INFLUENCE OF CONSTRUCTION OF COMPOSITE INDICATOR ON EVALUATION OF NATIONAL COMPETITIVENESS IN MODIFIED PORTER'S SD MODEL: THE EU-28 EXAMPLE

Marta Nečadová

Abstract

Composite indicators are increasingly used by statistical offices and national and international organisations for ranking countries in various performance and policy areas. Composite indicators are popular and useful, because they provide a comprehensive view on the national competitiveness, a phenomenon, which cannot be captured by one single indicator. However, the explanatory power of a composite indicator is strongly influenced by the methodology of its construction, which is comprised of several necessary steps: development of theoretical framework, identification and development of suitable variables, standardisation of variables, weighting variables individually and in groups (two-step approach to weighting is typical), and finally conducting sensitivity tests on the robustness of aggregated variables. Our first aim is to analyse differences in countries' ranking depending on using different standardising approaches. We will apply different methods of standardising variables (standard deviation from the mean, distance from the group leader, distance from the mean, distance from the best and worst performers) and evaluate the changes in countries' ranking. Our second objective is to compare the performance of the EU Member States and to identify competitive advantages and disadvantages of individual countries. Our analysis and comparison are based on the modified Porter's Diamond Model. We use only hard data because they are perceived as more reliable compared to soft data, which are usually obtained from questionnaire surveys (executive opinion survey).

Key words: composite indicators, international comparison, national competitiveness, Porter's SD model

JEL Code: E29, F43, O49

Introduction

There is not a consensual view on the concept of international competitiveness. Due to the complexity of this phenomenon, one commonly-accepted definition does not exist. The term national competitiveness is usually connected with the ability to achieve certain overall outcomes, such as high standard of living and sustainable economic growth. However, some definitions concentrate on the ability to create suitable economic conditions and achieve specific economic outcomes, such as job creation, higher exports, or FDI inflow, while others underline the importance of specific local conditions (e.g. low wages, stable unit labour costs, balanced budget, competitive exchange rate) as prerequisites for success in global competition.

As Mulatu (2016) remarks, the concept of national competitiveness is - from the point of view of social planners - coherent in the presence of dynamic externalities, with a 'winner picking' exercise, but its usefulness for real-world policymaking can be limited due to political and informational imperfections in picking the 'real winners'.

Some authors, e.g. Aiginger and Vogel (2015), emphasise the usefulness of Porter's point of view on determinants of national competitiveness and connect Porter's concept with new developments in the theory of the firm, theories of growth, and with "Beyond GDP" literature. These authors distinguish between input and output competitiveness and arrange countries' ranking according to costs, structure and capabilities (drivers of competitiveness) as well as according to economic, social and ecological performance (performance pillars). Also, Fagerberg and Srholec (2017) highlight the aspect of sustainability[1]roles of technological and social capabilities in economic development. They see no conflict between improving technological capabilities and placing emphasis on sustainability and/or welfare. However, they warn about technological divergence, which is characteristic for the developing countries with slowly growing national technological capacities (laggards). One of the most famous comprehensive approaches to national competitiveness is the Diamond model developed by M. Porter in his book entitled The Competitive Advantage of Nations (Porter, 1990). According to Cho and Moon (2013), Porter's diamond satisfies two prerequisites for a good competitiveness theory: 1) this theory is comprehensive enough to capture most of the important variables, such as natural resources and labour, 2) Porter's theory is dynamic enough to explain the changing nature of national competitiveness, which is not effectively captured by classical theories (absolute and comparative advantage principles).

[1]. These authors recommend taking into account output measures 'beyond GDP', which adjust for depletion of natural resources, and measures like increased life expectancy.

The aim of Sölvell (2015) is to analyse how The Competitive Advantage of Nations project led by M. E. Porter (1990) has opened up new perspectives on competitiveness of nations and firms. Sölvell (2015) distinguishes between short-term, more static, and long-term, more dynamic, point of view and proposes a conceptualization into three interrelated concepts: 1. competitiveness and 2. innovativeness of firms (firm's static and dynamic advantages) and 3. attractiveness of nations and regions (national/regional advantages).

In this paper, we decided to respect Porter's logic and construct a simple composite index based on Porter's Diamond model (SD model).

Our analysis, due to the general critical view of wide using soft data (e.g. Moon, Cho, 2013), is mainly based on hard (statistical) data. Data selection and final calculation of the composite index is inspired by two experiments with the modified SD model (Cho and Moon, 2013; Balcarova, 2014).

