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How much confidence can we have on PMR ranking?

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Preface

The PMR indicator

Since the end of the 1990s the OECD has been collecting a set of indicators to measure the developments in the product market regulation across OECD countries. Those years (and the following decade) have been characterized by a number of product market reforms. Pushed by the globalization and the technological change many OECD countries have been experimenting a process of liberalization in the network sectors, opening its markets to foreign competition and products and redesigning both public intervention and regulatory policies. The policy agenda too has been largely influenced by the product market reform. The PMR composite indicator attempts at capturing the salient features of this product market regulation. It tries to transform qualitative laws and regulations that may affect competition into quantitative indicators using a bottom-up approach. The data used to construct the indicators used in the PMR are obtained from a survey of member states and subject to peer review to assure comparability across countries. Being based on laws and regulation the indicators are not subject to subjective assessment of market outcomes limiting the measurement error in the data (but reducing the ability of the PMR to reflect market outcomes).

Currently the PMR indicator[1] comes from the aggregation of 18 low-level indicators that are grouped in 7 sub-domains and subsequently in 3 domains, State Control, Barriers to Entrepreneurship and Barriers to Trade and Investment. Data are available for all OECD countries except Greece, Ireland and The Slovak Republic (and Luxembourg for 1998 data). Overall the PMR indicator is computed for 27 countries (26 in 1998) and for three years 1998, 2003, and 2007.

1. Introduction

The construction of a composite indicator (CI) involves stages where choices have to be made: the structure of PMR in domains and sub-domains, the normalization of the original data, the weighting of indicators, domains and sub-domains, and the aggregation method. All these choices will affect both the ranking and the message brought by the CI in a way that deserves analysis and corroboration. Robustness analysis is a powerful tool to test the sensitivity of PMR ranking to the different methodological assumptions. In particular we are interested in three questions:

(a) Does the use of one construction strategy versus another provide actually a partial picture of the countries' performance?

(b) Which countries have large uncertainty bounds in their rank (volatile countries)?

(c) Which are the factors that affect the countries rankings?

Two strategies can be employed to answer to these questions. Either we consider each methodological choice individually and we study its effect on PMR ranking or we consider all the possible sources of variability together and study its joint effect on the PMR ranking. The first strategy is addressed in the first tree sections by:

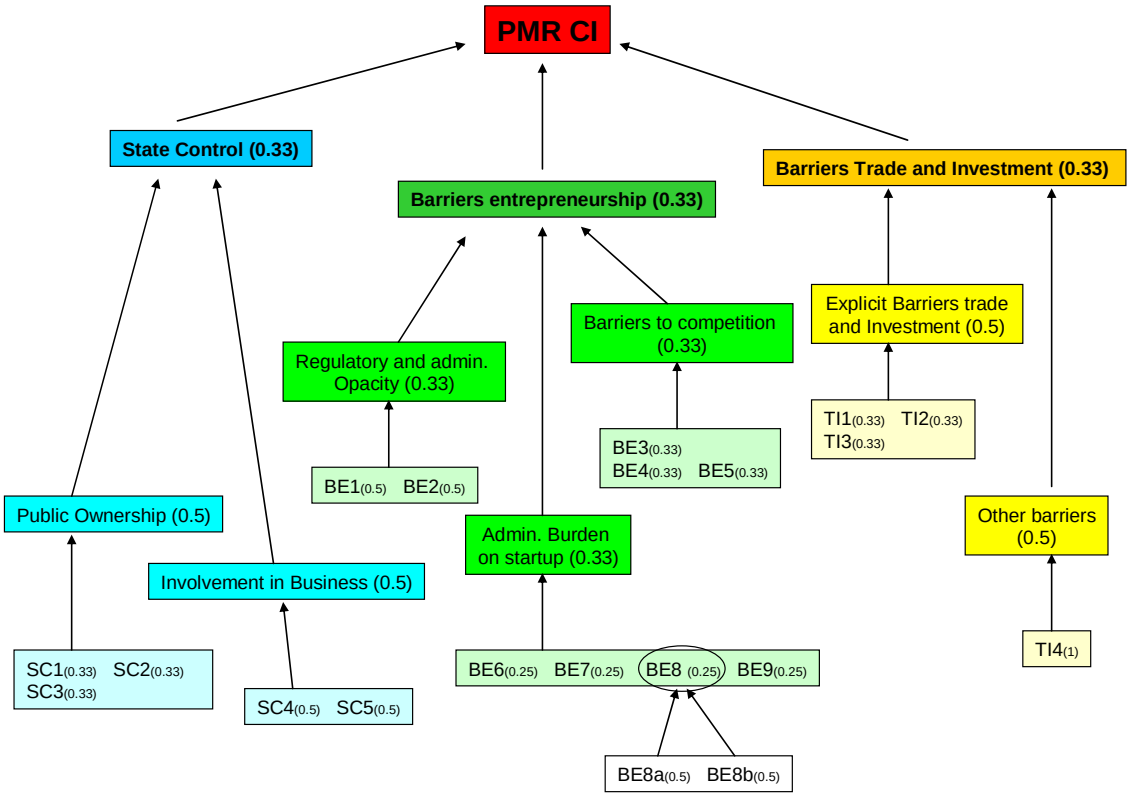
[1] For PMR indicator (of composite indicator) we refer to the "integrated PMR" as described in the OECD Working Party n.1 on Macroeconomic and Structural Policy Analysis, *Product market regulation in OECD countries 1998-2007: update and extensions on the OECD indicators*, ECO/CPE/WP1(2008)12.

(i) comparing two weighting schemes: one derived from principal components analysis (PCA) on different datasets, and another that weights equally indicators, sub-domains and domains (EW in short);
(ii) exploring the issue of compensability;
(iii) eliminating one indicator sub-domain or domain at a time.

The second strategy will be the object of section five where the multi-modeling approach is described.

Section six compares the design chosen by the PMR modelers with the statistical analysis of the datasets while section seven analyzes the actual contribution of each indicator, domain and sub-domain to the composite. Section eight concludes. Before proceeding with the robustness analysis we briefly present the "baseline" PMR composite indicator, i.e., the scenario in which data are not normalized, equal weight is assigned to each domain, sub-domain and indicators and all information is linearly aggregated. **Figure 1** below displays the structure of PMR CI and, under parenthesis, the weights assigned in the baseline scenario. The country rankings of the baseline PMR CI are displayed in **Table 1** for the years 1998, 2003 and 2007.

Figure 1. Structure of PMR composite indicator. Under parenthesis the weights assigned to each indicator, sub-domain, and domain.



The analysis of the different years (**Table 1**) highlights a number of countries whose position in the ranking varies a lot along the years. Australia goes from the 5th position in 1998 to the 11th of 2007. This is essentially due to a worsening of the performance in the *state control* domain (especially IBO sub-domain, see list of acronyms at the end of this document). Belgium sees its performance in *state control* worsening from 2003 and 2007, while Finland improves its position in 2003 due to the domain *barriers to entrepreneurship* (especially in the RAO and ABS sub-domains). The reverse happens to Hungary that has a worsening of its ranking position only in 2003. The drop in 2003 with respect to the 1998 rank is due to a worsening of the domain *barriers to entrepreneurship* (and to some extent of

barriers to trade and investment) and especially of the sub-domain BAC (from the 12th to the 23rd position).

The improvement of Italy from 2003 and 2007 is mainly due to *state control* and *barriers to entrepreneurship* (particularly sub-domains IBO and BAC). Japan climbs the 2007 ranking thanks to the performance in *state control* (IBO), while Korea experiment in 2007 (with respect to the 2003 ranking) an improvement in *barriers to entrepreneurship* (RAO) but a worsen of both *state control* (IBO) and especially *barriers to trade and investment* (OBA). Luxembourg and Spain are the countries with the highest variation in ranking. Luxembourg jumps down by 10 positions between 2003 and 2007 (1998 PMR CI has not been computed for this country given the high number of missing data). All domains and sub-domains worsen especially *state control* and *barriers to entrepreneurship*. Spain starts with a very low performance in 1998 and reaches the 7th place in 2007 thanks mainly to the improvement in IBO and BTI. New Zealand deteriorates its ranking in 2007 due to the domain *barriers to entrepreneurship* and in particular the sub-domain RAO. The upgrading of Switzerland is largely due to the domain *barriers to entrepreneurship* (and the sub-domain RAO: from the 26th to the 11th position).

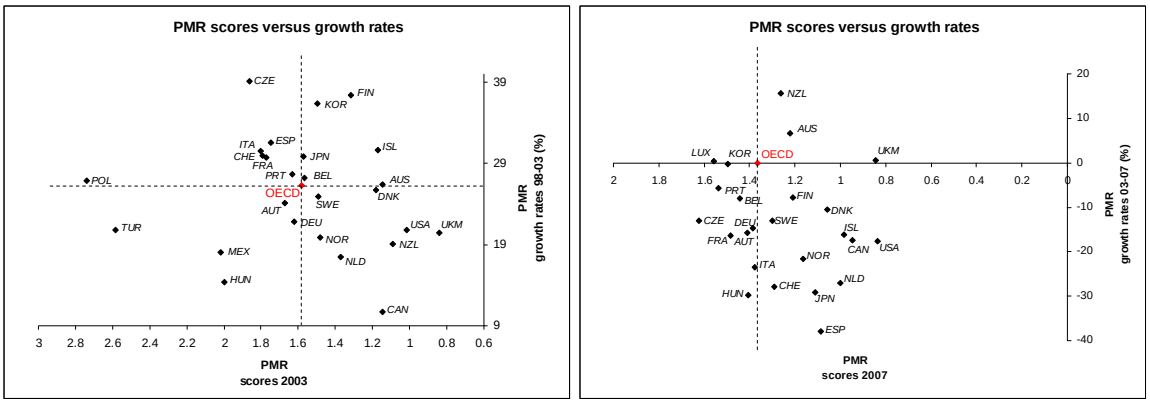
Table 1. PMR Composite indicator. Country ranking for the baseline scenario in 1998, 2003 and 2007.

	Ranks		
Country	**1998**	**2003**	**2007**
AUS	5	4	11
AUT	14	18	18
BEL	13	14	19
CAN	3	5	3
CZE	24	23	24
DNK	6	7	6
FIN	12	8	10
FRA	20	20	20
DEU	11	16	16
HUN	17	24	17
ISL	8	6	4
ITA	23	22	15
JPN	15	15	8
KOR	18	12	21
LUX	-	13	23
MEX	19	25	25
NLD	7	9	5
NZL	4	3	12
NOR	9	10	9
POL	26	27	27
PRT	16	17	22
ESP	21	19	7
SWE	10	11	14
CHE	22	21	13
TUR	25	26	26
UKM	1	1	2
USA	2	2	1

Figure 2 presents the relationship between levels and growth rates of the PMR indicator. In the X-axis the scores of the 2003 or 2007 PMR composite indicator and in the Y-axis the % change of the PMR composite between 1998 and 2003 and between 2003 and 2007. PMR data show a considerable

difference between the first period (namely 1998-2003) and the second period (2003-2007). In the first half decade is characterized by high efforts in opening the product market in all countries considered (that nevertheless had different levels of competition in those markets), while the pace of reforms slowed dawn in the following half decade. In 2007 data shows that, with the exception of 5 countries (New Zealand, Australia, Luxembourg and UK), all others have experienced higher levels of protectionism in product market as measured by the PMR.

Figure 2. PMR scores versus growth rates. 1998 versus 2003 and 2003 versus 2007



2. Robustness of the PMR composite indicator with respect to the weighting structure

In the 1998 round of PMR construction, the PMR indicator was computed using weights obtained via principal component analysis of a set of 21 OECD countries. In order to assure "weight neutrality" the same set of weights was applied to 2003 data. However, the current application of the 1998 dataset is no longer appropriate for three main reasons: (i) over the 1998-2007 period the regulatory data have changed radically and 1998 weights are no longer representative of current policy environments; (ii) 1998 weights may not reflect the relative importance of particular low level indicators since PCA was originally conducted on a subset of 21 OECD countries; (iii) the 2007 round of PMR update involves changes in country coverage and indicator structure that would make it impossible to assure "wage neutrality" across the various editions of PMR, unless back casting all PMR editions at each new update.

For these reasons the PMR composite indicator for 2007 is based on a weighting structure that weights equally each domain, sub-domains and indicators (**Figure 1**). This weighting structure has a number of theoretical advantages: it does not depend on the number of countries in the dataset nor on the figures themselves (allowing the comparability across years). The drawback with respect to the previous version of the PMR indicator based on weights derived from principal component analysis (PCA, as in Nicoletti *et als.*, 1999) is the correction for double counting. Equal weighting (EW) does not correct for double counting when indicators belonging to the same domain are highly correlated as PCA does. In order to see whether double counting indeed influences the country ranking of the PMR composite indicator, we compare the ranking obtained using EW with that obtained using PCA for different years and different sets of indicators and countries.

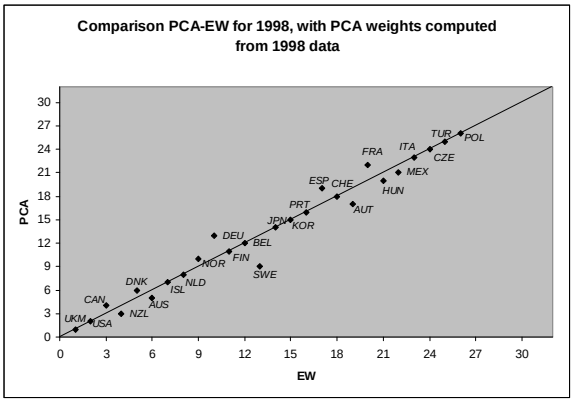
Figures 3 and **4** compare EW and PCA keeping fixed the number of indicators (18) and the number of countries (27), but varying the dataset object of the PCA. In **Figure 3** PCA has been performed using the 1998 dataset and the weights obtained have been applied to the 1998, 2003 and 2007 datasets.

