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Methodological notes on composite indicators for monitoring working conditions

by Andranik S. Tangian

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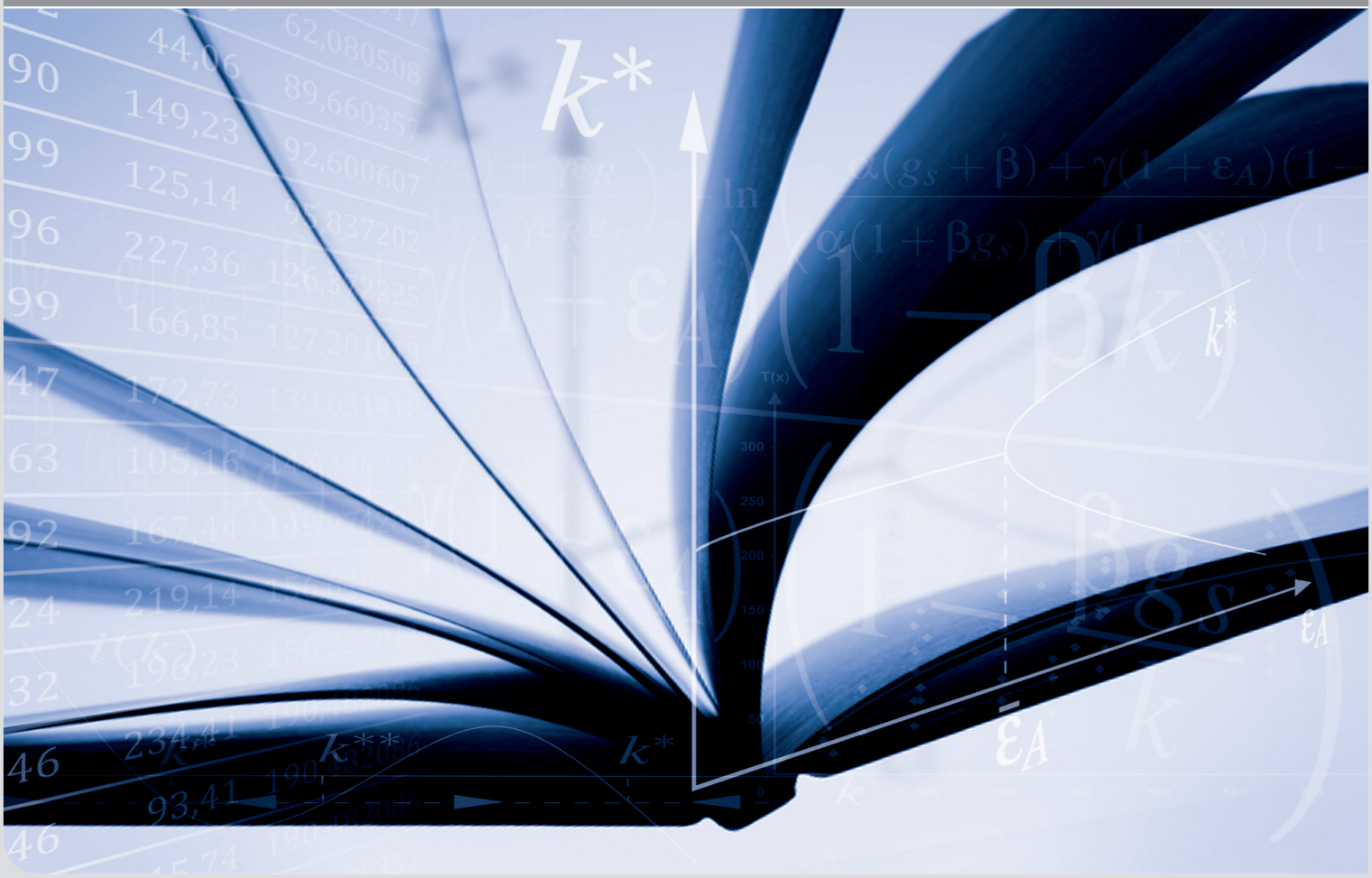

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Methodological Notes on Composite Indicators for Monitoring Working Conditions[1]

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Abstract

Several devices in designing composite indicators for policy monitoring and benchmarking are discussed: weighting and scaling of variables, hierarchical organization, handling rank-based variables, relief tables, survey simulation techniques which combine normative and empirical data. Some remarks are made on survey design to facilitate constructing composite indicators.