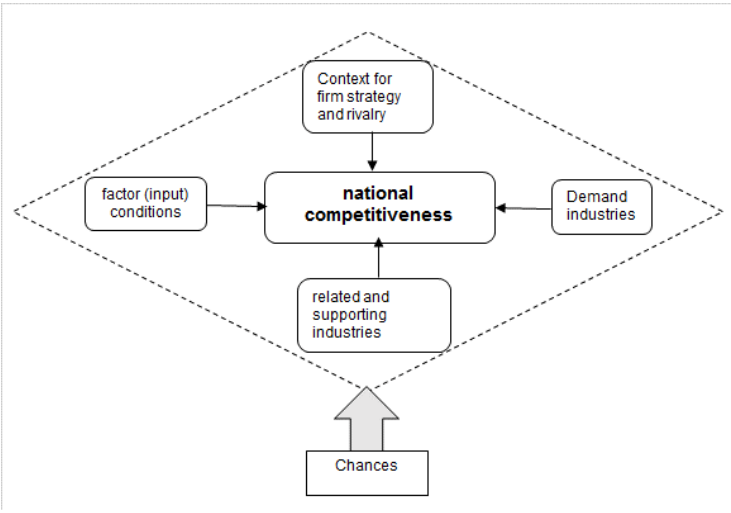
To construct reliable composite indicators, several steps need to be taken, and corresponding methods have to be chosen. The OECD handbook provides an overview of the individual steps in the construction of composite indicators and discusses the quality framework for composite indicators. The basic steps are the following: selection of sub-indicators, data selection, data editing, data normalisation, weighting scheme, weights' values and composite indicator formula. Saisana, M. et al. (2005) point out three types of disputable issues: normalisation methods for the values of sub-indicators, weighting approaches, and uncertainty in the weight, which should be attributed to the sub-indicators.

The first aim of this paper is to show the impact of different methods of data normalisation on the countries' results in the composite indicator. The next aim is to briefly describe the advantages and disadvantages of the normalisation methods used (standard deviation from the mean, distance from the group leader, distance from the mean, distance from the median, distance from the best and worst performers) in context with obtained results. Equal weight is assigned to all indicators (i.e. we calculate the arithmetic average of the normalized values) within their sub-groups, and the composite index is computed as the arithmetic mean of the values for four determinants of competitiveness (Input conditions, firm strategy and rivalry, demand industries, related and supported industries).

1 Original Porter's Single Diamond and variables in the modified model

One of the most famous comprehensive approaches to national competitiveness is the Diamond model developed by M. Porter in his book entitled The Competitive Advantage of Nations (Porter, 1990). According to Cho and Moon (2013), Porter's diamond satisfies two prerequisites for a good competitiveness theory: 1) this theory is comprehensive enough to capture most of the important variables, such as natural resources and labour, and 2) Porter's theory is dynamic enough to explain the changing nature of national competitiveness, which is not effectively captured by the classical theories (absolute and comparative advantage principles). Porter's Single Diamond satisfies these two important aspects by its dynamic aspect and by incorporating four competitiveness variables: Factor conditions, Demand conditions, Related and supporting industries, and Firms strategy, structure and rivalry. According to Porter, national competitiveness does not grow out of resource endowments or currency value; it can be built and created only by a combination of strategic choices along the four determinants of the Single Diamond (see Figure 1).

Fig. 1: The Single Diamond (Porter's SD model)



Source: Porter, M. 1990, own processing

As e.g. Hudrlikova (2013) summarises, the composite indicators reflect multi-dimensional issues, enable assessing the progress of countries over time, provide benchmarking, and rank countries according to a comprehensive phenomenon. On the contrary, these comprehensive indicators - if they are poorly constructed or misinterpreted - can give misleading messages. This danger is the reason for vigilance and transparency in the process of their construction.

Given the fact that our first aim is to create a simple and meaningful model which would enable us to compare different results obtained by different attitudes to the data normalisation,

we chose only a few indicators in each category, the ones which – from our point of view - shape the models most significantly. All variables of the SD model are specified in Table 1 (in brackets the data source and the last year recorded in the database are showed). It is not possible to find all required data for the same period, therefore we use the last available statistical data for all variables.