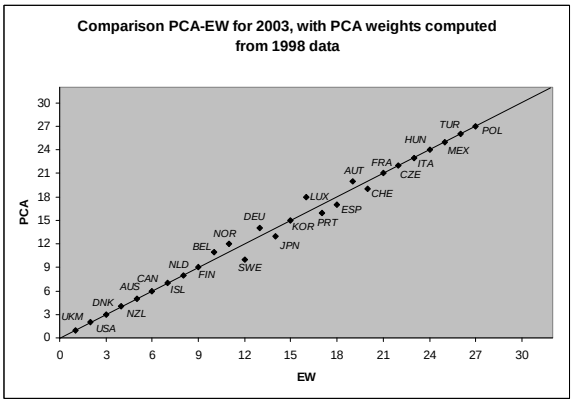
Overall the difference between the two weighting schemes appear to be rather small: on average less than 1 position for 1998 and 2003 and 1.3 positions for 2007.

In 1998, 13 out of 27 countries change their position in the ranking when PCA is applied instead of EW. The average change in ranking is of 0.8 positions with Sweden gaining 4 and Germany loosing 3 places. In 2003 the average shift in rank is a low 0.4 positions with no country shifting more than 2 positions in the ranking. In 2007 the change is slightly more pronounced (on average 1.2 positions) when PCA is used. Spain and Hungary shift down in the ranking by 4 and 3 positions respectively and Japan moves up by 3.

When PCA is conducted on the 2003 dataset or on the pooled 1998-2003 datasets and the resulting weights are applied to all the datasets available the absence of relevant changes is confirmed (**Figure 4** and **5**). In all years considered, no country shifts more than 3 positions moving from EW to 2003 PCA-derived weights, while the average change goes from 0.6 of 2003 to the 1.1 of 2007. When PCA weights are retrieved from the pooled dataset 1998-2003, the average shift in ranking by moving from EW to PCA-based weighting is 0.8 in 1998, and 0.4 and 1.3 in 2003 and 2007 respectively, with no countries shifting more than 1 position in 2003 and 1 country shifting 4 positions both in 2003 and 2007 (namely Sweden and Spain respectively).

Figure 3. **Impact of weighting on PMR ranking**. Comparison between equal weighting (EW) and principal component analysis (PCA) on 1998 dataset.





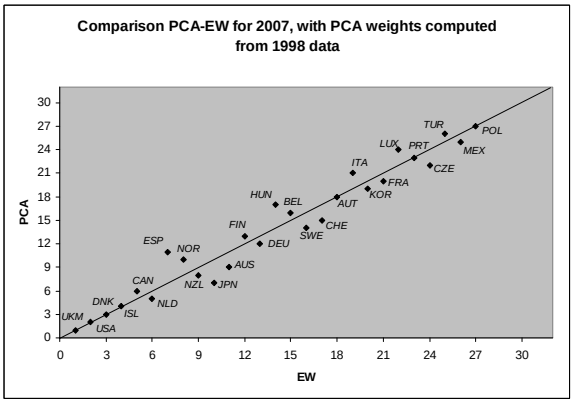


Figure 4. **Impact of weighting on PMR ranking**. Comparison between equal weighting (EW) and principal component analysis (PCA) on 2003 dataset.

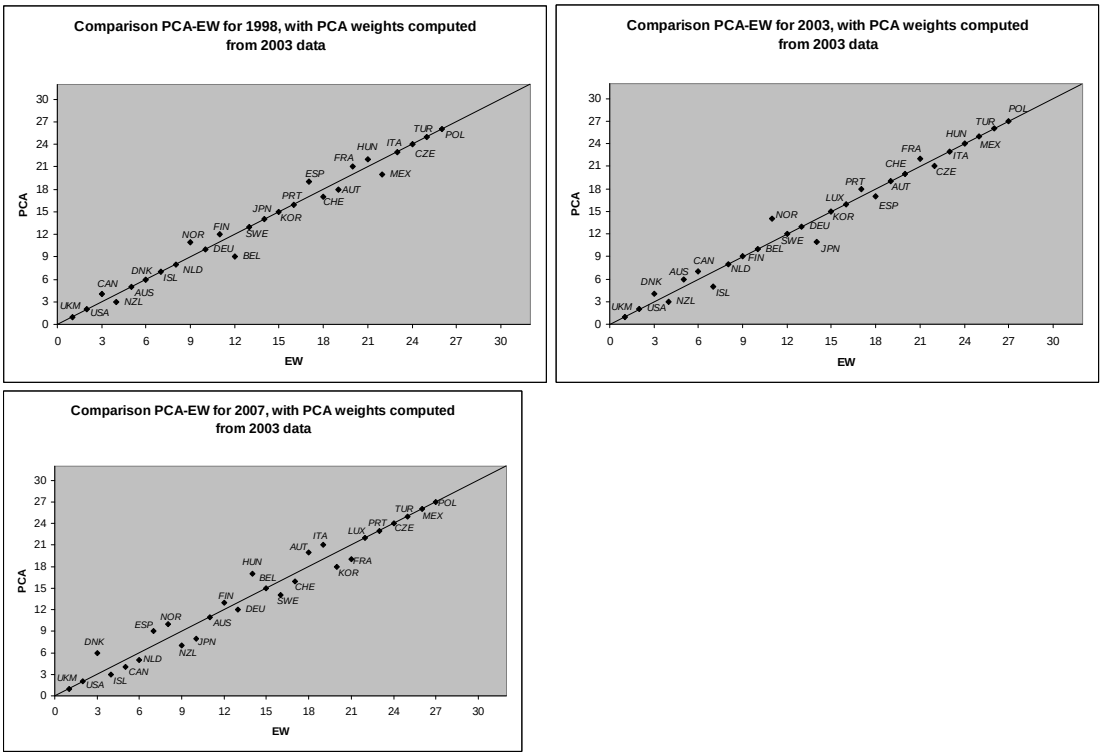
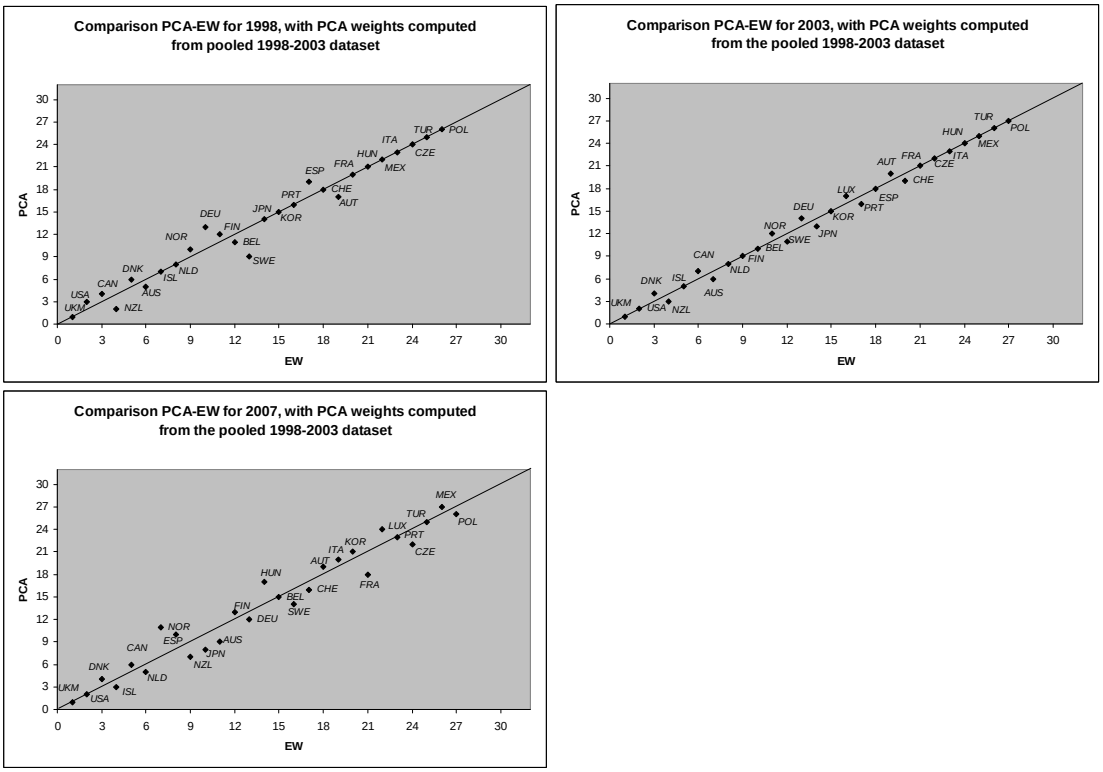


Figure 5. Impact of weighting on PMR ranking. Comparison between equal weighting (EW) and principal component analysis (PCA) on the pooled 1998-2003 dataset**.**

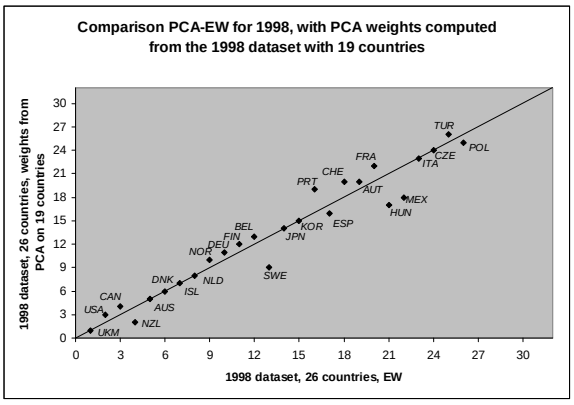


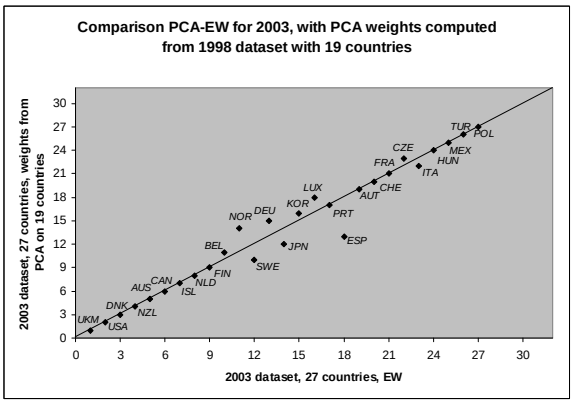
As mentioned above weights derived from PCA depend upon the number of countries in the dataset, while EW does not; this is one of the major theoretical shortcomings of PCA weighting schemes. Therefore in order to check the extent of this dependency we retrieve PCA weights from a dataset with a reduced number of countries but we apply the resulting weights to all dataset and we compare the ranking obtained with the baseline. In particular, PCA is calculated using a dataset with 19 countries,

as in the 1998 edition (thus all available OECD countries excluding CZE, HUN, POL, SVK, MEX, TUR, ISL, KOR, and LUX). The resulting weights are applied to all the available dataset of 27 countries (**Figure 6**) and compared with those calculated using EW. The average change goes from 1.2 positions in 1998 to 1 position in 2007, with 3 countries shifting by 4 positions in 1998 (MEX, SWE and HUN) and just one country, ESP, moving by 5 positions in 2003.

Any weighting method is sensitive to adding or subtracting indicators, especially weights derived from PCA which should correct for double counting. This is why we compare each weighting method using both a set of 15 indicators (as in the 1998 edition of PMR) and a set of 18 indicators (as in the current edition) in order to quantify the impact on country rankings of changing the indicator set. **Figures 7**, and **8** depict the comparison for the years 1998 and 2003. For both years the impact of changing the indicator set is slightly higher when the weighting method is PCA. If the average change in ranking is similar for both weighting methods (about 1 position in 1998 and 1.5 in 2003), PCA produces more outliers than EW, i.e. with PCA there are less countries varying its ranking but those countries display a larger shift.

Figure 6. Impact of weighting on PMR ranking. Comparison between equal weighting (EW) and principal component analysis (PCA) on 1998 dataset with 19 countries.





