1875*	0.3125**	0.1875*	29

Note: * The weight restriction attains the lower bound, ** The weight restriction attains the upper bound

IV. CONCLUSION

Composite indicators have slowly, but surely, become a source of valuable information for various stakeholders: from government representatives to individuals [31]. As the e-commerce is an unfolding phenomenon [1] composite indicator on this topic are being devised.

In this paper we presented a novel composite indicator which will rank European countries based on the level of e-commerce activities of their companies. The proposed European E-commerce Index consists of 12 indicators placed in four pillars: Sale, Purchase, Presence on the Internet and Software.

To calculate the index we had a two-fold weighting scheme. Indicators are weighted equally, while the weights of the pillars are devised using the BoD model.

The results show that the top countries have high values of pillars Purchase and Presence on the Internet. While at the bottom of the ranking, countries have low values of indicator Software. Ireland, Netherlands and Finland top the list, as expected.

During our research, we could identify several future directions of the study. One direction could be towards the application of data-driven weighting schemes such as I-distance [32], Composite I-distance Indicator (CIDI) methodology [33], BoD-CIDI model [26] or Data Envelopment Analysis (DEA) with constraints [34]. Herein, we used equal weights, which are not classified

as data-driven weighting scheme [35]. Another direction of the study would be to extend the list of indicators which make the EECI. Namely, Eurostat publishes a variety of indicators related to e-commerce [15]. Also, it could be interesting to include more countries in the index, depending on data availability.

The paper has several benefits that should be pointed out. Firstly, it proposes a novel composite indicator on e-commerce activities. Secondly, it shows that the BoD model can be constrained using an interval around initially equal weights. Finally, it provides evidence that . We believe our approach can act as a foundation for further academic research on composite indicators, their weighting schemes, e-commerce, and rankings based on the companies' e-commerce activities

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