Paper

Multiple Criteria Evaluation and Ranking of Social Penetration of Information Society Technologies

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Abstract—The paper presents a comparison of two ways of multiple criteria ranking of social penetration of information society technologies (ICT): the traditional one and the so-called objective ranking, illustrated on the example of Network Readiness Index. It is shown that objective ranking stresses a balanced development more than the traditional one. Another issue presented in this paper is the concept of dynamic ranking, a systematic presentation and prediction of the change of ranking in time. This is illustrated on the example of regions of three European countries: Finland, Italy and Poland.

Keywords—dynamic ranking, ICT social penetration, multiple criteria ranking, objective ranking.

1. Introduction

Classical ranking is a classification in the order of numerical values assigned to a specific index, criterion or indicator. *Multicriteria* ranking assumes some *aggregation* (called technically scalarization) of many such indexes, criteria or indicators. Usually, such an aggregation is fully subjective; only recently, see [1], an aggregation and *ranking that is as objective as possible* (none can be fully objective) was proposed. Thus, one of the goals of this paper is to compare different aggregations used for multiple criteria ranking of ICT development in different countries and regions. This is illustrated using Network Readiness Index (NRI) [2], [3] of World Economic Forum. The objective ranking might give different conclusions even if data prepared by experts might remain subjective.

However, rankings are usually perceived as static classification – with some repeated rankings changing in time. Therefore, we also illustrate in this paper the issue of dynamic ranking – a systematic presentation and prediction of the change of ranking in time – using the example of regions or provinces of three European countries: Finland, Italy and Poland. Such predictions might give additional arguments for decision-makers to plan and take appropriate action in the future.

1.1. Data

Contemporary evaluations of social or *socio-economic penetration of information society technologies*, often called ICT, information and communication technology, are based on many statistical measures, indexes or criterions. Example might be the data from Eurostat portal, e.g.:

- households with access to the Internet at home,
- households with broadband access to the Internet,
- individuals regularly using the Internet,
- individuals who ordered goods or services over the Internet for private use.

World Economic Forum uses much broader set of indexes and their evaluations, described in further sections. However, we shall see that such data supported only by expert evaluations and not by statistics might be biased. In Poland, we can also use data from the Local Data Bank of GUS (Polish Central Statistical Office), e.g.:

- schools equipped with computer laboratories, schools with broadband access to the Internet, etc.,
- households with computers,
- households with the Internet,
- households with mobile telephone.

Such data is typically presented according to a territorial unit classification.

1.2. NUTS Clasification

The Nomenclature of Territorial Units for Statistics (NUTS) classification[1] is a hierarchical system for dividing the economic territory of the EU up for the purpose of the collection, development and harmonization of EU regional statistics. It helps in diverse socio-economic analyses of regions, subdivided into three classes.

- NUTS 1: major socio-economic regions,
- NUTS 2: basic regions for the application of regional policies,
- NUTS 3: small regions for specific diagnoses.

[1] See also Regulation (EC) no. 1059/2003 of the European Parliament and of the Council of 26 May 2003 on the establishment of a common classification of territorial units for statistics (NUTS).

Such a classification is also used for framing of EU regional policies:

- Regions eligible for aid from the structural funds (Objective 1) have been classified at NUTS 2 level.
- Areas eligible under the other priority objectives have mainly been classified at NUTS 3 level.
- The Cohesion Report has so far been mainly prepared at NUTS 2 level.

The average size of the NUTS administrative units is limited by the following population thresholds (see Table 1).

Table 1
Population threshold

Level	Minimum	Maximum
NUTS 1	3 million	7 million
NUTS 2	800 000	3 million
NUTS 3	150 000	800 000

while the smallest member states might be classified as one NUTS territorial unit of a population just larger than that of the state.

1.3. Regions Considered in the Paper

We shall consider regions of Finland, Italy and Poland according to NUTS classification (see Figs. 1 and 2). Italy actually uses two-tier (NUTS 1 and 2) classification of its regions, which is listed in Table 2.

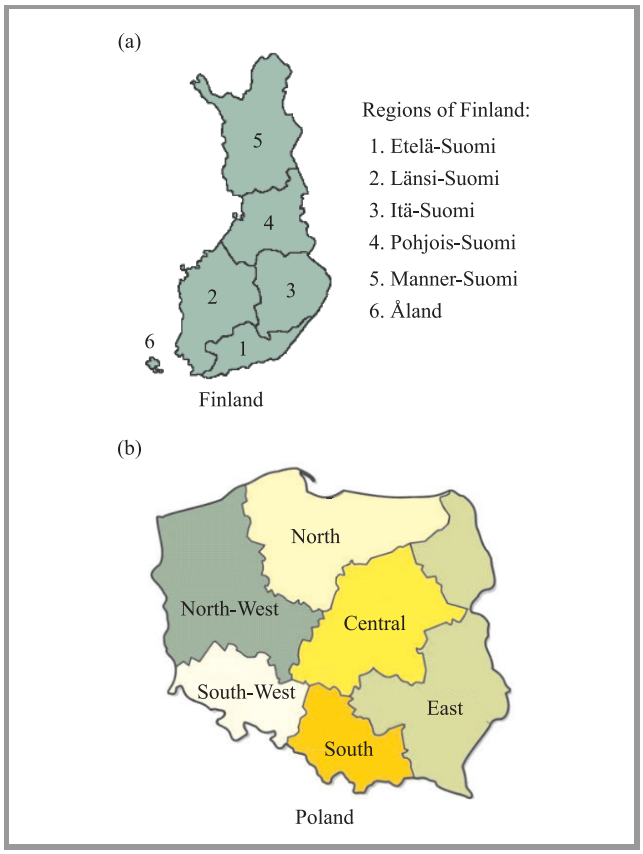

Fig. 1. Regions of Finland (a) and Poland (b).