Keywords

Composite indicators, methodology of policy monitoring and benchmarking, hierarchy of indices, scaling, rank-based variables, relief tables, survey design, working conditions.

Contents

What is not quantified is ignored.

Business rule

Measure what is measurable and make measurable what is not so.

Galileo (1564–1642)

Introduction

For the first time, the quality of jobs was officially specified through the 2001 Laeken indicators [European Commission 2001, 2002, 2008] in response to the 2000 Lisbon summit's claim for 'more and better jobs'. 'More jobs' was well measurable, but 'better jobs' looked hardly quatifiable, and it was proposed to monitor it by the number of accidents at work. The adequacy of this indicator is rather conditional; for instance, football professionals are constantly exposed to 'accidents at work', but nobody would doubt that they have dream jobs. However, the European Commission found no better solution, even having disposed detailed European Working Conditions Surveys (EWCS) carried out since 1995 by the European Foundation for Living and Working Conditions (called usually European Foundation) assisted by national statistical offices.

Such a gap between the general formulation of policies and their fragmental statistical representations is quite usual. During the last two decades, this gap is filled in with aggregate composite indicators, or summary indices, which 1–1 link policy targeting and policy wordings. One of early examples is the Employment Protection Legislation (EPL) indicator introduced by [OECD 1999] to monitor labour flexibilization; for its regular updates see [OECD.Stats 2018]. Methodological foundations of composite indicators are described in the handbook [OECD 2008], and [European Parliament 2009] has reviewed about 20 approaches to measuring the job quality, in particular, using composite indicators.

In spite of propagation of composite indicators, they are often too thoughtlessly constructed, too literally interpreted or, alternatively, too severely mistrusted. In this paper we summarize our experiences in handling composite indicators and their derivation from working conditions

surveys; see [Tangian 2011] for more details and references to technical reports. The main conclusion is that composite indicators can be very useful for policy monitoring and benchmarking but they need special treatment and the surveys have to be designed appropriately to facilitate their construction.

Justification of Composite Indicators

A composite indicator is a function f in n statistical variables (formula with n entries) which to each set of input values $x_1, \ldots, x_n$ puts into correspondence the indicator value $y = f(x_1, \ldots, x_n)$. A composite indicator is not expected to abruptly change its behaviour, meaning differentiability of f. Then its Taylor expansion in a neighbourhood of reference point $(x^0_1, \ldots, x^0_n)$ gives the first-order approximation of f:

$$f(x_1,\ldots,x_n) \approx f\left(x_1^0,\ldots,x_n^0\right) + \sum_{j=1}^{n} \frac{\partial f\left(x_1^0,\ldots,x_n^0\right)}{\partial x_j}\left(x_j - x_j^0\right)$$

$$= \underbrace{f\left(x_1^0,\ldots,x_n^0\right) - \sum_{j=1}^{n} \frac{\partial f\left(x_1^0,\ldots,x_n^0\right)}{\partial x_j} x_j^0}_{\text{Constant } C} + \underbrace{\sum_{i=1}^{n} \frac{\partial f\left(x_1^0,\ldots,x_n^0\right)}{\partial x_j} x_j}_{\text{Weighted sum } \sum_{j=1}^{n} a_j x_j}$$

$$= C + \sum_{j=1}^{n} a_j x_j$$

Since composite indicators are primarily used for monitoring relative progress and benchmarking, the constant C is omitted. Hence, the remaining weighted sum of variables is the composite indicator to within its first-order approximation. The signs of coefficients a_j (which are often just ±1s) are coordinated to indicate the overall improvement either by the indicator's increase, as in the case of job quality, or decrease, as in the case of disability risks.

Weighting of variables is made explicitly by attributing weight coefficients a_j, or implicitly, either due to a hierarchy of indicators or by scaling. As for explicit weighting, 'most composite indicators rely on equal weighting, i.e., all variables are given the same weight' [OECD 2008, p. 31]. If no information is available, equal weights have maximal statistical likelihood [Kendall and Moran 1963]. Another reason for equal weighting is that if certain variables have higher weights then the persons for whom these variables are important are overrepresented. For instance,

women with children can be most interested in most generously paid maternity leave, and single men in long unemployment insurance. Therefore, a higher weight for paid maternity leave favours women with children and discriminates single men. It means that unequal weights of variables result in inequality of some individuals. Since individuals are usually assumed equal, regardless of education, experience, or intelligence (in line with the principle 'one voter—one vote'), the weights of variables are assumed equal as well.