Tab. 1: Variables in the modified SD model

Factor conditions	Value added in industry (World Bank, 2016, % of GDP)	VA_I
	Gross domestic expenditure on R&D (Eurostat, 2015, Euro per inhabitant)	GD_EXP
	Researches in R&D (Eurostat, 2016, per million inhabitants)	RES_ R&D
Demand conditions	Final consumption expenditure (Eurostat, 2016, Chain linked volumes (2010), euro per capita)	Cons_EXP
	Public expenditure on education (Eurostat, 2015, % of GDP)	PUB_EXP
	Tertiary graduates (Eurostat, 2015, per 1000 inhabitants, aged 20-29 years)	GRAD
	Turnover from innovation (Eurostat, 2012, % of total turnover)	TURN_IN
Related and supporting industries	Mobile cellular subscriptions (World Bank, 2015, per 100 inhabitants)	MOB
	Logistic performance index: Logistics quality and competence (WB, 2016)	LPI_Q
	Logistic performance index: Quality of trade and transport-related infrastructure (WB, 2016)	LPI_INF
Firm strategy, structure and rivalry	R&D expenditure (capital expenditure) in business sector (2014, % of GDP, Germany and Austria 2013)	EXP_ R&D
	Knowledge and technology outputs (Global Innovation Index, 2017)	GII
	Innovation expenditure in total business economy (2014, % of turnover)	IN_EXP

Source: Eurostat, World Bank, Cornell University, INSEAD, and WIPO, own processing

The first determinant of competitiveness (factor conditions) includes rather advanced and specialized variables: value added in industry, gross domestic expenditure on research and development (R&D), and a number of researchers in research and development (R&D). In case of demand conditions, a sophistication of home demand plays the key role in the competitive advantage creating process. Therefore, final consumption expenditure, number of tertiary graduates, public expenditure on education, and sales of innovative products were chosen as indicators encouraging competitiveness from the demand side. We suppose that the parts of the Logistic performance index and mobile infrastructure can shape the third vertex of the diamond. The advantage created in the last part of the diamond has an impact on the innovation activity of enterprises and the whole economy as well. This should be evaluated using the last three factors of the modified diamond model.

In our simple modified SD model we assign the same importance to variables in each determinant of competitiveness. Therefore the final value for the determinants is counted as the arithmetic mean. The same aggregation method (the arithmetic mean) was applied for the final aggregation, e.g. for an ascertainment of the value for the final composite indicator.

1.1 Competitive advantages and disadvantages of Visegrad group countries and the EU-28

The competitive advantage of the original member countries is evident from the descriptive statistics of the selected data - the new member country (Slovenia) obtained the first place within the EU 28 in only one indicator (EXP_ R&D) only. Indicators with minimum value were found in countries with problematic aspects of their economic performance after the economic crisis and in the least developed new member countries (Bulgaria, Romania). The minimum value for Luxembourg in tertiary graduates per 1000 inhabitants represent an exception to the above mentioned.

Tab. 2: Variables in the modified SD model-descriptive statistics

	MAX	MIN	CZ	SVK	st.dev.	median	mean
VA_I	41,52 (IRL)	10,99 (CYP)	37,72	34,84	7,27	26,24	25,47
GD_EXP	1495,9 (SWE)	39,4 (ROU)	308,40	171,00	455,78	296,00	511,28
RES_ R&D	7387,12 (DNK)	878,63 (ROU)	3613,59	2657,27	1700,06	3421,68	3580,50
Cons_EXP	35200 (LUX)	10700 (BGR)	17000,0	16600,0	5570,08	19450,0	20517,9
PUB_EXP	7 (DNK)	3,1 (ROU)	4,90	4,20	0,93	5,20	5,15
GRAD	126,8 (IRL)	27,4 (LUX)	74,30	78,30	18,87	70,35	72,50
TURN_IN	13,04 (GBR)	2,79 (LVA)	10,22	12,62	3,08	6,25	6,78
MOB	157,41 (AUT)	95,4 (CYP)	123,16	122,31	15,47	123,35	123,61
LPI_Q	4,28 (DEU)	2,72 (CYP)	3,65	3,12	0,48	3,57	3,55
LPI_INF	4,44 (DEU)	2,35 (BGR)	3,36	3,24	0,52	3,53	3,56
EXP_ R&D	0,23 (SVN)	0,01 (CYP)	0,18	0,02	0,05	0,09	0,09
GII	62,9 (NLD)	20,4 (GRC)	45,80	33,50	10,98	36,20	38,10
IN_EXP	24,45 (SWE)	3,14 (ROU)	11,18	5,64	5,19	8,84	9,65

Source: Eurostat, World Bank, Cornell University, INSEAD, and WIPO, own processing

Our dataset gives an overview about the competitive advantages and disadvantages of the Visegrad group countries. The table 3 summarizes strengths and weaknesses of their competitiveness on our sample of variables.