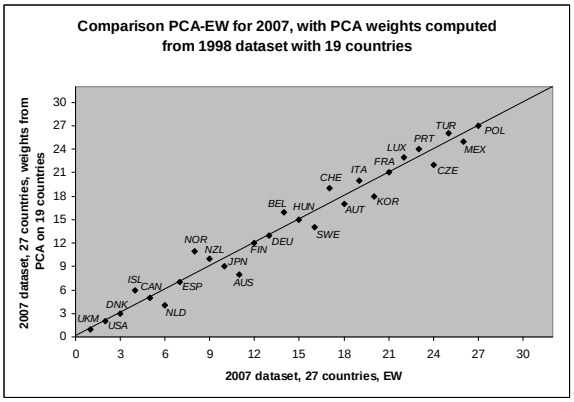
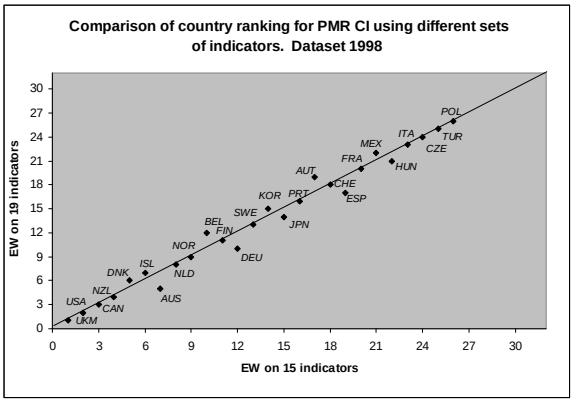


Figure 7. **Impact of weighting on PMR ranking**. Comparison between equal weighting (EW) and principal component analysis (PCA) for 1998 using different sets of indicators**.**



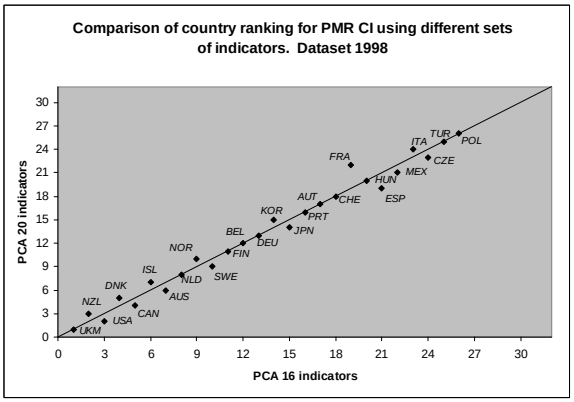


Figure 8. **Impact of weighting on PMR ranking**. Comparison between equal weighting (EW) and principal component analysis (PCA) for 2003 using different sets of indicators**.**

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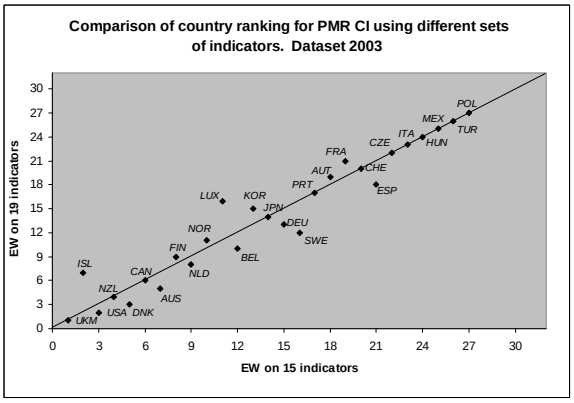
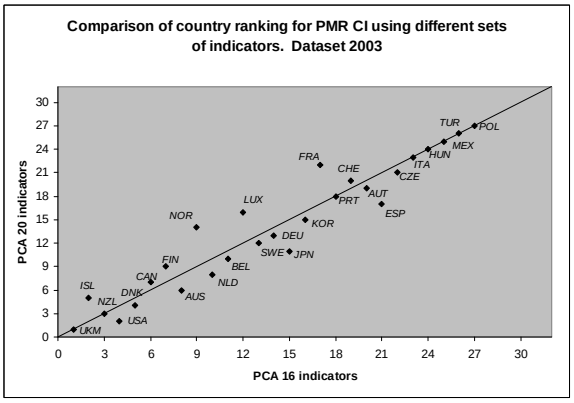




Findings on the robustness of the PMR composite indicator with respect to the weighting structure

Overall, within the available datasets, there is no significant difference in country rankings between using equal weighting or PCA-retrieved weights, pointing to a negligible effect of double counting which is diluted by the structure of the PMR composite indicator. Yet the theoretical dependency of PCA weighting scheme on the number of countries and the year of calculation make EW a preferable solution for the calculation of the PMR indicator

3. The issue of compensability: non compensatory Multi-Criteria Analysis

An appropriate aggregation technique should also ensure that overall country rankings are not distorted by averaging out scores on regulatory areas that are not necessarily close substitutes. For example, while a country could offset the negative impact on competition of relatively numerous licensing requirements for business start-ups by having relatively light and transparent administrative procedures, it is not clear that high barriers to entry in potentially competitive markets can be compensated by a relatively low level of state control in the business sector. Yet, a purely linear aggregation approach would provide the same overall score to two countries that have opposite scores on these latter two dimensions of regulation (barriers to entry and state control). Therefore, while linear aggregation and compensation may be acceptable within each regulatory domain, they can lead to misleading results when aggregating domains into an overall country score. There is another (and related) reason to use a non compensatory approach. Munda and Nardo, 2003, noticed how weights, customarily conceived as 'importance' measures, are instead, in linear aggregations, substitution rates. As a result only non compensatory aggregations can maintain the role of weights as "importance measures".

The non compensatory multi-criteria procedure (MCA, Munda, 2008) tries to resolve the conflict arising in countries comparisons as some indicators are in favor of one country while other indicators are in favor of another. The approach employs a mathematical formulation (Condorcet-type of ranking procedure) to rank in a complete pre-order (i.e. without any incomparability relation) all the countries from the best to the worst after a pair-wise comparison of countries across the whole set of the available indicators. This method is therefore totally different from the standard linear aggregation of weighted indicators as in the baseline PMR CI and in all the analysis performed so far (and also afterwards).

We offer here a 'hand waiving' description of the algorithm' and then an example. Imagine to have three countries, A, B and C and aiming at ranking their overall performance according to N indicators. We build to this effect an 'outranking matrix' whose entries e_{ij} tells us how much country 'i' does better than country 'j'. e_{ij} is in fact the sum of all weights of all indicators for which country 'i' does better than country 'j'. e_{ji} will likewise be the sum of all weights for which the reverse is true. If the two countries do equally well on one variable, its weight is split between e_{ij} and e_{ji}. As a result $e_{ij} + e_{ji} = 1$ if weights have been scaled to unity. We now write down all permutations of county order (ABC,ACB,BAC,BCA,CAB,CBA) and compute for each of them the ordered sum of the scores, e.g. for ABC we compute $Y=e_{AB}+e_{AC}+e_{BC}$.

We do this for all permutations and take as the multi-criteria country ranking the one with the highest total score Y. Note that this ordering is only based on the weights, and on the sign of the difference between countries values for a given indicator, the magnitude of the difference being ignored (this method can also be applied to ordinal data). With this approach no compensation occurs, to exemplify, a country that does marginally better on many indicators comes out better than a country that does a lot better on a few ones because it cannot compensate deficiencies in some dimensions with outstanding performances in others. In other words to attain a reasonably good position in the ranking a country must devote a reasonably high attention to all policy indicators under a non compensatory approach. Note that the MCA method provides results in terms of country rankings, and not of a score, so it is particularly suited for categorical variables.

The results of the MCA and the comparison with the baseline PMR indicator are shown in **Table 2**. We applied the MCA algorithm to the 3 domains of the PMR composite indicator weighting them equally. We therefore allow compensation at an indicator and sub-domain level but not at the domain level. That's why we talk about a partially non compensatory method or ranking.

Table 2. **Compensatory versus partially non compensatory ranking**. Comparison between the baseline, fully compensatory, PMR CI and the partially non compensatory PMR ranking (MCA).

	1998			2003			2007		
	Baseline	MCA	B-MCA	Baseline	MCA	B-MCA	Baseline	MCA	B-MCA
AUS	5	5	*0*	4	6	*-2*	11	10	*1*
AUT	14	12	*2*	18	16	*2*	18	21	***-3***
BEL	13	14	*-1*	14	11	***3***	19	18	*1*
CAN	3	3	*0*	5	5	*0*	3	5	*-2*
CZE	24	23	*1*	23	22	*1*	24	24	*0*
DNK	6	7	*-1*	7	7	*0*	6	6	*0*
FIN	12	17	***-5***	8	9	*-1*	10	14	***-4***
FRA	20	22	*-2*	20	20	*0*	20	19	*1*
DEU	11	15	***-4***	16	19	***-3***	16	20	***-4***
HUN	17	16	*1*	24	25	*-1*	17	13	***4***
ISL	8	8	*0*	6	3	***3***	4	1	***3***
ITA	23	24	*-1*	22	18	***4***	15	16	*-1*
JPN	15	9	***6***	15	8	***7***	8	11	***-3***
KOR	18	18	*0*	12	15	***-3***	21	17	***4***
LUX	-	-	-	13	14	*-1*	23	22	*1*
MEX	19	19	*0*	25	24	*1*	25	25	*0*
NLD	7	6	*1*	9	10	*-1*	5	4	*1*
NZL	4	4	*0*	3	4	*-1*	12	8	***4***
NOR	9	10	*-1*	10	13	***-3***	9	9	*0*
POL	26	25	*1*	27	26	*1*	27	26	*1*
PRT	16	11	***5***	17	17	*0*	22	23	*-1*
ESP	21	20	*1*	19	23	***-4***	7	7	*0*
SWE	10	13	***-3***	11	12	*-1*	14	12	*2*
CHE	22	21	*1*	21	21	*0*	13	15	*-2*
TUR	25	26	*-1*	26	27	*-1*	26	27	*-1*
UKM	1	1	*0*	1	2	*-1*	2	3	*-1*
USA	2	2	*0*	2	1	*1*	1	2	*-1*

The average difference between the two aggregation methods is about 1.7 positions for all the years considered (with a similar standard deviation of 1.4-1.7). There are however a number of outliers each year. Japan is the most volatile country in 1998 and 2003: it performs much better under the MCA than under the fully compensatory scenario. In the baseline, Japan, ranks 16th and 27th in the sub-domains *state control* and *barriers to entrepreneurship*, but ranks 3rd in *barriers to trade and investment*. The outstanding performance in the third domain is more than compensated by the reduced performance in the others, producing a medium ranking position.

Notice that the first two domains count more on the composite than the third one (see below, section 7). This is also why in 2007 Japan by scoring 5th in the first domain but 16th and 15th in the other two gets the 8th position in the baseline PMR ranking while only the 11th under MCA. The non compensatory multicriteria, is not influenced by the range of variation of the indictors since it is not based on scores. Good (bad) performance in "heavy" indicators is thus the main reason of the discrepancy between the two rankings for Finland and Germany in 1998 and 2007, Portugal in 1998, and Italy and Spain in 2003.

Findings on the issue of compensability

Overall, if compensation between domains is not allowed, the country ranking is moderately affected. The most volatile countries are those who perform better (worse) in

indicators belonging to the domains *state control* and *barriers to entrepreneurship*. With non compensability the unbalanced contribution of each domain to the composite is overcome, given the independency of the final ranking from the scores.

4. Robustness of the PMR composite indicator with respect to the weighting structure

The robustness of the PMR ranking can be tested by eliminating one indicator, sub-domain or domain at a time. In doing so it will be possible to draw attention to the indicator (sub-domain or domain) whose exclusion mostly affects the PMR ranking; and also to the country mostly affected by this drop out. **Table 3** displays the average change in rank between the baseline and the PMR CI that would be calculated eliminating, one at a time, each indicator, sub-domain and domain (with weights properly scaled). This can be seen as a proxy of the average impact of an indicator in the composite.

The PMR CI for 1998 seems to be mainly receptive to indicator TI4, the sub-domain *other barriers* and the domain *state control*. In 2003 the largest effect in the ranking is produced by indicator BE2, the sub-domains *public ownership* and *administrative burdens on startups*, and the domain *state control*. This domain, the sub-domain *public ownership* and the indicators SC5 are mostly affecting the 2007 ranking. The indicators recently introduced (SC3, BE8 and BE9) do not seem to have a large impact on the PMR results for all years considered (in 1998, BE9 shows the lowest impact). **Table 4** shows the average effect in each country rank of eliminating one at a time indicators, sub-domains and domains, while **Table 5, 6 and 7** display for each year, the absolute value of the shift.

Table 3. Average shift from the baseline rank when eliminating one indicator (sub-domain or domain) at a time. Data ordered by indicator, sub-domain and domain.

	Average shift in rank		
	1998	**2003**	**2007**
SC1	0.46	0.59	0.44
SC2	0.69	0.74	1.48
SC3	0.77	1.19	0.74
SC4	1.31	1.48	1.48
SC5	1.08	1.41	**2.22**
BE1	1.23	1.78	1.85
BE2	1.31	**1.85**	1.70
BE3	0.46	0.44	0.74
BE4	0.23	0.44	0.44
BE5	0.23	0.59	**0.15**
BE6	0.23	0.44	0.52
BE7	0.15	0.37	0.67
BE8	0.46	0.74	0.74
BE9	0.15	0.59	0.52
TI1	0.62	**0.37**	0.52
TI2	0.54	0.74	0.81
TI3	0.77	0.52	1.04
TI4	**1.85**	1.19	1.48
PUO	1.85	**2.52**	**2.74**

IBO	1.69	2.30	1.93
RAO	1.85	2.15	2.07
ABS	1.54	2.52	1.93
BAC	1.00	2.00	1.63
BTI	1.23	1.78	1.48
OBA	2.23	2.00	1.63
SC	2.38	3.19	4.15
BE	1.77	2.15	1.70
BT	2.00	1.48	1.56

Table 4. Average shift from the baseline rank when eliminating one indicator (sub-domain or domain) at a time. Data ordered by country.