Unequal weights are explicitly applied if the relative importance of factors is known, which is quite seldom. On the other hand, there are surveys in which the interviewed are asked for their subjective weighting; see the *Gute-Arbeit (Good Work)* index of [DGB 2007, 2009]. It should be however noted that statistical variables are often correlated, which reduces the effect of their unequal weighting. For more advanced methods of constructing composite indicators as objective functions, which measure the degree of attainment of policy targets, see [Tangian and Gruber 2002].

Weighting in Hierarchical Composite Indicators

A composite indicator is hierarchical if it is a sum of several composite (sub-)indicators. For example, the DGB indicator *Gute Arbeit* is a sum of three equally weighted sub-indicators: resources (work organization) based on ten composite sub-sub-indicators, strains based on three composite sub-sub-indicators, and stability and income based on two composite sub-sub-indicators — each summarizing unequal numbers of variables. Such a hierarchy implicitly leads to the unequal weighting of variables. To illustrate this, let us consider the average of two composite indicators, the first one being the average of three and the second — of two statistical variables:

$$f(x_1, \dots, x_5) = \frac{\frac{x_1+x_2+x_3}{3} + \frac{x_4+x_5}{2}}{2}.$$

Then the effective weights of x_1, x_2, x_3 are $1/3 \times 1/2 = 1/6$, and the effective weights of x_4, x_5 are $1/2 \times 1/2 = 1/4$.

The uncontrollable implicit weighting in hierarchical composite indicators can lead to inconsistencies. For instance, the EPL indicator of the OECD is a sum of three indicators: EPL for regular employment, EPL for temporary employment and EPL for collective dismissals. Since

they are defined independently with different number of variables, the temporary employed in Belgium, France, Italy, Norway and Spain look better protected than the permanently employed which is an evident contradiction; see Table 1.

Table 1. OECD indicators of strictness of employment protection legislation (EPL)

	Regular employment			Temporary employment			Collective dismissals	
	Late 1980s	Late 1990s	2003	Late 1980s	Late 1990s	2003	Late 1990s	2003
Austria	2.9	2.9	2.4	1.5	1.5	1.5	3.3	3.3
Belgium	1.7	1.7	1.7	4.6	2.6	2.6	4.1	4.1
Czech Republic	…	3.3	3.3	…	0.5	0.5	2.1	2.1
Denmark	1.5	1.5	1.5	3.1	1.4	1.4	3.9	3.9
Finland	2.8	2.3	2.2	1.9	1.9	1.9	2.6	2.6
France	2.3	2.3	2.5	3.1	3.6	3.6	2.1	2.1
Germany	2.6	2.7	2.7	3.8	2.3	1.8	3.5	3.8
Italy	1.8	1.8	1.8	5.4	3.6	2.1	4.9	4.9
Netherlands	3.1	3.1	3.1	2.4	1.2	1.2	3.0	3.0
Norway	2.3	2.3	2.3	3.5	3.1	2.9	2.9	2.9
Poland	…	2.2	2.2	…	0.8	1.3	4.1	4.1
Portugal	4.8	4.3	4.3	3.4	3.0	2.8	3.6	3.6
Spain	3.9	2.6	2.6	3.8	3.3	3.5	3.1	3.1
Sweden	2.9	2.9	2.9	4.1	1.6	1.6	4.5	4.5
Switzerland	1.2	1.2	1.2	1.1	1.1	1.1	3.9	3.9
United Kingdom	0.9	0.9	1.1	0.3	0.3	0.4	2.9	2.9

Source: [OECD 2004, p. 117]

Scaling Variables for Composite Indicators

Scaling is aimed at making statistical variables commensurable. For instance, yearly income in Euro and the type of contract (Permanent/Temporary) are not commensurable, since the type of contract coded by 1 and 0 becomes negligible compared with many thousand Euro. Therefore, the range of certain variables is reduced, of others — increased. The most used scaling methods are normalization and standardization [OECD 2008, pp. 84–85].