Tab. 3: Strengths and weaknesses of Visegrad group countries

CZ	strengths	weaknesses	SVK	strengths	weaknesses
	VA_I (2.)	Cons_EXP (20.)		VA_I (3.)	EXP RaD (27.)
	EXP RaD (2.)	PUB_EXP (19.)		GRAD (10.)	LPI_Q (23.)

	TURN_IN (5.)	LPI_INF (16.)		TURN_IN (3.)	PUB_EXP (23.)
HU	EXP RaD (3.)	Cons_EXP (25.)	POL	VA_I (4.)	Cons_EXP (23.)
	TURN_IN (8.)	GRAD (25.)		TURN_IN (4.)	GD_EXP (23.)
	VA_I (8.)	GD_EXP (21.)		MOB (4.)	LPI_INF (22.)

Source: Eurostat, World Bank, Cornell University, INSEAD, and WIPO, own processing

Our table shows the similar competitive advantages and disadvantages of the Visegrad group countries. However, due to our final results (see Table 5), it is necessary to mention one important difference between them. While more balanced values in chosen indicators are typical for the Czech Republic and Hungary (the standard deviation of the country ranking in the whole group of our indicators is relatively small), there are more differences between the country rankings for the Slovak Republic and Poland.

1.2 Normalisation methods

Since our indicators are not measured in the same units, data transformation is another important step in the construction of the composite indicator. The key goal of this step is to select suitable normalisation procedure(s) concerning the theoretical framework and data properties. In this paper we used the same normalisation methods as Freudenberg (2003) - see Table 4.

Tab. 4: Normalisation methods

Distance from the group leader	$(\frac{actual\_value}{\max\_value})*100$	A_NM
Distance from the median	$(\frac{actual\_value}{median\_value})*100$	B_NM
Distance from the mean	$(\frac{actual\_value}{mean\_value})*100$	C_NM
Standardization	$(\frac{actual\_value - mean\_value}{st.deviation})*100$	D_NM
Min-max	$(\frac{actual\_value - \min\_value}{\max\_value - \min\_value})*100$	E_NM

Source: Freudenberg (2003), OECD (2008), own processing

Each normalisation method has its advantages and disadvantages. Standardisation (or z – scores) is most commonly used due to its desirable characteristics for aggregation (it converts all variables to a common scale with a mean of zero, and standard deviation of one and assumes a normal distribution). Indicators with extreme values thus have a stronger effect

on the composite indicator. This might not be desirable if the intention is to reward exceptional behaviour, i.e., if an extremely good result in a few indicators is thought to be better than a lot of average scores[2]. (OECD, 2008) Min-Max normalises indicators to have an identical range [0, 1] by subtracting the minimum value and dividing the range of the indicator values. However, extreme values/or outliers could distort the transformed indicator[3]. Distance to a reference point measures the relative position of a given indicator vis-à-vis a reference point. In our analysis, the reference country is the group leader (the leading country receives 100, and the other countries are given percentage points away from the leader)[4]. Furthermore, we use other possible variations of this method and apply the mean and the median in the role of the reference point.

2 Results

Table 5 offers the EU 28 countries' results (founding values and countries/ranking) and therefore summarises the results of our analysis.

Tab. 5: The modified SD model_ the rankings of the EU28 according to the different methods of normalisation

		A_NM		B_NM		C_NM		D_NM		E_NM	
EU 28/normal. method		value	rank	value	rank	value	rank	value	rank	value	rank
AUT	Austria	72,64	5	46,99	5	41,17	5	0,79	5	63,87	5
BEL	Belgium	65,53	10	40,58	8	36,21	8	0,39	10	55,74	7
BGR	Bulgaria	42,55	26	22,74	25	22,04	24	-0,87	26	20,01	26
HRV	Croatia	43,72	25	23,37	23	22,49	23	-0,80	25	24,45	25
CYP	Cyprus	41,12	27	20,14	27	19,28	27	-0,97	27	19,75	27
CZE	Czech Republic	64,55	11	37,70	12	35,54	10	0,32	11	50,47	12
DNK	Denmark	75,01	3	49,01	3	42,37	3	0,82	4	67,72	2
EST	Estonia	54,90	16	30,47	16	28,89	16	-0,10	15	40,23	15
FIN	Finland	74,47	4	47,27	4	41,75	4	0,84	2	66,15	3
FRA	France	67,18	7	41,05	6	37,05	7	0,40	9	53,48	10
DEU	Germany	75,47	2	49,19	2	43,60	2	0,83	3	65,09	4

[2] This effect can be corrected in the aggregation methodology, e.g. by excluding the best and worst individual indicator scores from inclusion in the index or by assigning differential weights based on the "desirability" of the individual indicator scores.