Fig. 2. Regions of Italy.

Table 2
Regions of Italy by the Eurostat NUTS clasification

NUTS 1	NUTS 2
North West	Aosta Valley, Liguria, Lombardy, Piedmont
North East	Emilia-Romagna, Friuli-Venezia Giulia, Trentino-Alto Adige/Südtirol, Veneto
Centre	Lazio, Marche, Tuscany, Umbria
South	Abruzzo, Apulia, Basilicata, Calabria, Campania, Molise
Islands	Sardinia, Sicily

2. Traditional Ranking of World Countries

2.1. Network Readiness Index

Network Readiness Index (NRC) is an overall measure of socio-economic penetration of information and communication technology (ICT), quite detailed and comprehensive but based on expert evaluation of diverse aspects of ICT [2]. Thus the relation of these evaluations to statistical data is not fully transparent, see below. However, the evaluations are fully accessible in the Internet, thus they can be analyzed in diverse ways.

These evaluations are the basis of the Global Information Technology Report (GITR) series produced by the World Economic Forum (WEF), as a part of WEF research on competitiveness. In this research, the Networked Readiness Index (NRI) was developed.

The WEF concentrates its analysis on economic and social impact of ICT. Although a positive impact of ICT diffusion on GDP growth of a country has been documented, estimates show that a 10% increase in mobile phone penetration is associated with a 1% growth in GDP (actually, the impact of the Internet penetration is even stronger). There are still open questions about using ICT to improve the condition of each individual, and about the impact of ICT on socio-political relations. Leaving these questions aside, we concentrate here on the methodology used by WEF.

2.2. The Method of Calculating the Ranking by WEF

Diverse indicators used in WEF report take diverse counting units and diverse numerical values. Therefore, the report uses normalization of indicators that are statistical or expert opinion based, to the values between 1 and 7, while 7 denotes the best result. For those indicators that are best when they increase (such as GDP), the used transformation is as follows:

$$6 \cdot \left(\frac{country\ score - sample\ \min imum}{sample\ \max imum - sample\ \min imum} \right) + 1 \qquad (1)$$

For those indicators that are best when they decrease (such as unemployment) the used transformation is:

$$-6 \cdot \left(\frac{country\ score - sample\ \min imum}{sample\ \max imum - sample\ \min imum} \right) + 7 \qquad (2)$$

The structure of Network Readiness Indicators is as follows. The following indicators are assessed subjectively by experts, later simply aggregated (by taking most simple averages after normalization):

Environment

1. Market environment
2. Political and regulatory environment
3. Infrastructure environment

Readiness

4. Individual readiness
5. Business readiness
6. Government readiness

Usage

7. Individual usage
8. Business usage
9. Government usage

Thus the method of calculating NRI is simple:

Networked Readiness Index = 1/3 **Environment subindex** + 1/3 **Readiness subindex** + 1/3 **Usage subindex**

Environment subindex = 1/3 Market environment + 1/3 Political and regulatory environment + 1/3 Infrastructure environment

Readiness subindex = 1/3 Individual readiness + 1/3 Business readiness + 1/3 Government readiness

Usage subindex = 1/3 Individual usage + 1/3 Business usage + 1/3 Government usage

However, the sub-subindexes called *pillars* in NRI computations consist of an aggregation (again, using simple averaging) of several indicators, selected by experts. Their numbers and changing in time (see the example of their structure in the Appendix). Data on the numbers of indicators used in diverse pillars in 2003, 2009, 2011 are presented in Table 3.

Table 3
Number of variables in the reports NRI 2003, 2009 and 2011

Pillar	NRI 2003	NRI 2009	NRI 2011
1. Market environment	9	14	10
2. Political and regulatory environment	7	9	11
3. Infrastructure environment	5	7	10
4. Individual readiness	10	9	9
5. Business readiness	5	10	8
6. Government readiness	3	4	3
7. Individual usage	4	5	8
8. Business usage	3	5	8
9. Government usage	2	5	4

Thus the final NRI score is an average of the three composing subindex scores, while each subindex score is an average of those of three composing pillars, but pillars are defined as an average of a changing number of normalized indicators. When using such an averaging, it is not only assumed that all index components give a similar contribution to national networked readiness, but also that the evaluation of pillars is done, as objectively as possible by the experts.

2.3. Examples of NRI Rankings

While Fig. 3 presents graphically an example of recent NRI ranking, Table 3 shows changes of NRI ranking and the position of Poland in this ranking during the recent years. We see that Poland is classified on the positions between 58 and 69, while Italy, for example, is classified on the positions between 38 and 51. A natural question that will be addressed in a further section is whether Poland has the chance to overtake Italy.

World Economic Forum also uses World Bank classification of countries into income groups. It is significant that the first twenty countries in the NRI ranking all belong to the highest income group [2].

In order to check methodological validity of simple average aggregation of diverse indicators used by WEF in NRI ranking, in the next section we use WEF data, but apply a different and more complex but also more objectively aggregated.