	1998			2003			2007		
	indicators	sub-dom.	domains	indicators	sub-dom.	domains	indicators	sub-dom.	domains
AUS	0.50	1.14	1.67	1.39	3.57	1.67	0.83	1.86	1.67
AUT	1.39	3.29	3.33	0.61	1.86	1.67	1.28	2.29	2.00
BEL	0.67	3.86	1.33	1.83	5.57	2.00	1.39	6.29	5.33
CAN	0.67	0.86	0.67	1.28	2.29	1.00	0.89	0.86	1.33
CZE	0.00	0.57	1.67	0.72	1.43	1.33	0.28	1.00	1.33
DNK	0.72	1.00	1.00	1.28	2.00	4.33	0.72	1.14	2.67
FIN	0.67	1.57	1.67	0.06	2.57	1.00	0.83	0.57	1.00
FRA	1.17	1.71	2.00	0.89	3.00	1.33	1.00	1.14	2.67
DEU	0.56	0.71	1.67	1.28	2.71	3.67	1.67	2.29	3.00
HUN	1.06	3.00	3.33	0.33	0.57	0.33	1.50	3.29	2.33
ISL	0.61	1.86	2.33	0.83	1.43	5.67	1.11	1.14	6.67
ITA	0.94	1.00	3.00	1.00	1.14	3.00	1.89	2.00	4.00
JPN	1.22	4.29	5.00	1.28	6.00	4.67	1.39	1.86	3.67
KOR	1.22	2.00	4.67	1.22	0.86	2.33	2.11	3.57	5.00
LUX	-	-	-	1.44	2.29	1.33	0.56	1.57	2.67
MEX	0.89	1.71	3.00	0.56	1.57	3.00	0.00	0.14	0.67
NLD	0.56	1.29	1.00	0.28	1.29	2.00	0.89	1.57	1.67
NZL	0.22	0.43	2.33	0.39	1.57	2.00	1.28	2.00	4.67
NOR	0.17	1.29	1.33	0.94	4.14	2.33	0.72	3.43	1.00
POL	0.06	0.14	0.33	0.11	0.14	0.33	0.39	0.14	0.67
PRT	0.83	1.14	4.33	1.44	1.43	3.67	0.89	1.29	2.33
ESP	1.06	2.29	1.33	1.28	3.71	2.00	0.83	1.29	1.67
SWE	0.61	3.71	1.33	0.94	5.00	5.67	1.17	6.29	4.67
CHE	1.72	2.14	2.33	1.61	1.71	2.00	1.39	2.43	1.67
TUR	0.06	0.57	1.00	0.11	0.14	0.67	0.39	0.29	0.67
UKM	0.00	0.00	0.00	0.00	0.29	0.67	0.56	0.71	0.67
USA	0.56	0.71	1.67	0.11	0.57	1.67	0.39	1.29	1.00

In 1998 the most sensitive countries to the drop-out of one indicator at a time are Austria (especially when BE1 and BE2 are eliminated), France (SC5), Hungary (BE1), Japan (TI2), Korea (SC4 and TI4), Spain (TI4) and Switzerland (BE1 and TI4). Much less sensitive is the Czech Republic with no change in rank. A drop in rank of 8 (7) positions is experimented by Belgium (Japan) when eliminating the sub-domain *public ownership*, while 7 positions are the shift of Japan and Korea when the domain *barriers to trade and investment* is eliminated.

Table 5. Shift from the baseline rank for 1998 when eliminating one indicator (sub-domain or domain) at a time.

1998	AUS	AUT	BEL	CAN	CZE	DNK	FIN	FRA	DEU	HUN	ISL	ITA	JPN	KOR	MEX	NLD	NZL	NOR	POL	PRT	ESP	SWE	CHE	TUR	UKM	USA
SC1	-1	1	-1	0	0	1	0	-1	1	0	1	0	-1	0	0	-1	0	0	0	1	1	-1	0	0	0	0
SC2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SC3	-1	2	0	1	0	2	0	2	1	0	1	-3	-3	0	0	-2	-2	1	0	1	1	-2	0	0	0	1
SC4	0	2	-2	-1	0	0	-1	-2	3	1	0	0	0	-1	1	0	0	0	0	-1	2	-1	-1	0	0	1
SC5	-1	-1	0	-1	0	4	4	2	1	1	0	-2	1	-5	1	-2	0	-1	0	0	2	-1	-3	0	0	1
BE1	1	2	-1	2	0	-2	-1	-5	2	1	-1	-1	-2	3	1	0	0	0	0	2	-1	-1	1	0	0	0
BE2	1	5	-3	1	0	0	2	-1	2	4	1	0	-3	-3	0	-2	-1	1	0	1	2	-2	-5	0	0	0
BE3	-1	-3	2	-1	0	1	-1	1	2	-2	0	-5	1	1	2	0	0	0	0	-1	0	2	1	0	0	1
BE4	-1	1	-1	-1	0	1	0	0	1	1	1	-1	0	-1	0	-1	0	0	0	0	3	-1	-2	0	0	1
BE5	-1	2	-1	0	0	1	0	0	1	0	1	0	-2	0	0	-1	0	0	0	1	2	-1	-2	0	0	0
BE6	0	1	-1	-1	0	0	0	-1	1	0	1	-1	-1	0	0	-1	0	0	0	1	1	-1	1	0	0	1
BE7	-1	1	-1	-1	0	1	0	0	1	0	1	0	-1	0	0	-1	0	0	0	1	2	-1	-2	0	0	1
BE8	-1	2	-1	0	0	1	0	-1	1	0	1	0	0	0	0	-1	0	0	0	-1	1	-1	0	0	0	0
BE9	-1	1	-2	-1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	2	-1	-2	0	0	1
TI1	-1	1	-1	0	0	1	0	-1	1	1	1	-1	-1	-1	0	-1	0	0	0	1	1	-1	1	0	0	0
TI2	-1	-1	0	0	0	1	-1	-2	3	0	0	-2	-1	0	4	0	0	0	0	1	0	-1	0	0	0	0
TI3	-1	2	-1	0	0	1	0	0	0	-3	1	0	3	0	-2	-1	0	0	0	1	0	0	0	0	0	0
TI4	0	3	0	-1	0	0	0	0	1	1	1	0	-3	-1	1	-1	-1	0	0	0	2	-1	-3	0	0	2
PUO	0	5	-1	0	0	2	-1	-1	0	4	-2	-1	0	-6	4	0	0	0	-1	4	-3	3	-7	1	0	0
IBO	0	-1	7	1	0	2	-1	-3	3	-3	3	-4	6	-2	-2	-3	-1	0	0	0	3	-3	-2	0	0	0
RAO	0	2	-6	-1	1	0	2	1	1	2	0	0	-6	-1	1	1	0	3	0	-2	-2	5	-1	-1	0	1
ABS	1	6	-5	1	1	0	2	0	1	5	-1	0	-6	-3	-1	0	-1	4	0	1	0	1	-5	-1	0	0
BAC	0	5	-2	-1	0	2	1	1	-1	3	-2	-2	-5	-1	-3	0	0	1	0	0	-1	3	1	0	0	1
BTI	0	2	-3	0	1	0	1	0	2	2	0	0	-6	-1	-1	0	0	0	0	1	0	3	0	-1	0	0
OBA	0	6	-4	-1	0	0	2	1	1	-2	0	0	-3	0	-3	0	-1	0	0	2	0	1	-1	0	0	2
SC	0	6	-5	-1	-1	2	2	1	1	4	-2	1	-3	-6	1	0	0	1	-1	3	-5	5	-5	1	0	1
BE	-3	-3	-2	-1	1	-1	4	-2	3	-2	4	-5	1	4	4	-2	4	-2	0	-6	0	3	-1	-1	0	3
BT	2	3	0	1	1	2	1	-3	2	5	-2	-3	-7	-3	-2	-2	-1	2	0	4	3	-1	-1	-1	0	0

Table 6. Shift from the baseline rank for 2003 when eliminating one indicator (sub-domain or domain) at a time.

2003	AUS	AUT	BEL	CAN	CZE	DNK	FIN	FRA	DEU	HUN	ISL	ITA	JPN	KOR	LUX	MEX	NLD	NZL	NOR	POL	PRT	ESP	SWE	CHE	TUR	UKM	USA
SC1	-3	0	-2	2	0	2	0	0	2	0	0	1	0	-1	1	0	0	-1	0	0	0	0	0	-1	0	0	0
SC2	0	0	-1	0	0	1	0	-1	2	0	-1	2	3	2	-3	0	0	0	-3	0	0	0	0	-1	0	0	0
SC3	-3	1	3	-1	2	2	0	1	-2	0	3	-1	-1	-1	1	0	0	-1	0	0	2	-3	-3	1	0	0	0
SC4	-2	-1	-6	2	2	0	0	-2	1	0	1	4	1	3	1	0	-1	-1	-1	0	1	-4	-2	4	0	0	0
SC5	-1	0	4	-2	2	3	0	4	-3	0	0	0	0	-5	-1	0	0	0	-2	0	-3	6	0	-2	0	0	0
BE1	-2	-2	4	-3	5	3	-1	1	2	0	1	-1	-2	-1	-2	0	2	1	-1	0	-4	-3	-1	5	0	0	-1
BE2	0	4	-4	3	-1	0	0	-1	-4	2	0	3	-1	-1	-2	2	-1	-2	-1	1	8	2	-1	-4	-1	0	-1
BE3	0	0	0	-1	0	2	0	-1	1	0	-1	0	-1	1	0	0	0	0	0	0	0	-1	-1	2	0	0	0
BE4	-1	-1	-1	1	0	0	0	0	-1	0	0	0	1	-1	1	0	0	0	-1	0	1	1	1	0	0	0	0
BE5	-2	0	0	1	0	0	0	0	0	-1	1	1	2	0	-4	1	0	0	0	0	2	0	0	-1	0	0	0
BE6	0	0	1	-1	0	0	0	-1	-1	0	1	0	1	0	-2	0	0	0	-1	0	1	0	1	1	0	0	0
BE7	1	0	0	-1	0	2	0	0	0	-1	-1	0	0	0	0	1	0	-1	-1	0	0	0	1	0	0	0	0
BE8	-2	0	-1	0	0	0	0	-1	-1	-1	2	0	2	2	-1	1	0	0	-2	0	1	-1	0	2	0	0	0
BE9	-3	1	0	1	1	2	0	0	0	0	0	1	0	0	2	0	0	0	0	0	-1	0	-2	-2	0	0	0
TI1	0	0	-1	-1	0	0	0	-1	-1	0	1	2	1	0	0	0	0	0	0	0	1	0	0	-1	0	0	0
TI2	0	0	2	0	0	1	0	-1	0	-1	-1	-2	0	2	-1	5	0	0	-3	0	0	0	0	-1	0	0	0
TI3	-3	0	-1	1	0	2	0	-1	0	0	0	0	3	-1	-1	0	0	0	0	0	0	0	0	1	0	0	0
TI4	-2	-1	2	-2	0	3	0	0	2	0	1	0	4	-1	-3	0	-1	0	1	1	-1	2	-4	0	-1	0	0
PUO	3	3	-7	-6	4	0	3	4	-1	-1	2	2	-7	-1	1	2	1	1	0	0	3	-5	2	3	0	-2	-4
IBO	-5	-1	8	2	0	3	-3	-2	2	0	-2	2	8	0	-2	0	-1	-2	-6	0	-1	6	-6	0	0	0	0
RAO	-4	-3	5	-1	3	2	-3	-2	4	-1	2	-1	5	-1	-2	1	2	0	-4	0	-1	0	-6	5	0	0	0
ABS	-4	2	5	2	1	1	-4	-4	2	-1	2	2	8	1	-2	2	-1	-2	-7	0	-2	6	-7	0	0	0	0
BAC	-3	-1	5	2	-1	2	-2	-1	3	-1	2	0	7	0	-2	2	-2	-3	-4	0	-1	3	-6	1	0	0	0
BTI	-3	-2	4	2	0	2	-1	-5	3	0	0	0	3	1	-3	4	1	-1	-5	0	-1	2	-3	2	0	0	0
OBA	-3	-1	5	1	1	4	-2	-3	4	0	0	1	4	-2	-4	0	1	-2	-3	1	-1	4	-5	1	-1	0	0
SC	1	3	2	1	0	-6	2	1	-5	0	-12	6	5	-5	2	-1	-5	-4	2	0	8	-1	9	-1	1	0	-3
BE	-2	2	2	-2	2	2	-1	0	3	-1	4	-2	4	2	-1	2	1	-1	-5	0	-1	-3	-8	4	0	-2	1
BT	-2	0	-2	0	-2	5	0	-3	3	0	-1	1	-5	0	-1	6	0	-1	0	1	2	2	0	-1	-1	0	-1

In 2003 the number of volatile countries increases with respect to 1998, with Belgium highly sensitive to the drop out of many indicators in the sub-domains *involvement in business operation* and *regulatory and administrative opacity* (**Table 6**). Eight positions are gained by Portugal by dropping BE2 and 6 are gained by Spain by eliminating SC5. Belgium, Japan, Norway, Spain and Sweden are highly sensitive to the drop out of almost any sub-domain while the highest change when purging domains is experimented by Iceland that looses 12 positions.

In 2007 the effect of eliminating variables is even bigger than in the previous years (Table 7). Ten positions in the PMR rank are gained by Belgium when eliminating SC5 and 8 are obtained by Korea when purging TI4. New Zealand improves by 8 positions its rank by eliminating BE1 but looses 8 places when dropping out BE2. Mexico, Turkey, UK and US seems to be rather stable. Belgium and Sweden are the most volatile when dropping sub-domains, while 15 places are lost by Iceland when eliminating the domain state control from the dataset. The volatility is not necessarily a symptom of weakness of the ranking. In this case individual indicators have become more homogenous across countries in the decade 1998-2007: the standard deviation of each low level indicator, as a proxy of similarity between countries, has decreased over the sample period mainly for the domains state control (especially for SC3 and SC5) and barriers to trade and investment (particularly for TI4 and to a lower extent TI3). When scores become similar, slight modification of one score is likely to have a large impact in the ranking, determining in increase in volatility for that country.

Table 7. Shift from the baseline rank for 2007 when eliminating one indicator (sub-domain or domain) at a time.