[3] As OECD experts observe, Min-Max normalisation could widen the range of indicators lying within a small interval, increasing the effect on the composite indicator more than the z-score transformation. (OECD, 2008)

[4] The reference could also be an external benchmark country (e.g. the United States and Japan are often used as benchmarks for the composite indicators built in the framework of the EU Lisbon agenda). The reference country could be the average country of the group and would be assigned a value of 1, while other countries would receive scores depending on their distance from the average. Hence, standardised indicators which are higher than 1 indicate countries with above-average performance. (OECD, 2008, p.28)

GRC	Greece	45,33	22	23,84	22	22,62	22	-0,75	24	24,94	24
HUN	Hungary	55,23	14	30,98	14	29,63	14	-0,17	18	37,69	18
IRL	Ireland	70,09	6	40,83	7	37,35	6	0,57	6	53,82	9
ITA	Italy	53,77	19	29,70	18	27,62	18	-0,16	17	40,27	14
LVA	Latvia	44,41	23	22,63	26	21,93	25	-0,65	22	26,54	22
LTU	Lithuania	55,23	15	30,70	15	29,40	15	-0,06	14	40,05	16
LUX	Luxembourg	63,31	12	39,27	10	33,82	13	0,29	12	53,32	11
MLT	Malta	43,91	24	22,76	24	21,65	26	-0,73	23	26,51	23
NLD	Netherlands	66,40	9	39,68	9	35,56	9	0,48	7	57,49	6
POL	Poland	54,41	17	29,75	17	28,64	17	-0,11	16	39,17	17
PRT	Portugal	50,88	21	27,98	20	26,48	20	-0,42	21	35,05	21
ROU	Romania	39,21	28	19,71	28	19,22	28	-1,06	28	15,40	28
SVK	Slovak Republic	52,47	20	27,64	21	26,31	21	-0,31	20	35,96	20
SVN	Slovenia	61,81	13	37,46	13	34,92	12	0,07	13	44,11	13
ESP	Spain	53,90	18	29,37	19	27,53	19	-0,23	19	37,64	19
SWE	Sweden	80,17	1	53,77	1	46,50	1	1,12	1	73,30	1
GBR	United Kingdom	66,78	8	39,12	11	35,44	11	0,46	8	54,29	8

Source: Eurostat, World Bank, Cornell University, INSEAD, and WIPO, own processing

Our results confirm the above mentioned characteristics of the normalisation methods. In the following commentary, we concentrate on the biggest differences in the rankings, the special commentary for the Visegrad group countries will be included in the conclusion. If the countries achieve more balanced values in the whole group of indicators, the application of the B_NM or C_NM method (distance from the median and from the mean) brings better rank compared to the E-NM method (min-max), which rewards rather countries with outliers. This fact explains the biggest ascertained differences between country rankings according to different normalisation methods for France (a drop of four places using B-NM and E-NM) and Hungary (a drop of four places using C-NM and E-NM).

Conclusion

We constructed the modified SD model and tested the impact of different normalisation methods on the countries' rankings with respect to Porter's attitude to the determinants of national competitiveness. Selection of a suitable normalisation method is an important step during the process of construction of the composite indicator because the chosen method can have a key effect on the explanatory power of the final composite indicator. The chosen normalisation method should take into account the data properties, as well as the objectives of the composite indicator. The results of our analysis corroborate the methodologic notes regarding the explanatory power of the applied normalisation methods. The Visegrad group

countries have almost identical competitive advantages and disadvantages (see Table 3). Application of different normalisation methods is reflected in the different changes in their final ranking. The Czech Republic and Hungary (10th place, 14th place respectively) achieved the best evaluation when the C-NM method was applied. The relatively low variability inside the country's data sample (i.e. relatively stable values for indicators in the country's data sample) is typical for both countries. Therefore the E_NM method (Min-max method), which emphasizes the countries 'differences (if the interval for chosen variables is relatively narrow), brings worse results, i.e. the country's drop in ranking. In case of Poland and the Slovak Republic, the higher variability of indicators has "a balancing effect" on the differences between the results obtained by the normalisation methods used.

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Contact

Marta Nečadová

Department of Microeconomics

Faculty of Business Sciences

University of Economics, Prague

necadova@vse.cz