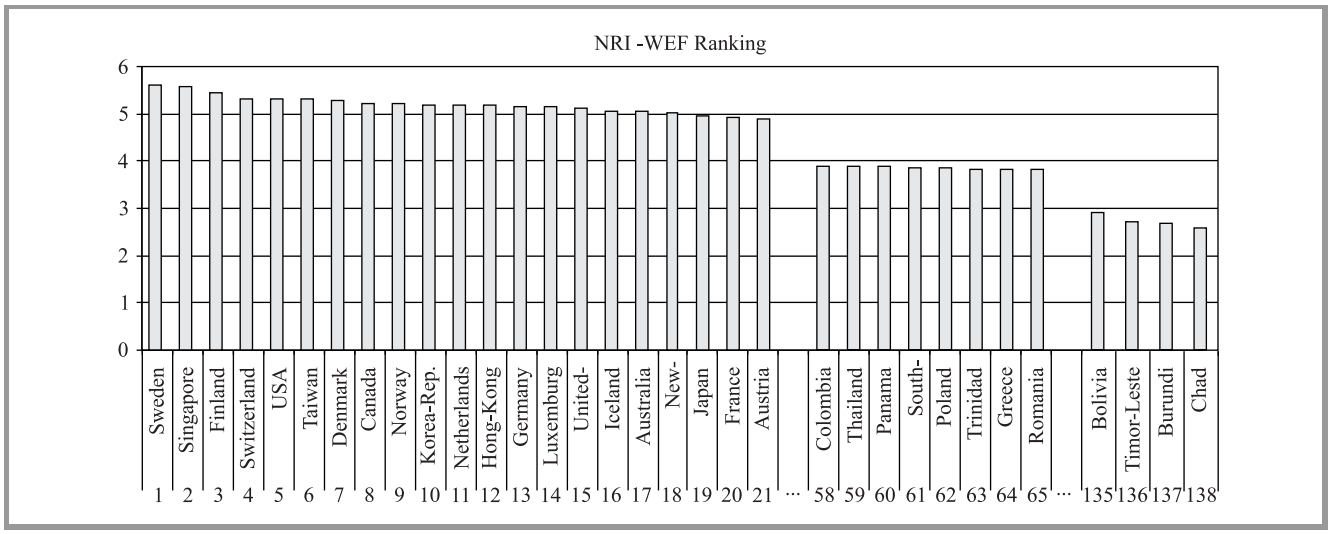

Fig. 3. Classification according to the NRI ranking.

Table 4
Position of Poland in NRI ranking in the last few years

No.	Country	2006/2007	2007/20082	2008/2009	2009/2010	2010/2011
European Union						
1	Sweden	2	2	2	1	1
2	Finland	4	6	6	6	3
3	Denmark	1	1	1	3	7
4	Netherlands	6	7	9	9	11
5	Germany	16	16	20	14	13
6	Luxembourg	25	24	21	17	14
7	United Kingdom	9	12	15	13	15
8	France	23	21	19	18	20
9	Austria	17	15	16	20	21
10	Belgium	24	25	24	22	23
11	Estonia	20	20	18	25	26
12	Malta	27	27	26	26	27
13	Ireland	21	23	23	24	29
14	Cyprus	43	41	33	32	31
15	Portugal	28	28	30	33	32
16	Slovenia	30	30	31	31	34
17	Spain	32	31	34	34	37
18	Czech Republic	34	36	32	36	40
19	Lithuania	39	33	35	41	42
20	Hungary	33	37	41	46	49
21	Italy	38	42	45	48	51
22	Latvia	42	44	48	52	52
23	Poland	58	62	69	65	62
24	Greece	48	56	55	56	64
25	Romania	55	61	58	59	65
26	Bulgaria	72	68	68	71	68
27	Slovak Republic	41	43	43	55	69
Other						
1	USA	7	4	3	5	5
2	Korea, Rep.	19	9	11	15	10
3	Japan	14	19	17	21	19
4	China	59	57	46	37	36
5	India	44	50	54	43	48
6	Croatia	46	49	49	51	54
7	Turkey	52	55	61	69	71
Source: https://wieloletni.itl.waw.pl						

3. Objective Ranking

3.1. The Concept of Objective Ranking

This concept was introduced in [1]. Such a ranking consists of:

- counting overall average of a given partial indicator (such as market environment subindex),
- counting the worst under-achievement among all partial indicators,
- correcting slightly this worst under-achievement by the sum of under-achievements (or over-achivements).

In more detail, all partial indicators are transformed into partial achievement indicators (by comparing them to their statistical averages), then these partial achievement indicators are aggregated into an overall achievement indicator determined by the worst under-achievement with a slight correction by the sum of all partial achievements. The aggregated achievement indicators are used for ranking. Thus such ranking assumes, similarly as the NRI ranking, that all indicators are significant, but selects as most significant such indicators that have among all partial indicators the worst underachievement when compared to statistical averages for a given indicator.

No ranking can be absolutely objective, because the choice of the method of ranking is subjective itself. However, the so-called objective ranking is *as objective as possible*, because most parameters of aggregation depend on statistical averages, not on subjectively determined weighting coefficients.

3.2. Method of Calculating Objective Ranking

The method as described in [1] is based on a specification of double reference levels: aspiration level a_j and reservation level r_j, for each criterion or indicator. After this specification, the approach uses a nonlinear aggregation of criteria by an achievement function that is performed in two steps.