Normalization reduces the range of variable x_j with m records $x_j = (x_j^1, \dots, x_j^i, \dots, x_j^m)$ to the segment [0;1]:

$$x_j \rightarrow y_j = \frac{x_j - \min_i x_j^i}{\max_i x_j^i - \min_i x_j^i}.$$

Normalization is a linear transformation which preserves all 'good properties' of the variables . A composite indicator which consists of normalized variables is the weighted mean of the corresponding codes. It attains 0 or 1 if *all* the codes are lowest or highest, respectively. The simple interaction of variables makes normalized indicators transparent and practical. However, normalization is not appropriate for data with outliers (few large deviations from 'typical' values), because the typical values get clustered to give room for the outliers. Normalization works well if answers to questions are restricted to a few choices, because then there are no outliers. For instance, if income is given in absolute figures then a few top earners result in outliers and normalization is inappropriate; in this case income can be first given in deciles and only then normalized.

Standardization, particularly promoted by the OECD, brings the mean of a variable to 0 (reference), and the standard deviation to 1 (scale unit):

$$x_j \rightarrow y_j = \frac{x_j - \mu_j}{\sigma_j},$$

where

$\mu_j = \frac{1}{m}\sum_{i=1}^{m} x_j^i$ (mean)

$\sigma_j = \sqrt{\frac{1}{m-1}\sum_{i=1}^{m}(x_j^i - \mu_j)^2}$ (standard deviation).

Standardization does not cluster typical values even in the presence of outliers but, being a non-linear transformation, results in some questionable effects. Under standardization, 'good' and 'bad' values are relativized, which sometimes makes composite results counterintuitive. For example, let four individuals characterize their satisfaction with job security and income in % as shown in the upper section of Table 2. In the bottom section, these figures are standardized. As follows from the top section, all the individuals are better satisfied with their income than job stability, and Individual 1 is the second best satisfied with his job, having 169 points and approaching Individual 4. After standardization, Individuals 2 and 3 look better satisfied with

their job stability than income, and Individual 1 looks the least satisfied with his job, being far behind Individual 1.

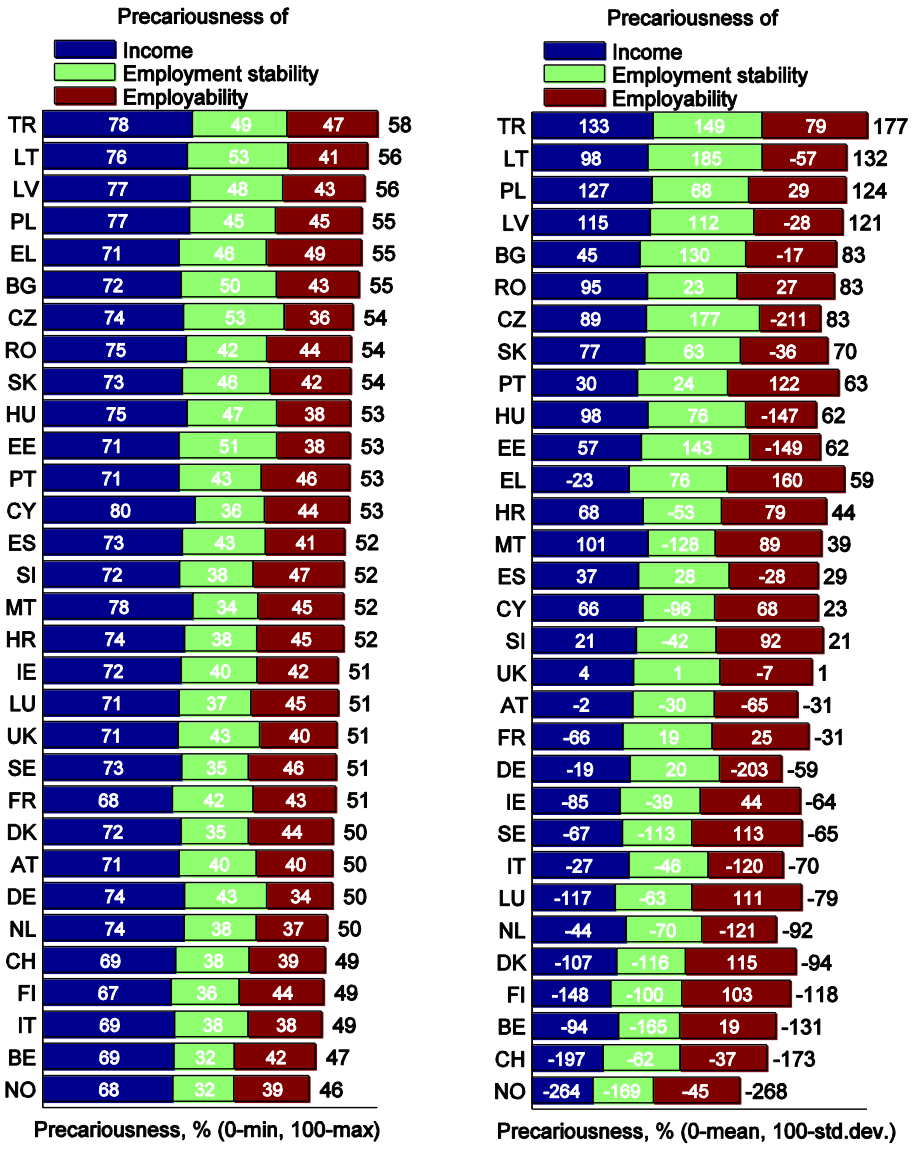
Table 2. Index of job satisfaction before and after standardization of variables