2007	AUS	AUT	BEL	CAN	CZE	DNK	FIN	FRA	DEU	HUN	ISL	ITA	JPN	KOR	LUX	MEX	NLD	NZL	NOR	POL	PRT	ESP	SWE	CHE	TUR	UKM	USA
SC1	0	0	0	0	0	0	0	0	0	0	0	1	-1	-1	0	0	-2	-1	1	0	1	2	-1	1	0	0	0
SC2	2	2	0	-1	0	-1	-3	-1	2	0	-2	-5	3	3	0	0	2	0	-2	1	0	-1	4	-2	-1	1	-1
SC3	-2	2	2	-1	0	0	2	0	-3	-1	2	0	-2	0	0	0	0	0	0	0	0	0	0	2	0	-1	0
SC4	1	0	-4	1	0	-1	-2	-2	1	-2	1	-1	3	4	3	0	-1	-2	1	1	1	-2	3	0	-1	-2	0
SC5	-1	-1	10	-3	2	2	2	4	-4	3	-3	-3	-5	-3	0	0	2	1	-1	0	1	2	-3	-2	0	1	-1
BE1	-1	-1	3	-3	1	1	-1	3	3	-3	2	-3	1	-1	2	0	-3	8	0	0	-2	-3	-1	-1	0	1	-2
BE2	0	3	0	1	0	-1	0	-1	-6	5	-2	2	0	4	0	0	1	-8	0	1	4	2	-2	-1	-1	-1	0
BE3	1	1	1	0	0	0	-1	-1	1	-3	-1	-1	1	2	0	0	1	0	0	1	0	-1	0	0	-1	1	-1
BE4	0	0	0	0	0	0	1	-1	-1	2	0	-1	0	-2	1	0	0	0	-1	0	2	0	0	0	0	0	0
BE5	0	0	0	0	0	0	0	0	1	0	0	-1	0	0	0	0	0	0	0	0	0	0	1	-1	0	0	0
BE6	0	-1	1	-1	0	0	0	-1	1	0	1	-1	0	1	0	0	0	-2	0	0	0	0	1	1	0	1	-1
BE7	3	3	0	0	0	2	-1	0	-2	0	-2	-1	-1	0	0	0	0	0	-1	0	0	0	1	-1	0	0	0
BE8	-2	1	-1	-1	0	-2	0	-1	0	-2	1	0	2	3	1	0	0	0	0	0	-1	0	0	2	0	0	0
BE9	0	1	-1	0	0	0	0	1	1	-1	0	2	0	-1	0	0	0	0	0	1	1	0	0	-3	-1	0	0
TI1	1	2	0	0	0	0	1	0	-1	-1	0	1	0	0	0	0	0	0	-2	1	0	0	1	-2	-1	0	0
TI2	0	-2	2	0	0	0	0	-1	0	2	-1	-4	-1	3	1	0	1	0	1	0	-1	0	0	0	0	1	-1
TI3	-1	0	0	-2	2	-1	-1	0	1	1	1	-2	4	-2	-1	0	-1	-1	0	1	1	-1	0	3	-1	0	0
TI4	0	3	0	-2	0	2	0	-1	2	-1	1	-5	-1	8	1	0	-2	0	3	0	-1	-1	-3	-3	0	0	0
PUO	1	4	-5	-4	3	-2	-2	2	-1	-5	-1	-1	-5	1	0	0	3	-3	6	1	3	-2	10	2	-1	1	-5
IBO	-2	-5	10	0	0	1	0	1	1	5	0	-2	1	3	3	0	-1	1	-5	0	0	-1	-7	-3	0	0	0
RAO	-3	-4	6	-1	1	1	0	0	4	1	3	-3	2	2	2	-1	-3	5	-2	0	-2	-2	-3	-2	1	0	-2
ABS	-3	0	8	-1	0	-1	0	-2	-3	8	1	-1	0	4	3	0	-1	-1	-3	0	-1	2	-7	-2	0	0	0
BAC	-1	-1	6	0	0	0	1	0	1	3	2	-3	3	4	1	0	-2	1	-1	0	-1	-1	-7	-3	0	-2	0
BTI	0	-2	5	0	3	-1	1	-2	3	0	0	0	2	2	-1	0	0	2	-7	0	-1	-1	-4	1	0	1	-1
OBA	-3	0	4	0	0	2	0	-1	3	1	-1	-4	0	9	1	0	-1	1	0	0	-1	0	-6	-4	0	1	-1
SC	4	-3	9	-3	1	-6	-3	6	-6	1	-15	4	-7	-3	3	-2	3	-6	1	1	5	3	9	4	1	1	-2
BE	-1	1	3	-1	1	0	0	-1	1	4	3	-5	3	-3	4	0	-2	3	-2	0	0	-1	-4	-1	0	-1	-1
BT	0	2	-4	0	2	2	0	-1	2	-2	-2	-3	1	9	-1	0	0	-5	0	1	2	-1	-1	0	-1	0	0

Findings on eliminating one variable at a time

For all years considered the indicators inducing more volatility in the country ranking are those belonging to the sub-domains *involvement in business operation* and *regulatory and administrative barriers*, while the most influent domain is *state control*. Overall Belgium and Sweden together with Japan, Norway, and Spain are the most volatile countries when eliminating one at a time each sub-domain.

5. Uncertainty analysis: a multi-modeling approach

In the previous sections we have considered, one at a time, a number of sources of volatility in the PMR CI ranking. However, more information on the robustness of this ranking could come by considering simultaneously the impact on the ranking of all methodological choices made so far. To do so we use a multi-modeling approach: we perform simulations (saturated sampling) based on the combination of three main assumptions on (a) the number of indicators, sub-domains and domains included; (b) the weights attached to each indicator, sub-domain, domains, and (c) the aggregation procedure.

The multi-modeling approach expands the analysis of the first section given that it allows to count for the joint effects in ranking of the different methodological hypothesis (in the first section we only analyze "direct" effects). This approach has already proven to be useful in the development and validation of several composite indicators (e.g., Composite Learning Index, Environmental Performance Index, Knowledge Economy Index, Alcohol Policy Index[2]) and was also included in the JRC/OECD (2008) Handbook on Composite Indicators.

Table 8 below briefly illustrates the scenarios and their motivations.

Table 8. Scenarios for the robustness analysis of the PMR composite indicator.

Assumption	***Alternatives***	***Comments***
Number of indicators	All 18 indicators included or one-at-the-time excluded	The chosen set of indicators and its division in sub-domains and domains is only one representation of the reality. It is therefore important to verify the relevance and the explicative capacity of the conceptual framework used. Eliminating one indicator (sub-domain or domain) at the time allows us to verify the impact of this indicator (sub-domain, domain) in the final ranking of the PMR indicator.
Number of sub-domains	All 7 sub-domains included or one-at-the-time excluded	
Number of domains	All 3 domains included or one-at-the-time excluded	
Normalization of the dataset	No normalization	The "baseline" PMR composite indicator is calculated from the original data expressed in a theoretical [0,6] scale with no manipulation. In the dataset, however, some variables have a much narrower range of variation. This makes that the maximum for some indicators is near the minimum of others (e.g TI4 and SC1 in 2007). This in turn implies that indicators with a broader range will have higher overall weight in the composite. To obviate we consider two alternatives. The fist is rescaling the dataset in order to have all sub-domains' maxima (minima) equal to 1
	z-scores (subtracting the mean and dividing by the standard deviation) on the sub-domains scores	
	Sub-domains scored to be between 0 and 1.	

[2] See http://composite-indicators.jrc.ec.europa.eu/

		(0), and the second is calculating the z-score of the original dataset.
Weighting method	Weights obtained by PCA on 1998 dataset but applied to all dataset available Weights obtained by PCA on 2003 dataset but applied to all dataset available PCA within domain and PCA across domains (as in Nicoletti et als. 1999) Equal weighting (EW) of the domains and the indicators disregarding the sub-domain layer. EW of domains, sub-domains and indicators (baseline)	Usually there is no theoretical justification in the choice of a set of weights with respect to another. If PCA has the advantage of correcting for "double counting", it is also sensitive to the new countries in the dataset and has to be calculated each year making the consecutive ranking not comparable. Furthermore, given the limited number of countries and indicators within sub-domains PCA has to be performed within domains. That's why we consider as an option the EW of the 3 domains and of the indicators within each domain disregarding the layer of sub-domains.
Aggregation rule	Additive (linear) Non compensatory on the domains	We compare two different aggregations: the fully compensatory (additive) and the partially non compensatory. This latter implies a linear aggregation of the information up to the domain level but a non compensatory aggregation of the three domains (see Section 3. for an explanation of the technique)

Combining all the possible choices of number of indicators/domains/sub-domains, normalization, and weighting, more than 400 scenarios have been produced for each year considered (1998, 2003 and 2007).[3] For each country we calculated the median rank of all scenarios generated and the frequency matrix of all rankings, that is, for each country the percentage of time that country obtained the first, second, third,… position in the ranking. **Tables 9**, **10**, and **11** summarize our findings. These findings only refer to the linear aggregation of all the information.

[3] The exact number is (18+7+3)*3*5*1=420 scenarios for the linear aggregation..

Table 9. Results of the robustness analysis for 1998. Percentage of times each country ranks 1st, 2nd, 3rd, ….. , 27th.

CI	median		Rank 1	Rank 2	Rank 3	Rank 4	Rank 5	Rank 6	Rank 7	Rank 8	Rank 9	Rank 10	Rank 11	Rank 12	Rank 13	Rank 14	Rank 15	Rank 16	Rank 17	Rank 18	Rank 19	Rank 20	Rank 21	Rank 22	Rank 23	Rank 24	Rank 25	Rank 26
1	1	UKM	**99**																									
2	2	USA		**60**	22	12																						
4	3	NZL		11	42	**23**																10	6					
3	4	CAN		12	**19**	40	8								10	5												
5	6	AUS					**25**	40	20	8																		
6	6	DNK				9	35	**22**	11	8	12																	
7	7	NLD					12	20	**46**	17																		
8	8	ISL					13	13	11	**44**																		
9	10	NOR									**40**	34	10															
10	10	SWE									17	**30**		9	6	7					15							
13	11	BEL			6	6					8	8	15	19	**12**	7												
11	11	DEU		7		6			5		6	15	**32**	19	7													
12	12	FIN											29	**16**	25	14	6											
15	14	JPN								10	7				13	18	**16**	9		6								
14	15	AUT												8	6	**20**	15	15	8	8	12							
16	16	PRT												12	8	8	16	**28**	12	7								
18	17	KOR												5	6	11	19	4	12	**13**	11	5	4	6				
17	19	HUN																	**23**	10		10	11	25				
20	20	FRA															6	1	14	10	12	**20**	14	15	7			
19	20	MEX																	8	11	**16**	18	11	6	14	7		
21	20	ESP																17	6	9	12	10	**16**	21				
22	21	CHE															5	7	9	6	4	14	25	**6**	22			
23	22	ITA																		18	6	6	6	15	**40**	7		
24	24	CZE																								**58**	33	
25	25	TUR																							6	27	**59**	8
26	26	POL																									8	**91**

Table 9 has the following reading: given all 420 scenarios generated from the dataset 1998, UKM ranks first 99% of the time, USA ranks between the 2nd and the 4th position 94% of the time, while NZL does it 76% of the time. The rows do not sum up to 1 because the tails of the distribution (5%) are not shown, considering them representative of extreme cases.

A robust ranking would see the rank of each country quite stable across scenarios. This means that different choices of normalization, aggregation or weighting do not affect so much the position of the country. Robustness, in this context, is therefore a synonym of neutrality with respect to the modeling choices. As a rule of thumb[4] we consider stable countries, those whose rank does not vary more that 7 positions (roughly one fourth of the 27 ranks available). Therefore volatile countries will be those switching in rank by more than 7 positions. In 1998 Austria, Korea, France, Mexico Spain and Switzerland can be defined as volatile countries.

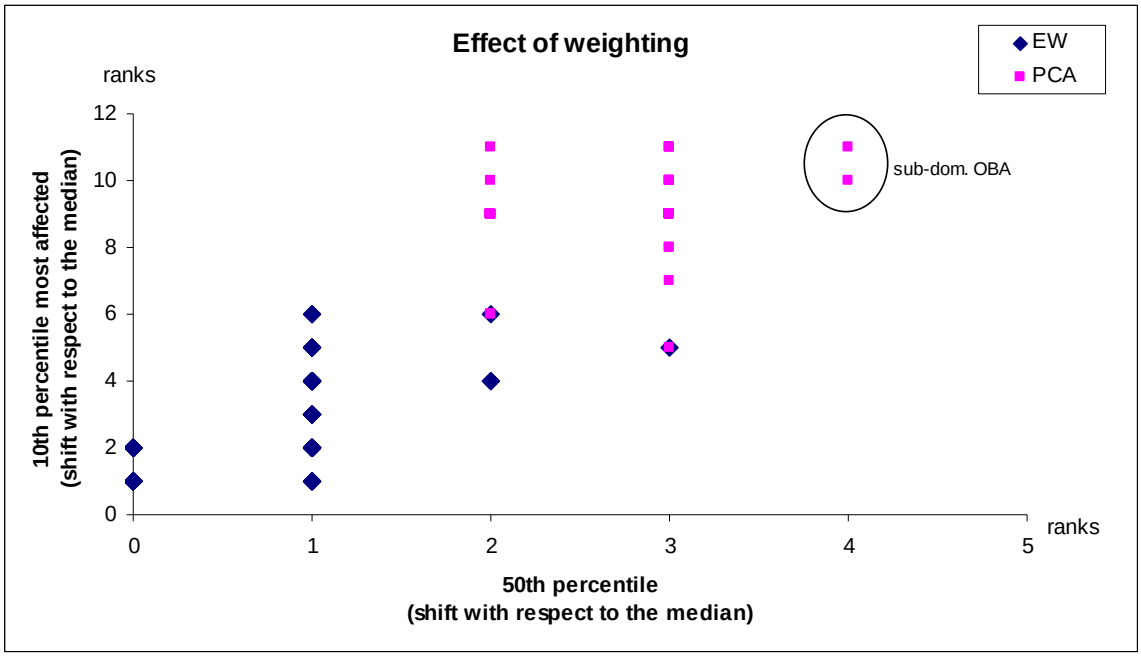
Overall, the PMR CI seems rather robust to the assumptions tested. The median of the 420 scenarios considered and the PMR CI rank never differ by more than 2 positions. Only 7 out of 27 countries display a volatile rank. Notice that for many countries (e.g. USA, Australia, Norway, Hungary and the Czech Republic) the baseline leads to the best possible ranking: any other methodological choice would have produced to a worst result. Moreover the baseline is never the "worst case scenario" backing the choice of equal weighting as baseline solution for the PMR indicator.