First, we count achievements for each individual criterion or satisfaction with its values by transforming it (monotonically and piece-wise linearly), for example in the case of maximized criteria as shown in Eq. (3). In this transformation, we can choose its coefficients to have a reasonable interpretation of the values of the *partial* (*or individual*) *achievement function*. In the original objective ranking approach, the of [0; 10] points for eliciting expert opinions was used, but a modification to the range [1; 7] used in NRI calculations is easy.

$$\sigma_j(q_j,a_j,r_j) = \begin{cases} \alpha(q_j-q_j^{lo})/(r_j-q_j^{lo}), & \text{for } q_j^{lo} \le q_j < r_j \\ \alpha+(\beta-\alpha)(q_j-r_j)/(a_j-r_j), & \text{for } r_j \le q_j < a_j \\ \beta+(10-\beta)(q_j-a_j)/(q_j^{up}-a_j), & \text{for } a_j \le q_j \le q_j^{up} \end{cases} \quad (3)$$

where q_j is the value of j-th indicator, q_j^{lo} is the lowest value and q_j^{up} is the highest value of this indicator between all alternatives (countries, regions etc.). The parameters a_j and r_j are defined statistically as in Eq. (5). The parameters α and β, $0 < \alpha < \beta < 10$ if we use the [0; 10] range, denote correspondingly the values of the partial achievement function for $q_j = r_j$ and $q_j = a_j$. The value $\sigma_{jk} = \sigma_j(q_{jk},a_j,r_j)$ of this achievement function for a given ranked alternative (country, region, etc.), $k \in \mathbf{K}$ signifies the satisfaction level with the criterion or indicator value for this alternative. Thus, the above transformation assigns satisfaction levels from 0 to α (say, $\alpha = 3$) for criterion values between q_j^{lo} and r_j, from α to β (say, $\beta = 7$) for criterion values between r_j and a_j, from β to 10 for criterion values between a_j and q_j^{up}.

After this transformation of all criteria values, we might then use the following form of the overall achievement function:

$$\sigma(\mathbf{q},\mathbf{a},\mathbf{r}) = \min_{j\in\mathbf{J}} j_i(q_j,a_i,r_j) + \varepsilon/J \sum_{j\in\mathbf{J}} \sigma_j(q_j,a_j,r_j), \quad (4)$$

where $\mathbf{q} = (q_1,\ldots,q_j,\ldots,q_J)$ is the vector of criteria values, $\mathbf{a} = (a_1,\ldots,a_j,\ldots,a_J)$ and $\mathbf{r} = (r_1,\ldots,r_j,\ldots,r_J)$ are the vectors of aspiration and reservation levels, while $\varepsilon > 0$ is a small regularizing coefficient. The achievement values $\sigma_k = \sigma(\mathbf{q}_k,\mathbf{a},\mathbf{r})$ for all $k \in \mathbf{K}$ can be used either to select the best alternative, or to order the alternatives in an overall ranking list or classification list, starting with the highest achievement value.

A statistical determination of reference levels concerns values m_j that would be used as *basic reference levels*, an upward modification of these values to obtain *aspiration levels* a_j, and a downward modification of these values to obtain reservation levels r_j. These might be defined as follows:

$$m_j = \sum_{k\in\mathbf{K}} \mathbf{q}_{jk}/K;\ r_j = 0.5(q_j^{lo}+m_j);\ a_j = 0.5(q_j^{up}+m_j),\ \forall j \in \mathbf{J} \quad (5)$$

where K denotes the number of alternative options, thus m_j are just average values of criteria in the set of all alternative options. Aspiration and reservation levels are, therefore, just averages of these averages and the lower and upper bounds, respectively.

3.3. Objective Ranking on WEF – NRI Data

The calculations were performed on WEF data as used for NRI calculations, but using the objective ranking method, and the resulting rankings were compared. We start with illustrating results concerning Poland (Fig. 4).

We see that the essential differences are in the evaluations of Pillar 4 and, therefore, Subindex B: objective ranking identifies weak points and decreases the ranking if weak points are found. See also Table 5 for more detailed numerical data for two yearly rankings: 2009 and 2011. However, the sudden drop of the evaluation of WEF experts of

Table 5
The position of Poland in the world – according to NRI 2009 and 2011 data and two methods of ranking: objective ranking and WEF ranking

Poland	Ranking	WEF 2009	Objective 2009	WEF 2011	Objective 2011
Pillar 1	Market environment	87	74	74	68
Pillar 2	Political and regulatory environment	100	82	81	59
Pillar 3	Infrastructure environment	41	36	43	46
Pillar 4	Individual readiness	43	35	83	126
Pillar 5	Business readiness	52	40	54	42
Pillar 6	Government readiness	103	125	103	107
Pillar 7	Individual usage	46	43	46	43
Pillar 8	Business usage	69	64	60	55
Pillar 9	Government usage	127	124	93	100
Subindex A	Environment component	68	65	60	63
Subindex B	Readiness component	62	72	73	112
Subindex C	Usage component	80	79	57	50
NRI		69	67	62	67

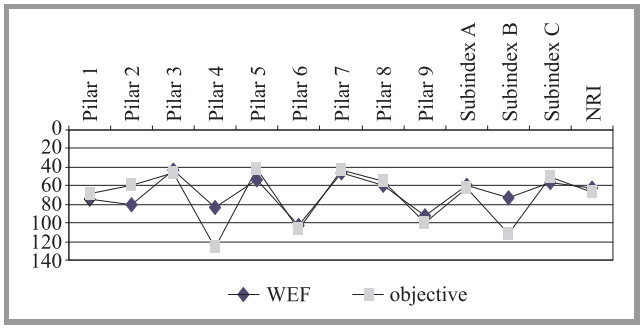

Fig. 4. The position of Poland in the world – according to NRI 2011 data and two methods of ranking: objective ranking (grey) and WEF ranking (black).

individual readiness pillar in Poland (from 43 to 83 place in ranking during two years, even more drastic – from 35 to 126 place – when the objective ranking method was applied) indicates that the expert evaluation applied by WEF might be contested.