	Satisfaction with job security x_1	Satisfaction with income x_2	Index $f = x_1 + x_2$
Individual 1	70	99	169
Individual 2	50	100	150
Individual 3	50	100	150
Individual 4	70	100	170
Mean μ_j	60	99.75	
Std. dev. σ_j	11.55	0.5	
	Standardization $x_1 \rightarrow y_1$	Standardization $x_2 \rightarrow y_2$	Index $f = y_1 + y_2$
Individual 1	0.87	–1.5	–0.63
Individual 2	–0.87	0.5	–0.37
Individual 3	–0.87	0.5	0.37
Individual 4	0.87	0.5	1.37

This non-monotonicity of composite indicators is well seen in Figure 1, where the precariousness of jobs in European countries is indexed using normalized and standardized variables and composite sub-indicators. In both charts, the countries are ordered by decreasing composite indices. The lengths of colour bars are proportional to the (composite) sub-indices, but in the right-hand chart the same constant is added to all the sub-indices to visualize their negative values. In the left-hand chart, the decreasing total length of the colour bars implies a monotonous decrease of the composite indicator, but not in the right-hand chart. For example, the total precariousness of jobs in Czech Republic (CZ) and Greece (EL) is estimated with 83 and 59 points, respectively, whereas the Czech total bar is much shorter. The composite indicator's non-monotonicity in variables argues against their standardization in this type of applications.

Method of Total Ranks for Non-Metrical Variables

The OECD guidelines for constructing composite indicators assume that the input first-level indicators are all metrical statistical figures. It is not the case of qualitative issues, which can be only ranked. According to the OECD, the major problem of rank-based scales is the dependence of new alternatives:



Source: [Tangian 2011, p. 91–92] based on data [European Foundation 2007]

Figure 1. Composite indicators of job precariousness in European countries

One limitation of a summary indicator based on ranking is that a given country's … score could either rise or fall over time, even though its … practice were completely unchanged, for the simple reason that other countries changed their policies. Even more fundamentally, it would be invalid to compare rank-based score for the late 1980s, which was based on an analysis of 16

European countries, with a rank-based score for the late 1990s based on a sample of 27 countries. Quite independently of any changes in EPL, the maximum rank score has nearly doubled.

[OECD 1999, p. 115].

To illustrate this effect, let us consider the duration of unemployment insurance in 1994–2004 in Denmark and the Netherlands. In 1994, the duration of Danish insurance was 30 months, and of the Dutch 6–54 months, depending on the length of service and age. In 2004 Denmark extended the duration unconditionally to 48 months. Although the practice remained unchanged, the Dutch rank changes, implying the change of its rank-based score:

Rank	1994		2004	
	Country	Insurance duration	Country	Insurance duration
1	Netherlands	6–54 months, conditioned	Denmark	48 months, unconditioned
2	Denmark	30 months, unconditioned	Netherlands	6–54 months, conditioned

To overcome this effect, the ranking method is modified as follows. As items, we consider the pairs 'Country/Year', implying (Denmark 1994) and (Denmark 2004) to be two different items (as they actually are). Hence, we obtain the *total ranks:*

Rank	1994		2004	
	Country	Insurance duration	Country	Insurance duration
1			Denmark	48 months, unconditioned
2	Netherlands	6–54 months, conditioned	Netherlands	6–54 months, conditioned
3	Denmark	30 months, unconditioned		