The principal reason for the volatility is the weighting method based on PCA, which combined with dropping one at-a-time indicators could push up the performance of Austria, Spain and Italy; on the contrary net losers would be Korea, France and Mexico. The same explanation holds for the sudden shift from an otherwise stable ranking for some countries like New Zealand, Canada, Belgium, Germany and Japan.

[4] There is no literature available.

Figure 9 disentangles the effect of weighting within the multimodelling approach and confirms the role of PCA in the volatility of the 1998 PMR ranking. In this figure we compare the median performance with the performance of the most variables countries by contrasting the absolute shift in rank of 50% of the countries with the same shift of the 10% most volatile countries. It is clear from **Figure 9** that, when taking into account all methodological choices made in the construction of the baseline, PCA weighting not only produces the higher median shift (sort of average behavior) from the baseline but also it produces the highest volatility. The higher average shift is produced when PCA is associated to the elimination of the sub-domain OBA.

Figure 9. Sensitivity of weighting choices.



Findings on the robustness of the PMR composite indicator for 1998

Overall, the PMR CI seems rather robust to the assumptions tested. The median of the 420 scenarios considered and the PMR CI rank never differ by more than 2 positions. Only 7 out of 27 countries display a volatile rank. The weighting method based on PCA seems to mainly drive the volatility of ranking and the existence of "anomalous" performances. This weighting method makes the ranking particularly sensitive to the modification of the number indicators pertaining to each sub-domain and domain.

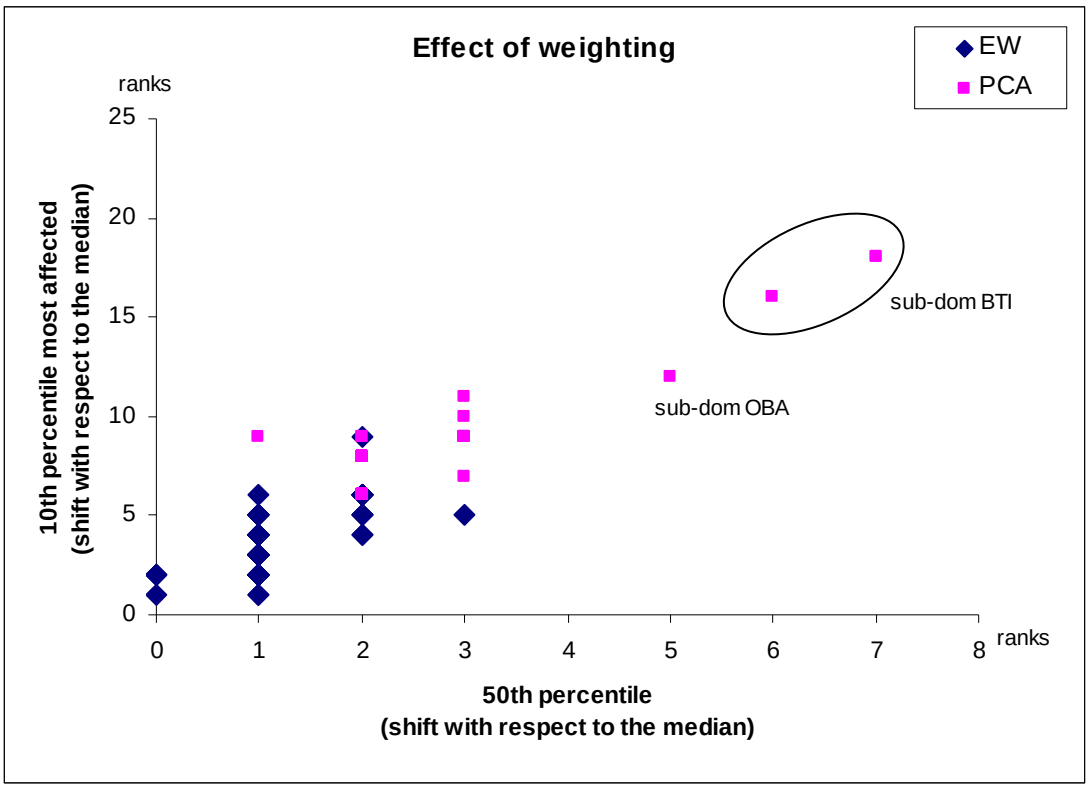
Table 10. Results of the robustness analysis for 2003. Percentage of times each country ranks 1st, 2nd, 3rd, ….. , 27th.

CI	median		Rank 1	Rank 2	Rank 3	Rank 4	Rank 5	Rank 6	Rank 7	Rank 8	Rank 9	Rank 10	Rank 11	Rank 12	Rank 13	Rank 14	Rank 15	Rank 16	Rank 17	Rank 18	Rank 19	Rank 20	Rank 21	Rank 22	Rank 23	Rank 24	Rank 25	Rank 26	Rank 27
1	1	UKM	80		7	10																							
3	3	USA		37	26	13		17																					
2	3	ISL	17	32	28	15																							
4	5	ESP		8	13	27	13	7	9	2	18																		
6	5	NLD			8	11	38	19	11																				
7	7	DNK				8	10	14	15	10	8								6		11								
5	8	CAN					11	10	15	13	10	8	4	6	11														
8	8	NZL					9	21	13	39	9																		
9	9	AUS							16	20	29	20																	
14	10	NOR		11			7				8	18	16	8	6	5													
12	12	FIN							11			9	18	22	20	7													
11	12	JPN										17	14	11	9	7	4	14	3	6									
15	13	SWE		6	6	5							6	9	9	19	10	7											
13	13	CHE											23	12	22	14	10	7											
10	15	BEL										13	8	6	6	8	12	14	20										
18	16	FRA												11	2	13	18	11	15	14	9								
20	18	HUN														13	4	16	13	7	9	14	10	8					
16	18	DEU														7	9	10	7	13	11	13	17						
17	18	ITA															20	6	11	18	13	9	9						
19	19	AUT																6	9	20	17	6	9	14	8				
23	20	LUX																			15	30	17	14	15				
21	21	PRT																		5	8	15	21	22	15				
22	23	CZE																					9	30	40	6			
24	24	KOR																							7	58	31		
25	25	MEX																							5	9	54	17	8
26	26	TUR																								18		70	6
27	27	POL																										12	86

2003 ranking of PMR CI is more sensitive to the methodological choices made with respect to the 1998 edition (**Table 10**). The difference between the median and the baseline rank is of 3 positions for Canada and the Czech Republic, 4 positions for Belgium and 5 for Norway. One third of the countries in the dataset can be considered as volatile countries and for Norway and Luxemburg the baseline constitutes the worst possible methodological choice. Notice that the assumptions embedded in the baseline guarantee to Canada and Belgium the best possible position: any other methodological assumption would not push these two countries up in the 2003 PMR ranking.

PCA jointly with the elimination (one-at-a-time) of the indicators belonging to the domains *state control* and *barriers to entrepreneurship* mainly determine the instability of Portugal and Australia. For Sweden, Austria and France volatility is principally due to the interaction of 2 factors: a weighing method based on PCA and the normalization of sub-domains scores. Normalization plays a crucial role also in the volatility of Norway and Germany when associated to the one-at-a-time drop out of indicators especially those of domains *state control* and *barriers to entrepreneurship*. Finally Spain is particularly sensitive to the elimination of the sub-domains *public ownership* and *regulatory and administrative opacity*. The joint effect of normalization, weighting based on PCA and elimination of indicators pertaining to the domains *barriers to entrepreneurship* and *barriers to trade and investment* explain the sudden change in rank for Denmark, Korea and Japan, while for Belgium the joint effect of normalization and PCA is the only cause of the shift. PCA weighting seems, as in 1998, the main driver of most of the ranking instability. This is clearly shown by **Figure 10**. As in 1998 this weighting method account for both the higher median shift and the higher volatility. PCA combined with the elimination of the sub-domains OBA and BTI produce the highest shift in rank.

Figure 10. Sensitivity of weighting choices.



Findings on the robustness of the PMR composite indicator for 2003

Overall, the PMR CI seems more sensitive to the methodology used for its construction than its 1998 edition. There are two main sources of volatility: the use of PCA weights with a dataset with a different number of indicators, as in 1998, and the interaction between weighting based on PCA and the normalization of sub-domain scores. The simulations suggest that (i) varying the number of indicators in the dataset and (ii) allowing the normalization of sub-domain scores, could have strong effects in the ranking when the weighting method employed is based on PCA. When the weighting method is EW (as in the baseline) the ranking appears quite robust: only for Germany, Spain and Norway the choice not to normalize scores induces some volatility in the ranks.

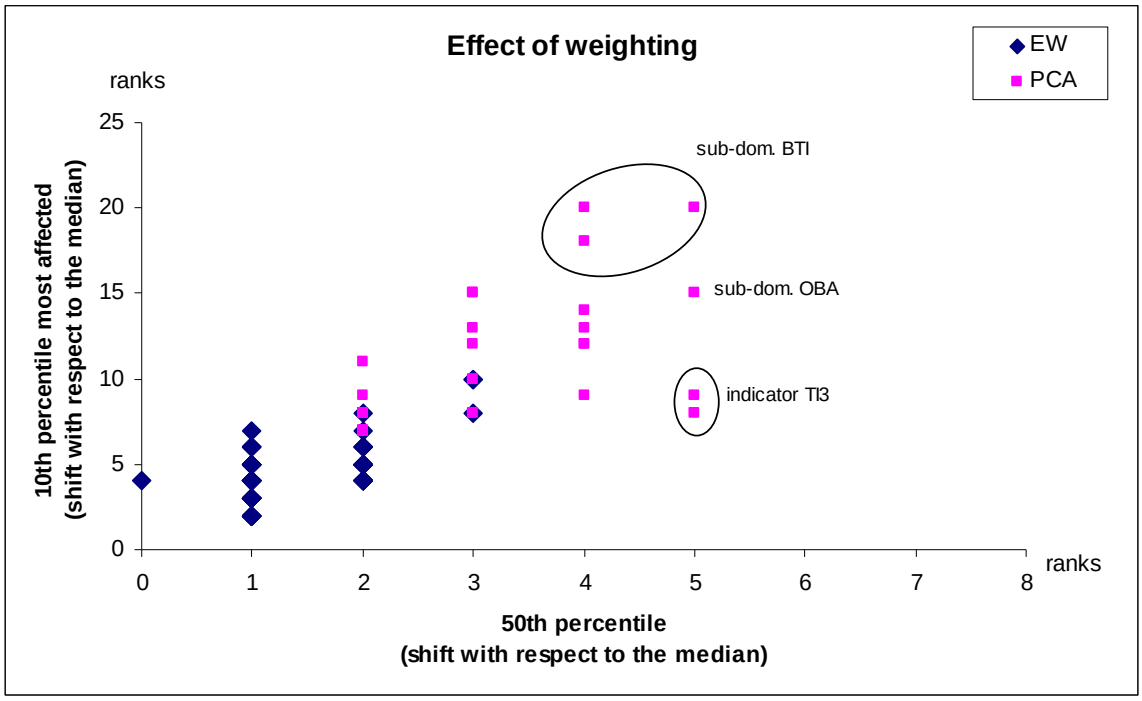
The analysis of the 2007 dataset shows the presence of 13 (out of 27) volatile countries with France and Australia particularly unpredictable (**Table 11**). The difference of the median rank with respect to the PMR CI is of 5 positions for Canada, 4 positions for France and New Zealand and 3 positions for a bunch of countries including Japan, Belgium, Italy, Luxemburg and Korea. Canada, Japan, Italy and Korea are the country mostly favored by the methodological choices of the baseline, while the "net losers" are New Zealand, Belgium, Luxembourg and to some extent France.

Table 11. Results of the robustness analysis for 2007. Percentage of times each country ranks 1st, 2nd, 3rd, ….. , 27th.

CI	median		Rank 1	Rank 2	Rank 3	Rank 4	Rank 5	Rank 6	Rank 7	Rank 8	Rank 9	Rank 10	Rank 11	Rank 12	Rank 13	Rank 14	Rank 15	Rank 16	Rank 17	Rank 18	Rank 19	Rank 20	Rank 21	Rank 22	Rank 23	Rank 24	Rank 25	Rank 26	Rank 27
2	1	UKM	84	7	8																								
1	2	USA	6	63	22																								
4	5	ISL	8	15	17	12	13	7	7																				
7	5	ESP			17	24	16	12	12	9																			
5	6	NLD			14	13	14	14	23	12																			
6	7	DNK				6	12	14	10	10	6	4	11				10												
3	8	CAN			9	17	11	7	5	10	12	13																	
12	8	NZL				12	6	7	9	14	21	9		5															
11	10	AUS					8	5	8	10	9	8	11	11	11	8	6												
9	10	NOR						6	7	10	14	9	8	6				7	6	6									
10	11	FIN									11	19	24	27	9														
8	11	JPN				6				10	7	16	7	4	3	12	10	5	6										
14	13	SWE										6	7	13	11	9	4	10	9	10									
13	15	CHE												6	19	14	14	13	11	8									
19	16	BEL						10	6								9	18	10	9	7								
20	16	FRA											6	6	11	9	11	6	10	11	6	9	7						
17	16	HUN					11	7								8	6	7	15	12	12								
16	18	DEU													7	7	11	7	7	8	15	11	11						
15	18	ITA															6	14	7	18	14	8	13	11					
18	20	AUT																6	6	6	9	21	17	11	16				
23	20	LUX													7	12					10	20	12	17	9				
22	22	PRT																			9	12	15	24	31	5			
24	23	CZE																					9	10	24	39	7		
21	24	KOR																					5	9	11	30	22		
25	25	MEX																								10	55	25	9
26	26	TUR																			5			6		8	13	50	15
27	27	POL																										23	75

Among the volatile countries Iceland improves its rank under the PCA weighting method when normalization of scores is allowed. In this case varying the number of indicators produces large jumps of its rank. This is the same explanation for the 15th position of Denmark, that is also sensitive to the inclusion of the indicator SC5 and TI1. Canada would shift down in the ranking if the normalization of sub-domain scores would be allowed. New Zealand is an interesting case, since the baseline PMR CI represents a sort of "extreme" scenario belonging to the 5% of scenarios not shown in **Table 11**. All other methodological choices are likely to improve its ranking position. Australia is especially responsive to the methodological choices employed for the construction of the composite. In particular the normalization of sub-domain scores is likely to improve Australian rank while the reverse happens when the PCA weighting is employed and the number indicators are allowed to vary. The overall effect of PCA is shown in **Figure 11** and is similar to that of 2003. The highest absolute shift is produced when PCA is associated with the drop-out of the domain BTI.