From the above, we can draw diverse conclusions, but most important are as follows. Since objective ranking concentrates on relatively worst component indexes, it is apt to draw attention to actual weaknesses of a country. In the case of Poland, to generally the readiness component and to its pillars: individual readiness and government readiness. The simple averaging method applied by WEF tends to overlook relative worst cases. It draws an attention to government readiness, but not so much to individual one, and ranks much higher overall readiness component. On the other hand, not very promising assessment of individual readiness in Poland results from the NRI data, and it is only stressed by the method of objective ranking. Other sources of data, e.g., the Eurostat data on the index IOGSI (Individuals who Ordered Goods or Services over Internet), indicate that Poland might be even ahead of some other European countries in individual readiness, see [4]. Thus the assessments of WEF experts might be biased.

Table 6 shows a comparison of rankings of the first 22 countries in the world when using NRI WEF ranking and when using an objective ranking based on WEF data. Classifica-

Table 6
Comparison of first 22 places in WEF NRI ranking and objective ranking based on the same data

Rank	WEF	Score	Objective	Score
1	Sweden	5.60	Sweden	5.60
2	Singapore	5.59	Singapore	5.50
3	Finland	5.43	Switzerland	5.36
4	Switzerland	5.33	Finland	5.20
5	United States	5.33	Iceland	5.02
6	Taiwan China	5.30	Luxembourg	4.93
7	Denmark	5.29	United States	4.90
8	Canada	5.21	United Kingdom	4.89
9	Norway	5.21	Germany	4.89
10	Korea Rep.	5.19	Canada	4.76
11	Netherlands	5.19	Canada	4.76
12	Hong Kong SAR	5.19	Denmark	4.72
13	Germany	5.14	France	4.68
14	Luxembourg	5.14	Netherlands	4.68
15	United Kingdom	5.12	Australia	4.64
16	Iceland	5.07	New Zealand	4.64
17	Australia	5.06	Austria	4.62
18	New Zealand	5.03	Hong Kong SAR	4.61
19	Japan	4.95	Korea Rep.	4.56
20	France	4.92	Taiwan China	4.55
21	Austria	4.90	Japan	4.52
22	Israel	4.81	Belgium	4.44

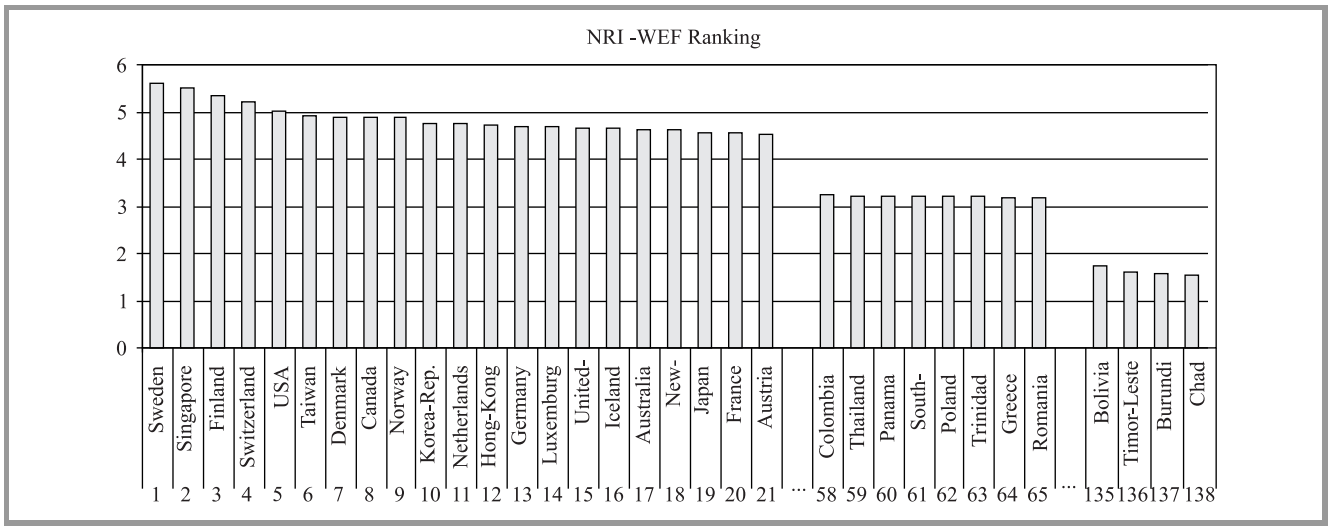

Fig. 5. Classification of countries in the world according to objective ranking based on WEF data.