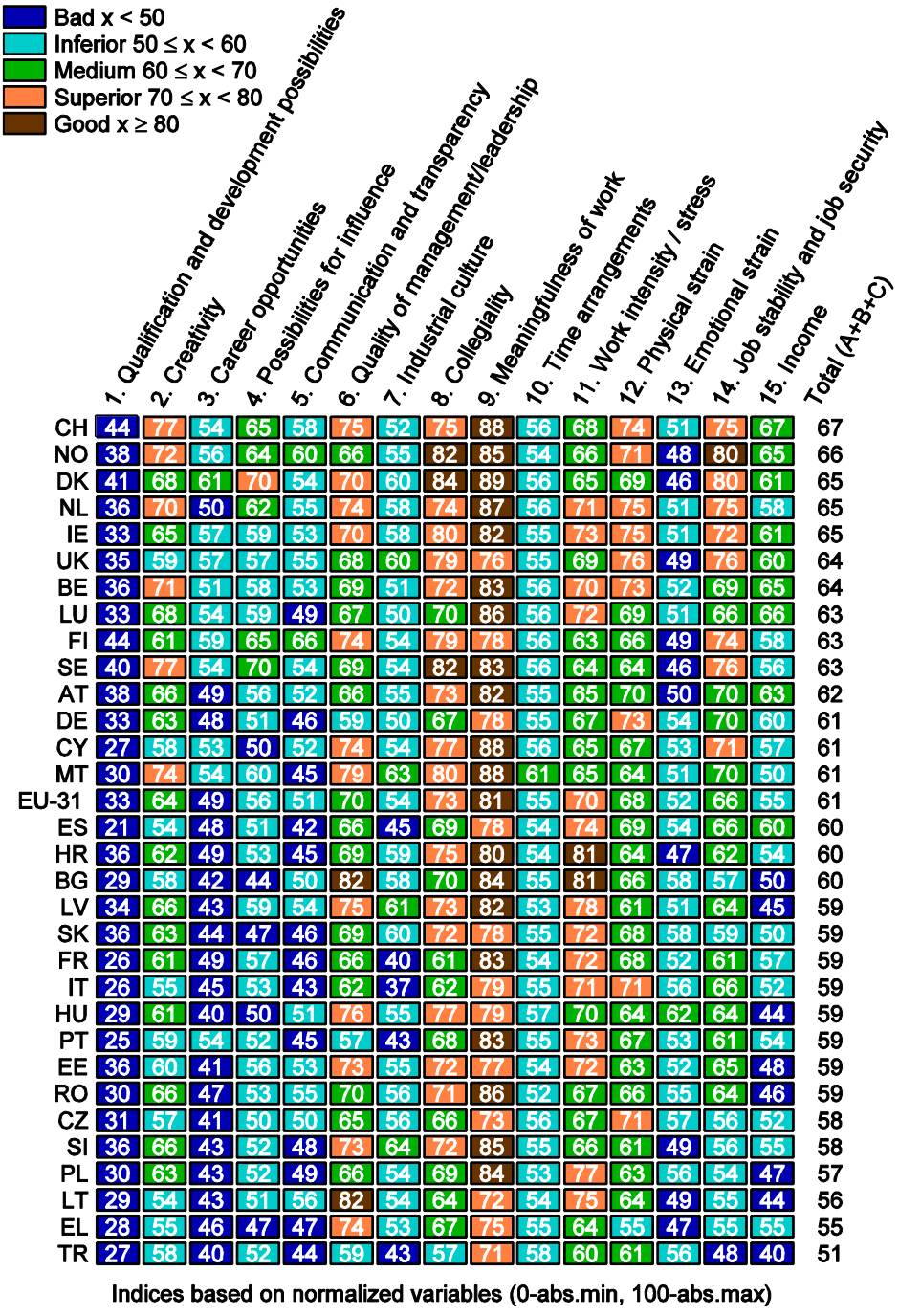
This device changes the Danish rank and keeps the Dutch rank invariable, surmounting the 'dependence on new alternatives' of rank-based indicators.

The second OECD's concern is that the rank-based indicators are misleading when the number of countries changes (e.g. the top rank of 27 countries almost doubles the top rank of 16 countries). This problem is easily resolved by normalizing the ranks, e.g., by always reducing their range to 0–1.

Relief Tables

Relief tables are practical to visualize and analyse composite indicators. For these purposes, the table cells are coloured like in geographical maps: high values are shown in brown — as mountains, the moderately positive in green — as plains, the moderately negative in pale blue — as shallow waters, and strongly negative ones in dark blue — as deep ocean.