Figure 11. Sensitivity of weighting choices



In **Table 11**, the worst ranking positions of Norway are mainly imputable to the normalization of sub-domain scores, while the upper jump of Japan occurs when TI1 is dropped from the dataset and scores normalized. Sweden is favored when allowing the renormalization of sub-domain scores while it is disadvantaged when the renormalization happens jointly with a weighing scheme based on PCA. Switzerland worsens its position in the PMR ranking by dropping one indicator at the time but does not seem to be sensible to any particular indicator. For France the baseline rank is at the lower end of the frequency matrix, i.e. with almost any other methodological choice France would see its position shifted up, especially renormalizing sub-domain scores.

The sudden jump up of Hungary is imputable to the weighting scheme (PCA), whereas Germany is favored by a weighting scheme which does not consider the sub-domain layer and is punished when indicators of the domain *barriers to entrepreneurship* are eliminated. Italy can only loose from changing the methodological assumptions of the baseline, especially when indicators of the domains *state control* and *barriers to entrepreneurship* are eliminated and PCA weighting is used. Finally Austria's volatility is mainly due to joint effect of the normalization and the PCA weighting structure.

Findings on the robustness of the PMR composite indicator for 2007

The sensitivity of the PMR CI to the methodology used for its construction is confirmed also for 2007 where about half of the countries have a volatile ranking position. Again the two main sources of volatility are: the use of PCA weights with a dataset with a different number of indicators, as in the previous editions, and the interaction between a weighting based on PCA and the normalization of sub-domain scores.
Notice that the increase over time of the number of volatile countries in the PMR ranking is probably a reflection of the convergence of regulatory environments. Small changes in underlying methodology are likely to reshuffle countries' rank the smaller is the difference in countries' score.

6. Structure of the PMR composite indicator: ex-ante analysis

Establishing a relationship between cause and effect is notoriously difficult; the widely accepted statement "correlation does not mean causality" has to be borne in mind. Practically, however, in the absence of a genuine theory on "what causes what", the correlation structure of the data set can be of some help in at least excluding causal relationships between variables (but not necessarily between the theoretical constructs of which the variable is a manifestation). We have simple tools to investigate the relationship between the composite and its components. Ex-ante, from raw data we employ factor analysis (FA) and Cluster analysis. Both use the correlation structure of the dataset to extract information.

FA aims at reducing the dimensionality of the dataset by grouping linear combination of indicators into orthogonal factors in order to maximize the information loaded by each factor. Ideally, the structure of PMR would be confirmed by the data if each factor would principally load the indicators belonging to one (or more) sub-domain(s). This would mean that (i) the indicators of each sub-domain convey "similar" or complementary information; (ii) if different domains or sub-domains convey different information they are likely to belong to different factors. Such clear-cut picture is however rare when dealing with datasets (especially of categorical nature). One has to bear in mind that FA cannot be used to include/exclude indicators but only to shed some light in the structure of the index.

Usually a robust FA requires a relationship 3:1 between data and indicators. Given that for each year we have 19 indicators and 27 countries, we are far from the 1:1 relationship. Therefore we pool the three years 1998, 2003, 2007 into one dataset where for each indicator we have 81 data points. We exploit the pooled dataset to see if the structure in domains is confirmed whereas we keep single datasets, thus considering each year separately, to see whether, once imposed the 3-domains structure the division in sub-domains is confirmed by the data.

Table 12 shows the results of the FA on the pooled dataset. This technique highlights 7 eigenvalues greater or equal to one, representing 77% of the variance of the whole dataset. These correspond to 7 orthogonal factors grouping the information of the dataset.

With different colors we underline the indicators belonging to different sub-domains. It is clear from **Table 12** that the only 2 sub-domains principally loaded by a single factor are *regulatory and administrative opacity* (BE1-2), and *administrative burdens on startups* (BE3-4-5), for the rest of indicators the grouping given by the factors does not correspond to the grouping by dimension or sub-dimension.

We then consider the indicators belonging to the 3 domains and we perform a FA on each domain separately in order to see whether, within each domain, the structure of sub-domains is confirmed. **Table 13**, **14** and **15** show the results. For the domain State Control, FA clearly confirms the division in sub-domains: the two sub-domains *public ownership* and *involvement in business operations* are principally loaded by two different factors. The distinction in sub-domains is less clear for the domain *barriers to entrepreneurship*, where the data clearly differentiate the sub-domains *regulatory and administrative opacity* and *administrative burdens on startup*s but not the third sub-domain *barriers to competition* which is split among two factors. A similar picture holds for the third domain *barriers to trade and investment* where the two sub-domains are not clearly split between the two relevant factors. In all cases, nevertheless, the number of factors retained is equal to the number of sub-domains.

Table 12. Factor loadings for the pooled dataset 1998-2003-2007. In bold the highest loadings.

Factor Loadings (Varimax normalized) dataset pooled 1998-2003-2007
Extraction: Principal components

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
SC1	**0.85**	0.02	0.32	0.10	0.11	0.03	0.13
SC2	0.46	-0.13	**0.63**	-0.33	-0.03	0.15	0.11
SC3	**0.77**	0.17	0.22	-0.06	0.00	0.28	0.14
SC4	0.03	**0.59**	0.43	-0.15	0.12	0.32	0.01
SC5	0.18	0.05	0.49	0.25	0.07	**0.70**	-0.09
BE1	0.03	0.12	-0.24	-0.32	-0.03	**0.70**	0.20
BE2	0.19	0.48	0.08	0.20	0.02	**0.49**	0.14
BE3	0.35	0.23	**0.77**	0.00	0.11	-0.05	0.25
BE4	0.29	0.24	**0.79**	0.10	0.03	0.03	0.02
BE5	0.27	0.20	**0.81**	0.25	0.01	0.05	0.04
BE6	0.38	**0.68**	0.01	-0.33	-0.02	-0.02	-0.24
BE7	-0.03	0.06	-0.03	0.07	**-0.93**	-0.01	-0.06
BE8a	0.12	**0.67**	0.54	-0.08	-0.08	0.20	0.22
BE8b	-0.01	**0.81**	0.10	0.10	-0.10	0.02	0.27
BE9	0.09	-0.06	0.04	**0.91**	-0.05	-0.01	-0.04
TI1	**0.75**	0.18	0.31	0.14	-0.09	-0.03	0.24
TI2	0.07	0.02	**0.68**	-0.14	-0.50	-0.08	0.25
TI3	0.39	0.05	0.13	-0.02	-0.21	0.08	**0.65**
TI4	0.13	0.17	0.15	-0.04	0.16	0.09	**0.80**
Expl.Var	2.80	2.43	3.82	1.42	1.25	1.50	1.54
Prp.Totl	0.15	0.13	0.20	0.07	0.07	0.08	0.08

Table 13. Factor loadings for the pooled dataset 1998-2003-2007 and for the domain *state control*. In bold the highest loadings.

Factor Loadings (Varimax normalized)
Extraction: Principal components

	Factor 1	Factor 2
SC1	**0.91**	0.11
SC2	**0.64**	0.41
SC3	**0.88**	0.19
SC4	0.35	**0.67**
SC5	0.07	**0.90**
Expl.Var	2.12	1.48
Prp.Totl	0.42	0.30

Table 14. Factor loadings for the pooled dataset 1998-2003-2007 and for the domain *barriers to entrepreneurship*. In bold the highest loadings.

Factor Loadings (Varimax normalized)
Extraction: Principal components

	Factor 1	Factor 2	Factor 3
BE1	-0.29	**0.53**	-0.30
BE2	0.23	**0.58**	0.13
BE3	**0.89**	0.20	-0.09
BE4	**0.86**	0.19	0.03
BE5	**0.90**	0.15	0.12
BE6	0.16	**0.66**	-0.19
BE7	-0.21	0.26	**0.73**
BE8a	0.58	**0.68**	0.02
BE8b	0.24	**0.71**	0.15
BE9	0.24	-0.28	**0.69**
Expl.Var	3.00	2.26	1.20
Prp.Totl	0.30	0.23	0.12

Table 15. Factor loadings for the pooled dataset 1998-2003-2007 and for the domain *barriers to trade*. In bold the highest loadings.

Factor Loadings (Varimax normalized)
Extraction: Principal components

	Factor 1	Factor 2
TI1	0.48	**0.60**
TI2	**0.67**	0.41
TI3	**0.89**	0.00
TI4	0.03	**0.91**
Expl.Var	1.46	1.35
Prp.Totl	0.37	0.34

The FA analysis of each year separately confirms this picture where data support the layout of the index as far as the structure of correlation is concerned even if the indicators belonging to each domain are not fully loaded by the same component. We also perform k-means cluster analysis on the pooled dataset to explore similarities between indicators. We constrain the indicators to cluster in 3 groups of according to their degree of "similarity" and we check whether the 3 groups correspond to the 3 domains. **Table 16** shows the members of the 3 clusters. As in the FA the data does not fully support the loading of the indicators as the 3 clusters contain indicators belonging to different domains.[5]

Table 16. Results of the k-Means cluster analysis with k=3: indicators belonging to each cluster.

cluster 1	cluster 2	cluster 3
SC4	BE2	SC1
SC5	BE7	SC2
BE3	TI3	SC3
BE4	TI4	BE1
BE5		BE8
BE6		BE9
TI1		
TI2		

[5] A FA constraining to 3 the number of factors confirms the finding of the cluster analysis: only the sub-dimensions PUO and IBO can be clearly distinguished.

Findings on the structure of PMR composite indicator: ex-ante analysis

The analysis of the datasets 1998, 2003 and 2007 show a good correspondence between the structure of the composite indicator (i.e. it division in sub-domains and domains) and the pattern found in the data.

7. Structure of PMR composite indicator: ex-post analysis

Correlation analysis is used to examine the relationship between the indicators belonging to each of the 7 sub-domains of the PMR CI (in this case of categorical data Spearman correlation is used[6]). This is a basic but widespread tool for "confirming" ex post the structure of the index. Booysen (2002) in fact recommends the exclusion of an indicator if a low correlation between a given indicator and the composite would result. A high correlation (when not spurious) indicates a high association of the indicator to the composite. However correlation does not exactly quantify the "contribution" of a given indicator to the composite which is better represented by path analysis or by the "pie share" analysis.

Table 17. **Spearman correlation between indicators, sub-dimensions and dimensions and the PMR CI** (values not significant at 5% with an asterisk).

	correlation with the PMR CI					correlation with the PMR CI		
	1998	2003	2007			1998	2003	2007
SC1	0.69	0.65	0.48		PUO	0.78	0.76	0.8
SC2	0.69	0.63	0.65		IBO	0.71	0.73	0.65
SC3	0.66	0.67	0.75		RAO	0.2*	-0.09*	0.05*
SC4	0.47	0.56	0.54		ABS	0.86	0.88	0.67
SC5	0.52	0.61	0.4		BAC	0.43	0.19*	0.03*
BE1	0.09*	-0.14*	0.13*		BTI	0.61	0.82	0.74
BE2	0.47	0.21*	-0.30*		OBA	0.46	0.14*	0.16*
BE3	0.89	0.85	0.65					
BE4	0.77	0.8	0.53					
BE5	0.71	0.76	0.65					
BE6	0.34*	0.07*	-0.02*					
BE7	-0.08*	-0.16*	-0.17*		SC	0.86	0.88	0.89
BE8	0.79	0.34*	0.09*		BE	0.84	0.69	0.57
BE9	-0.03*	0.22*	0.27*		BT	0.74	0.76	0.71
TI1	0.61	0.54	0.53					
TI2	0.51	0.62	0.6					
TI3	0.40	0.63	0.47					
TI4	0.46	0.14*	0.16*					

Table 17 displays the correlation between each indicator, sub-dimension and dimension with the composite. All significant correlations are positive as expected. Notice that the indicators belonging to the sub-dimensions *regulatory and administrative opacity*, b*arriers to competition* and to some extent

[6] Spearman's rank correlation coefficient is defined as follows: $r_s = 1 - 6[\sum_i d_{is}^2 / n(n^2 - 1)]$, with d_{is} indicating the difference between the rank of country *i* in the indicator *s* and the rank of the same country in the PMR CI, while *n* is the number of countries in the dataset.

(for the years 2003 and 2007) also *other barriers* are not significantly correlated with the composite, suggesting a negligible contribution to it.

Another possibility to verify the contribution of each indicator, sub-domain or domain to the composite index is the calculation of the pie shares. Pie shares give a first impression of the actual "weight" of an indictor on a composite. If the composite for each country n for $n = 1,...,27$ can be expressed as $CI_n = \sum_{i=1}^{18} w_i I_{in}$, the pie share of indicator I_{in} is given by $PS_{in} = \frac{w_i I_{in}}{CI_n}$, i.e. the score of indicator I_{in} divided by the score of the composite. The average across all countries gives the average pie share. The comparison between the weight assigned to each indicator and its average pie share supplies a first insight on the contribution of this indicator to the overall index score. The principal difference with the correlation displayed in **Table 17** is that the pie share depends on the scores of the indicators. Indicators with high scores will, ceteris paribus, contribute more to the composite. **Table 18** below shows the pie shares of the entire dataset, while **Table 19** displays the range of variation of each indicator, sub-domain, and domain.