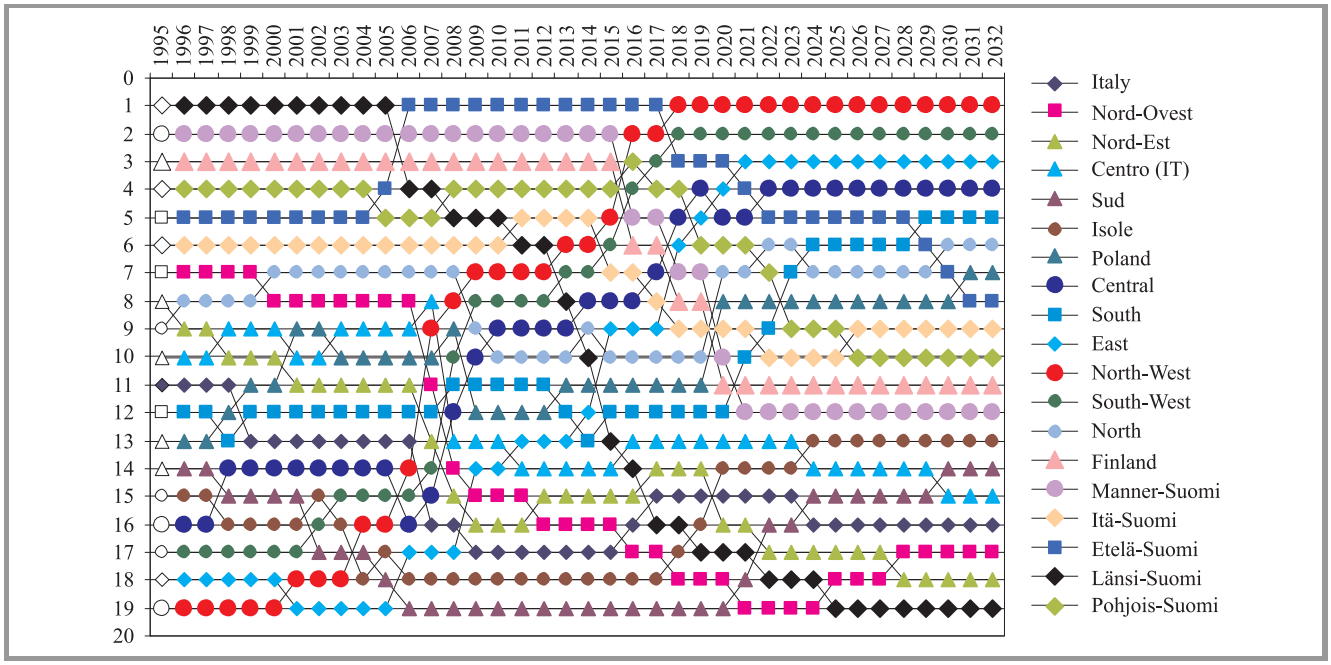

Fig. 6. Dynamic ranking of regions of Finland, Italy and Poland.

tion of other countries, according to objective ranking, is presented in Fig. 5. We see that the overall rankings based on WEF data and applying the averaging method of ranking (NRI WEF Ranking) do not differ substantively form the rankings based on the same data but applying an objective ranking (NRI Objective Ranking). Nevertheless there are astonishing differences. For example, Taiwan is ranked in the 6th place in the world according to NRI WEF Ranking, but only in the 20th place according to NRI Objective Ranking, which indicates that Taiwan has some weak points that were averaged out by the method applied in WEF ranking. Similar comments concern Hong Kong. Objective ranking places countries, such as Iceland or Luxembourg higher as they have more balanced achievements in network readiness indicators.

4. Dynamic Ranking of Regions in Finland, Italy and Poland

In order to estimate future ICT development, we selected three European countries: Finland, Italy, and Poland and analyzed Eurostat data on three indicators of information society development in regional focus:

– households with access to the Internet at home,

– households with broadband access to the Internet,

– individuals regularly using the Internet.

We used an aggregation of these three indicators as in objective ranking, hence stressing the weak points. However,

Table 7
Dynamic ranking of ICT penetration in Polish voivodeships (places in ranking)

Year/Voivodeships	Łódzkie	Mazowieckie	Małopolskie	Śląskie	Lubelskie	Podkarpackie	Podlaskie	Świętokrzyskie	Lubuskie	Wielkopolskie	Zachodniopomorskie	Dolnośląskie	Opolskie	Kujawsko-Pomorskie	Pomorskie	Warmińsko-Mazurskie
1995	11	6	4	2	9	10	3	16	12	5	8	7	14	15	15	13
2000	8	3	10	2	11	9	5	16	12	4	6	7	14	15	15	13
2005	8	2	14	3	12	6	15	16	10	4	5	7	9	11	11	13
2010	11	1	10	6	14	8	16	15	5	9	7	4	3	2	2	13
2015	14	4	5	6	15	10	16	11	2	9	7	8	3	1	1	12
2020	15	6	4	5	14	11	16	7	2	9	8	10	3	1	1	12