The relief table in Figure 2 shows the composition of indicator ‘Total quality of work’ based on 15 composite sub-sub-indicators, grouped into three sub-indicators as described in Section



Source: [Tangian 2011, p. 108] based on the data from [European Foundation 2007]

Figure 2. Composition of indicator ‘Total quality of work’ based on normalized variables

'Weighting in Hierarchical Composite Indicators'. It prompts two observations of particular importance. Firstly, the level of professional training is <50 all over Europe (dark blue). Among 15 aspects of working conditions considered, the first partial indicator *Qualification and development possibilities* gets the lowest evaluation — 'bad' in *all* European countries. This means that Europe is not yet really prepared to base its policy on lifelong learning. The second observation is that career chances all over Europe are quite poor, and income is but modest. The third column exhibits either 'bad' or 'inferior' evaluation of career chances in all countries except Denmark with 61 points. The income evaluation does not surpass the medium threshold either. This hardly meets the claims for 'better jobs' in the 2000 Lisbon Agenda.

Survey Simulation

Survey simulation is a technique of replacing a survey or its part with a computer model. The need for such a replacement emerges if there is no survey on the given topic, or if many persons cannot or do not wish to answer some questions.

Sometimes the answers required can be derived from the personal situation. For instance, taxes and benefits of unemployed are determined by public officials using special computer programs. Such programs input the data on income, employment record, family status, etc., and output taxes and benefits. Therefore, the net replacement rates of unemployed can be derived from their personal data collected in the existing household surveys. Thus, quite reliable individual 'responses' to problematic questions can be obtained by interfacing known normative formulas to empirical data from apparently irrelevant surveys.

For instance, tax-benefit formulas with which taxes and benefits are computed by the [OECD 2005] *Tax-Benefit Models* can be interfaced to the data of the *Labour Force Survey* of the Eurostat. This approach has been successively applied; see [Tangian 2011, Chapter 5].

The same approach helps to reveal the difference between the factual (empirical) and institutional (normative) situation at the labour market. For instance, according to the 2005 EWCS, Turkey has the highest labour flexibility among the 31 countries considered, but according to [OECD 2004, p. 117] it has the most strict employment protection; see Table 3. This contradiction is explained as follows. The OECD indicator evaluates institutional norms, reflecting that the

Table 3. Institutional and factual employment insecurity; country ranks in columns are given after the slash

	Institutional employment insecurity: Strictness of EPL as a weighted average of EPL indices for permanent employment, temporary employment and collective dismissals with the OECD weights 5/12, 5/12 and 2/12, respectively	Factual employment insecurity derived from interfacing the institutional flexibility indices to the 2005 EWCS data		
		Flexibility based on normalized variables	Flexibility, based on standardized variables	Employment with no contract
	OECD score 0–6	%	%	%
United Kingdom	0.7 / 1	27 / 6	56 / 6	15 / 6
Ireland	1.1 / 2	33 / 5	101 / 5	25 / 5
Switzerland	1.1 / 2	7 / 31	–77 / 30	4 / 20
Denmark	1.4 / 3	13 / 13	–32 / 13	8 / 11
Hungary	1.5 / 4	11 / 20	–50 / 19	4 / 18
Poland	1.7 / 5	17 / 12	–11 / 12	6 / 13
Czech Republic	1.9 / 6	11 / 19	–50 / 20	2 / 27
Italy	1.9 / 6	17 / 11	–10 / 11	9 / 8
Austria	1.9 / 6	19 / 9	2 / 9	11 / 7
Slovakia	1.9 / 6	9 / 25	–63 / 25	2 / 29
Finland	2.0 / 7	11 / 18	–48 / 18	3 / 24
Netherlands	2.1 / 8	9 / 23	–60 / 23	2 / 26
Belgium	2.2 / 9	8 / 28	–70 / 28	3 / 23
Germany	2.2 / 9	9 / 24	–61 / 24	3 / 21
Sweden	2.2 / 9	9 / 27	–65 / 27	1 / 30
Norway	2.6 / 10	7 / 29	–76 / 29	3 / 22
Greece	2.8 / 11	41 / 4	148 / 4	32 / 4
France	3.0 / 12	12 / 16	–42 / 16	5 / 16
Spain	3.1 / 13	22 / 7	27 / 7	9 / 10
Portugal	3.5 / 14	20 / 8	11 / 8	9 / 9
Turkey	3.7 / 15	71 / 1	356 / 1	67 / 1
Estonia	…	13 / 14	–34 / 14	7 / 12
Cyprus	…	48 / 2	199 / 2	42 / 2
Latvia	…	10 / 21	–57 / 21	4 / 19
Lithuania	…	13 / 15	–35 / 15	5 / 15
Luxemburg	…	7 / 30	–78 / 31	1 / 31
Malta	…	46 / 3	184 / 3	41 / 3
Slovenia	…	9 / 26	–63 / 26	2 / 28
Bulgaria	…	19 / 10	2 / 10	6 / 14
Croatia	…	12 / 17	–45 / 17	2 / 25
Romania	…	9 / 22	–59 / 22	5 / 17

Source: First column [OECD 2004, p. 117]; columns 2–4 [Tangian 2011, p. 94] based on [European Foundation 2007].

Turkish regulation of ‘hiring and firing’ is very strict. The EWCS 2005 reveals that 302 of 454 Turkish employees interviewed have no contract at all, that is, 67% are not covered by labour protection, being employed in the most insecure way. A similar situation is inherent in Cyprus,

where 201 of 482 = 42% employees work with no contract, Malta (201 of 507 = 40%), and Greece (179 of 629 = 28%). To construct an 'empirical' indicator of employment insecurity, as opposed to the normative EPL indicator by the OECD, the EPL indices for permanent and temporary employment and 0 for the employees with no contract should be weighed, using as weights the percentages of the employees with permanent, temporary and no contract, respectively.

Survey Design to Facilitate Constructing Composite Indicators for Monitoring Working Conditions

Below we provide a kind of check-up for design of a survey aimed at constructing composite indicators of working conditions.

Policy issues

1. Relevance to particular policies to be monitored

   Are the objectives of the survey formulated explicitly? (Which policies are monitored: quality of jobs, non-precariousness, flexibility of employment, etc.)

   How exhaustive is the questionnaire regarding these policies?

2. Target users

   Who are the target users of the data? (Policy makers, policy analysts, academics, trade unions, etc.)

   To which extent does the survey satisfy their needs?

3. Definition of working conditions

   Is the [ILO 1999] notion of *decent work* (with four pillars: income, employment stability, employability and integration in social security schemata, incl. pensions) taken into account?

   Which aspects do constitute the notion of working conditions?

   How these aspects are arranged into a hierarchy?

   Are all its levels labelled with titles?

Respectively, a hierarchical structure of the survey with titles and subtitles of ‘Chapters’ and ‘Sections’ associated with particular aspects of working conditions is very helpful. It could be used for constructing sub-indicators, sub-sub-indicators, etc.

Conceptual issues

4. Weighting questions by individuals

   It can make sense to ask individuals, how important for them is the given question?

5. Tracing working histories

   It can make sense to accompany certain questions with an inquiry ‘What was the situation 1, 2, 5, 10 years ago?’

6. Tracing expectations (about income, job stability, career, mobility, etc.)

   It can make sense to accompany certain questions with an inquiry ‘What do you expect in 1, 2, 5, 10 years?'

Questions

7. Avoiding misleading formulations

   Ambiguous questions like ‘Is your work emotionally demanding?’ should be explained with ‘in the positive sense’ or ‘in the negative sense’

8. Dealing with ambiguous values

   Questions on some issues like ‘Are your working hours flexible?’ should be accompanied by an inquiry ‘Do you appreciate it?’, because the given issue can be good for ones and bad for others.

9. Asking for absolute and harmonized figures

   It is practical to have, for instance, income both in harmonized units (A, B, C,…) and absolute figures (to compute the average, median, inequality in payment, gender gap, etc.)

Answers and their coding

10. Unification of codes

    To avoid re-coding while constructing composite indicators, ‘bad’ issues have to be coded by smaller numbers, and ‘good’ by larger numbers. Mediocre issues should be coded by

intermediate numbers. Instead of coding like 1 – bad, 2 – good, 3 – neither bad nor good, it is better to apply coding like 1 – bad, 2 – neither bad nor good, 3 – good.

11. Avoiding branching in questions and answers

    Instead of 'Do you work shifts?' If yes – go to the next question (Do your work night shifts, do you work day shifts,…) make one question: 'Do you work: no shifts (5), rotating shifts (4), morning shifts (3), afternoon shifts (2), night shifts (1)'

Sampling

12. Size of samples

    From the standpoint of mathematical statistics, the representativeness of a sample depends on its size but not on the size of the total population. To guarantee the same representativeness of regional samples, samples from small regions must be of the same size as that from large ones.

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