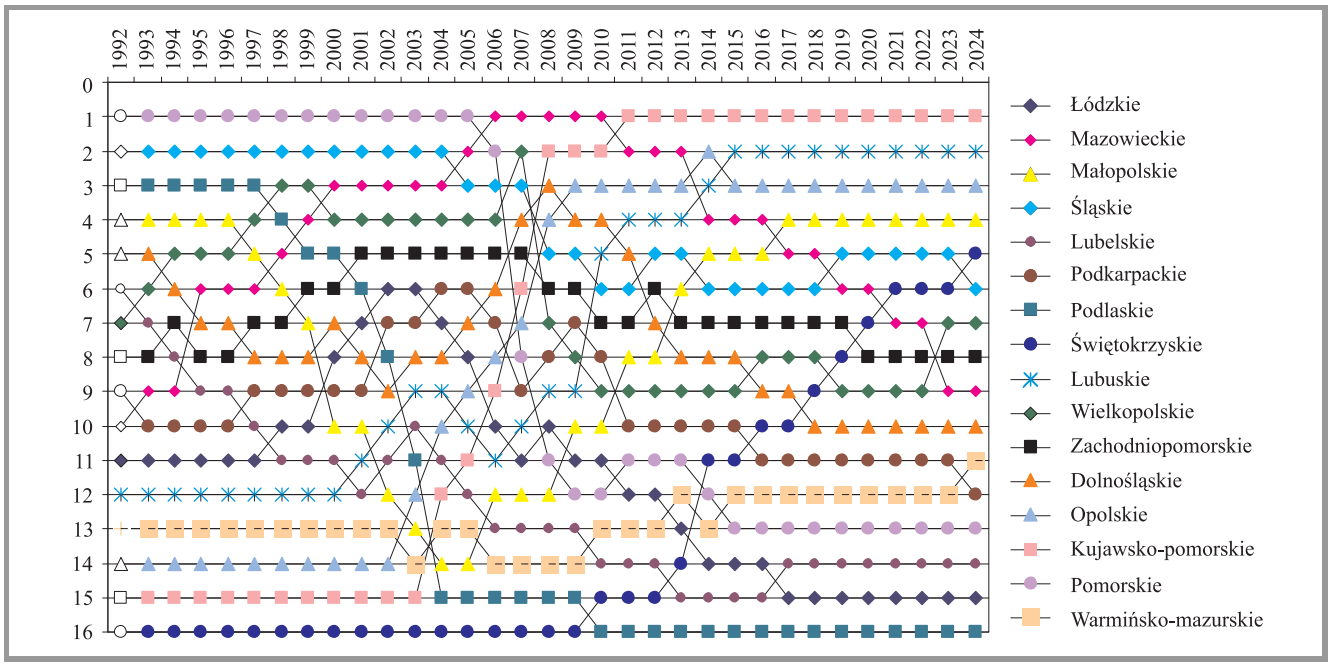

Fig. 7. Dynamic ranking of voivodeships in Poland.

in order to obtain predictions, we estimated the future development of these indicators by fitting statistically sigmoidal curves, which stresses regular changes and eliminates accidental changes. We analyzed first data for NUTS 1 regions of Finland, Italy and Poland (as illustrated in Figs. 1 and 2). The method applying objective ranking on past data and data predicted by statistically estimated sigmoidal curves might be called as *dynamic ranking*. The results are illustrated in Fig. 6.

As we see in Fig. 6, the regions of Finland maintain in majority the relatively high positions, although one of them, Länsi-Suomi, during the years 2005–2011 has lost its leading position and further projections may even indicate a decline to the last place, behind Polish and Italian regions. While the other region of Finland, Etelä-Suomi, from the year 2006 emerged as the first on the ranking position and might maintain it until 2017, further projections indicate a continuation of its relatively high (fifth or eighth) position. Poland and its regions are placed better than Italy and its regions[2] already in the period 2006–2011. Further forecasts indicate that Poland (but not Italy) after 2020 may surpass Finland; around 2018, two Polish regions, North-West (Północno-Zachodni) which began at the last, 19th place, but in 2011 already climbed to the seventh place and the South-West (Południowo-Zachodni) which in 2011 was already on the eighth place will take higher places. Italian

[2]This fact justifies our doubts about the objectivity of the very low evaluation of Poland's individual readiness indicators by WEF experts, since all three indicators used in the dynamic ranking discussed here concern individual network readiness and are based on Eurostat data.

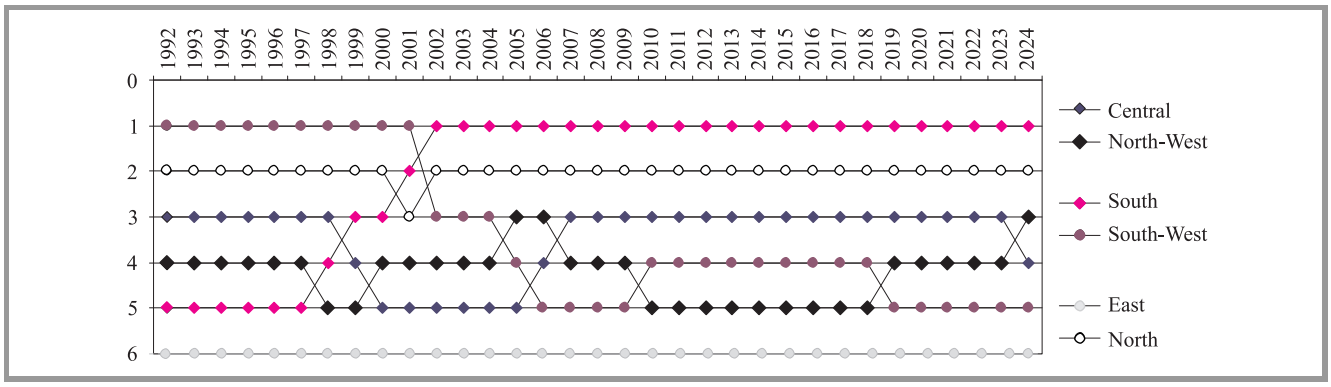

Fig. 8. Dynamic ranking of ICT penetration in Polish macro-regions.

regions, which initially occupied better position than Polish regions, already during the period 2006–2011 decline for further spaces. It is significant that the Italian region which has the best long term forecast is Isole region. Naturally, it can be questioned whether such long-term predictions might come true. It is evident that the development of penetration of the information society is an uneven process, not wholly dependent on the wealth of regions, more of their strategic determination, but historical data from years 2006 to 2010 indicate significant changes in the trends and future position of regions.

5. Dynamic Ranking of Polish Voivodeships and Regions

In order to illustrate method of dynamic ranking, we used data from GUS (Central Statistical Office of Poland) concerning Polish voivodeships (they are rather NUTS 2 regions, smaller than NUTS 1 macro-regions) on the same indicators, as used in the dynamic ranking of macro-regions above, using past data 1992–2011 and their extrapolations by sigmoidal curves 2012–2024. The results are illustrated by Table 7 and Fig. 7.

We see that Kujawsko-Pomorskie voivodeship has great chances to become the best one, due to a positive and strong dynamics of development in the years 2003–2010, while Podlaskie voivodeship might become the last one (good position until 2001, very negative trend 2002–2005). Eastern Region (Podlaskie, Lubelskie, Podkarpackie voivodeships) is generally low in the ranking. Mazowieckie voivodeship, currently the best one, might loose its leading position in the future. When applied to European macro-regions (NUTS 1) of Poland, see Fig. 8, the dynamic ranking shows more stable positions of regions, but confirms the worst position of the Eastern Region, the Southern Region has already become the best one and will probably keep this position.

Generally, GUS data are not quite consistent with Eurostat data. However, the above examples show that dynamic ranking can give more interesting information than just static one. An alternative way to dynamic ranking is counting delay or advancement times (how many years it takes to achieve the average level of an indicator or of aggregated indicators, see [5].

6. Conclusions

There are many indicators of socio-economic penetration of information society technologies, thus any evaluation of them requires multicriteria aggregation.

Simple aggregation using weighting coefficients is subjective and gives less interesting results than the so-called objective ranking.

Much more important conclusions for regional policy can be drawn by applying dynamic ranking – a method of objective ranking using past data and data predicted by statistically estimated sigmoidal curves leading to a change of ranking in time.

Other method of incorporating dynamic phenomena might be to compute delay or advancement times.

Appendix

Structure of NRI Indicators 2010–2011

Subindex A. Environment component
1st pillar: Market environment
1.01 Venture capital availability*
1.02 Financial market sophistication*
1.03 Availability of latest technologies*
1.04 State of cluster development*.
1.05 Burden of government regulation*
1.06 Extent & effect of taxation*
1.07 Total tax rate, % profits
1.08 No. days to start a business
1.09 No. procedures to start a business
1.10 Freedom of the press*
2nd pillar: Political and regulatory environment
2.01 Effectiveness of law-making bodies*
2.02 Laws relating to ICT*
2.03 Judicial independence*

2.04 Efficiency of legal system in settling disputes*
2.05 Efficiency of legal system in challenging regs*
2.06 Property rights*
2.07 Intellectual property protection*
2.08 Software piracy rate, % software installed
2.09 No. procedures to enforce a contract
2.10 No. days to enforce a contract.
2.11 Internet & telephony competition, 0-6 (best)
3rd pillar:Infrastructure environment
3.01 Phone lines/100 pop.
3.02 Mobile network coverage, % pop. covered.
3.03 Secure Internet servers/million pop.
3.04 Int'l Internet bandwidth, Mb/s per 10,000 pop.
3.05 Electricity production, kWh/capita.
3.06 Tertiary education enrollment rate, %.
3.07 Quality scientific research institutions*
3.08 Availability of scientists & engineers*
3.09 Availability research & training services*
3.10 Accessibility of digital content*
Subindex B Readiness component
4th pillar: Individual readiness 5.6 16
4.01 Quality of math & science education*
4.02 Quality of educational system*
4.03 Adult literacy rate, %..
4.04 Residential phone installation (PPP $).
4.05 Residential monthly phone subscription (PPP $)
4.06 Fixed phone tariffs (PPP $) .
4.07 Mobile cellular tariffs (PPP $)
4.08 Fixed broadband Internet tariffs (PPP $)
4.09 Buyer sophistication*
5th pillar: Business readiness 4.1 53
5.01 Extent of staff training*
5.02 Quality of management schools*
5.03 Company spending on R&D*
5.04 University-industry collaboration in R&D*
5.05 Business phone installation (PPP $).
5.06 Business monthly phone subscription (PPP $)
5.07 Local supplier quality*
5.08 Computer, communications, & other services imports, % services imports.
6th pillar: Government readiness
6.01 Gov't prioritization of ICT*
6.02 Gov't procurement of advanced tech*
6.03 Importance of ICT to gov't vision* 6.04 Subindex C Usage component
7th pillar: Individual usage 4.7 35
7.01 Mobile phone subscriptions/100 pop.
7.02 Cellular subscriptions w/data, % total
7.03 Households w/ personal computer, %
7.04 Broadband Internet subscribers/100 pop
7.05 Internet users/100 pop.
7.06 Internet access in schools*
7.07 Use of virtual social networks*
7.08 Impact of ICT on access to basic services*
8th pillar: Business usage
8.01 Firm-level technology absorption*
8.02 Capacity for innovation*
8.03 Extent of business Internet use*
8.04 National office patent applications/million pop
8.05 Patent Cooperation Treaty apps/million pop
8.06 High-tech exports, % goods exports
8.07 Impact of ICT on new services and products*
8.08 Impact of ICT on new organizational models*
9th pillar: Government usage
9.01 Gov't success in ICT promotion.
9.02 ICT use & gov't efficiency*
9.03 Government Online Service Index, 0-1 (best)
9.04 E-Participation Index, 0-1 (best).

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