Table 18. Pie shares of each indicator, sub-domain and domain.

	pie shares					pie shares			
	1998	2003	2007	EW		1998	2003	2007	EW
SC1	9.2%	11.4%	11.1%	5.6%	PUO	27.7%	33.5%	36.1%	16.7%
SC2	8.9%	10.9%	10.4%	5.6%	IBO	19.8%	15.9%	14.3%	16.7%
SC3	9.6%	11.3%	10.0%	5.6%	RAO	12.1%	10.3%	8.5%	11.1%
SC4	9.1%	5.3%	2.9%	8.3%	ABS	11.4%	12.5%	12.0%	11.1%
SC5	10.7%	10.6%	5.6%	8.3%	BAC	13.3%	14.5%	15.0%	11.1%
BE1	9.5%	8.7%	6.4%	5.6%	BTI	11.3%	11.8%	11.9%	16.7%
BE2	2.7%	1.6%	0.9%	5.6%	OBA	4.3%	1.5%	2.2%	16.7%
BE3	3.9%	4.4%	5.8%	3.7%					
BE4	4.2%	4.4%	5.7%	3.7%					
BE5	3.4%	3.7%	4.8%	3.7%					
BE6	2.6%	2.7%	3.9%	2.8%					
BE7	1.2%	1.2%	2.0%	2.8%	SC	47.5%	49.4%	50.4%	33.3%
BE8	5.0%	4.6%	6.9%	2.8%	BE	36.8%	37.3%	35.5%	33.3%
BE9	4.6%	6.0%	11.9%	2.8%	BT	15.6%	13.2%	14.1%	33.3%
TI1	5.0%	5.8%	4.6%	5.6%					
TI2	3.6%	4.6%	4.1%	5.6%					
TI3	2.7%	1.4%	2.3%	5.6%					
TI4	4.3%	1.5%	0.7%	16.7%					

State Control is the domain contributing the most to the PMR composite indicator in all years considered: vis á vis a weight of 1/3, the actual pie share ranges from 48% to 50%. Within this domain the highest contribution is given by the indicators belonging to *public ownership*. Within *involvement in business operation* the indicator SC5 supplies the highest contribution. Notice, however, that this result partially depends on the scores of the indicators belonging to this domain: it is not a case that SC4, with the lowest range of variation, marginally contributes to the composite in spite of a correlation with the composite similar to the one of SC5.

The domain *Barriers to trade and investment* combine the lowest contribution in terms of pie shares with the lowest range of variation. The Spearman correlation coefficient, however confirms the absence of significant correlation only for the sub-domain *Other barriers* and for the years 2003 and 2007. Within the domain *Barriers to entrepreneurship* significant correlation with the composite is

found for the sub-domains *Administrative burdens on start-ups* for all years and *Barriers to competition* for the years 2003 and 2007. The average pie shares of indicators, sub-domains and domains are in line with the weights (slightly higher in the case of *Barriers to competition*).

It has to be noted that pie shares measure the importance of one low-level indicator as a percentage of the aggregate PMR indicator score. As a consequence, since most OECD countries have been reducing the level of aggregate regulation significantly over the 1998 to 2007 period, those regulatory areas where reform has been weaker than on the aggregate would receive an increasing importance in terms of pie shares. This is, for instance, the case for *barriers to entry in services* (BE9) as well as for the sub-domain *public ownership* (PUO).

Comparing Table 17 and Table 18 highlights differences in the importance of certain low-level indicators that might provide some guidance in view of possible future "interim" updates of the PMR based on working a subset of "core" low-level indicators. If the aim of the core subset of indicators is to choose indicators with relatively high scores, but which are representative for the aggregate PMR indicator (as reflected in a strong correlation) the selection of indicators would comprise the low-level indicators in the sub-domain *public ownership* of the domain *state control* (SC1, SC2, SC3), as well as the low-level indicators in the *administrative burdens for start-ups* (BE3, BE4, BE5) sub-domain within the *barriers to entrepreneurship* domain. Another candidate by these criteria would be the low-level indicator for *barriers to FDI* within the *barriers to trade and investment* domain.

However, if the aim of the core sub set of indicators is to cover (equally) those indicators with a large potential for future reform, the selection would (also) include the *barriers to entry in network sectors* and *in services* (BE8, BE9). These two indicators show a very strong contribution in terms of pie shares, but do not show a significant correlation with the aggregate PMR; the latter reflecting that most countries do show relatively high scores in these regulatory areas, *i.e.* also those countries that would otherwise be characterized by relatively liberal regulatory environments.

Table 19. Range of variation [min, max] for the score of each indicator-, sub-domain- and domain.

	range of variation					range of variation		
	1998	2003	2007			1998	2003	2007
SC1	[0.8, 6]	[0.8, 5.8]	[1.3, 6]		PUO	[1.5, 5.6]	[1.5, 5.3]	[1.3, 5.3]
SC2	[0.8, 5.6]	[0.7, 5.4]	[0, 6]		IBO	[1.1, 4.6]	[0.2, 3]	[0.1, 3.7]
SC3	[0.8, 5.8]	[0.8, 5.8]	[0.8, 4.2]		RAO	[0.3, 4]	[0.1, 3.3]	[0, 3.3]
SC4	[0.2, 4.2]	[0, 2.8]	[0.1, 2.9]		ABS	[0.3, 4.8]	[0.4, 3.9]	[0.5, 3.8]
SC5	[1, 5.2]	[0.1, 4.5]	[0.1, 4.4]		BAC	[1.7, 3.8]	[1.1, 3.3]	[0.8, 3.3]
BE1	[0, 6]	[0, 6]	[0, 6]		BTI	[0.5, 4]	[0.4, 3.1]	[0.2, 3]
BE2	[0.3, 2.6]	[0, 2.6]	[0, 1]		OBA	[0, 4.4]	[0, 1.6]	[0, 1.6]
BE3	[0.5, 5.5]	[0.8, 4.3]	[0.5, 4]					
BE4	[0.3, 4.3]	[0, 4]	[0, 4.3]					
BE5	[0, 4.7]	[0.3, 4.1]	[0.2, 3.8]					
BE6	[0.3, 3.5]	[0.3, 2.3]	[0.3, 2.6]					
BE7	[0, 3.6]	[0, 3]	[0, 3.1]		SC	[1.4, 4.9]	[1.2, 4.2]	[0.8, 3.8]
BE8	[1.1, 5.3]	[0.8, 4.7]	[0.3, 4.6]		BE	[1, 3.5]	[1, 2.6]	[0.8, 2.4]
BE9	[0.3, 5]	[0.6, 5.1]	[1.1, 5]		BT	[0.2, 4.2]	[0.2, 2.1]	[0.2, 1.6]
TI1	[0.2, 3.6]	[0.4, 3.4]	[0.2, 3.5]					
TI2	[0, 5]	[0, 6]	[0, 6]					
TI3	[0, 4.4]	[0, 1.4]	[0, 2.9]					
TI4	[0, 4.4]	[0, 1.6]	[0, 1.6]					

Findings on the structure of PMR composite indicator: ex-post analysis

The analysis of the relationship between the PMR composite indicator and its components (indicators, sub-domains and domains) shows a discrepancy between the theoretical "worth" of each component, i.e. the weight, and the actual influence of each component in the composite. The CI is rather imbalanced towards the domains *state control* and *barriers to entrepreneurship* which count the double or even the triple of the domain *barriers to trade and investment*. This in spite of the fact the weighting scheme takes into account the disparity in the number of indicators belonging to each sub-domain.

More on the normalization

The previous analysis draws attention to the role of normalization of row data. In spite of being theoretically expressed in [0, 6] scale, their range of variation is very different across indicators. Some of them (mainly the indicators belonging to the domains *state control* and *barriers to entrepreneurship*) take values nearer to six and some others nearer to zero (those belonging to *barriers to trade and investment*). This could have an effect on the final index favoring the first two domains with the "heaviest" indicators (**Table 18**). In order to sort out the effect of the normalization we compute the PMR CI using normalized data.

Table 20. Effect of the normalization.

				difference with the baseline	
	baseline	z-scores	min-max	z-scores	min-max
AUS	5	6	6	-1	-1
AUT	14	16	14	-2	0
BEL	13	12	12	1	1
CAN	3	4	4	-1	-1
CZE	24	24	24	0	0
DNK	6	5	5	1	1
FIN	12	13	13	-1	-1
FRA	20	21	21	-1	-1
DEU	11	11	11	0	0
HUN	17	18	18	-1	-1
ISL	8	8	8	0	0
ITA	23	23	23	0	0
JPN	15	14	15	1	0
KOR	18	17	17	1	1
LUX	-	-	-	-	-
MEX	19	19	19	0	0
NLD	7	7	7	1	1
NZL	4	3	3	0	0
NOR	9	9	9	0	0
POL	26	26	26	1	0
PRT	16	15	16	-1	-1
ESP	21	22	22	0	0
SWE	10	10	10	2	2

CHE	22	20	20	0	0
TUR	25	25	25	0	0
UKM	1	1	1	0	0
USA	2	2	2	0	0

Table 20 shows countries' rank when the data used are (i) the original ones (baseline), (ii) the z-score of the original data, and (iii) the min-max transformation of the original data.[7] According to the results normalization influences negatively the rank of Austria and Hungary but positively that of Korea, Spain but especially Switzerland. The two types of normalization do not produce appreciable differences in ranking.

In terms of pie shares **Table 21** shows the contribution of indicators sub-domains and domains when the data are normalized. The contribution of the single indicators is more balanced as well as that of sub-domains and domains. The landscape is however not dramatically changed with respect to the baseline: normalization only marginally reduces the disproportion on the contribution of different variables but the imbalance still remains and is due to the high number of zeros (and in general of low values) in the indicators belonging to the domain *barriers to trade and investment*.

Table 21. Pie shares with normalized data.

data in max-min									
	pie shares					**pie shares**			
	1998	**2003**	**2007**	**EW**		**1998**	**2003**	**2007**	**EW**
SC1	7.2%	8.0%	7.2%	5.6%	**PUO**	22.2%	24.1%	26.9%	16.7%
SC2	7.4%	8.4%	9.2%	5.6%	**IBO**	19.2%	19.2%	16.4%	16.7%
SC3	7.7%	7.8%	10.5%	5.6%	**RAO**	12.9%	10.1%	11.5%	11.1%
SC4	11.0%	8.6%	6.4%	8.3%	**ABS**	11.8%	12.1%	12.0%	11.1%
SC5	8.2%	10.6%	10.0%	8.3%	**BAC**	14.7%	16.0%	14.6%	11.1%
BE1	8.8%	7.1%	5.8%	5.6%	**BTI**	14.1%	14.6%	13.2%	16.7%
BE2	4.2%	2.9%	5.7%	5.6%	**OBA**	5.0%	3.9%	5.5%	16.7%
BE3	3.0%	3.2%	3.7%	3.7%					
BE4	4.9%	5.1%	4.6%	3.7%					
BE5	3.8%	3.7%	3.8%	3.7%					
BE6	3.6%	5.2%	3.5%	2.8%					
BE7	1.9%	1.9%	1.9%	2.8%	**SC**	41.4%	43.4%	43.2%	33.3%
BE8	4.3%	3.7%	3.7%	2.8%	**BE**	39.4%	38.1%	38.1%	33.3%
BE9	4.9%	5.2%	5.5%	2.8%	**BT**	19.1%	18.5%	18.6%	33.3%
TI1	6.9%	6.4%	6.1%	5.6%					
TI2	3.9%	3.6%	3.4%	5.6%					
TI3	3.3%	4.7%	3.7%	5.6%					
TI4	5.0%	3.9%	5.5%	16.7%					

[7] Z-scores are computed by subtracting to each indicator the mean and divide by the standard deviation. Min-max is calculate by subtracting the minimum and dividing by the difference by the max. and he min.

8. Conclusions

The *product market regulation* (PMR) composite indicator tries to transform qualitative laws and regulations that may affect competition into a quantitative indicator using a bottom-up approach; 18 low-level indicators obtained from a survey of member states are grouped in 7 sub-domains and subsequently in 3 domains, *state control*, *barriers to entrepreneurship* and *barriers to trade and investment*. Overall the PMR indicator is computed for 27 countries (26 in 1998) and for three years 1998, 2003, and 2007

We employ robustness analysis to test the sensitivity of PMR ranking to the different methodological assumptions. In particular we account for the structure of PMR in domains and sub-domains, the normalization of the original data, the weighting of indicators, domains and sub-domains, and the aggregation method. Our analysis is twofold: we consider each methodological choice individually (individual analysis) but also we consider all the possible sources of variability together and study its joint effect on the PMR ranking (multi-modeling approach).

The individual analysis shows that, within the available datasets, there is no significant difference in country rankings between using equal weighting or PCA-retrieved weights (used in the previous editions of PMR), pointing to a negligible effect of double counting which is diluted by the structure of the PMR composite indicator. Yet the theoretical dependency of PCA weighting scheme on the number of countries and the year of calculation make EW a preferable solution for the calculation of the PMR indicator. If compensation between domains is not allowed, the country ranking is only moderately affected proving that compensation is not an issue in the PMR. The most volatile countries are those who perform better (worse) in indicators belonging to the domains *state control* and *barriers to entrepreneurship*.

The solidity of the baseline is confirmed by the multi-modeling approach. The sensitivity of the PMR CI to the methodology used for its construction is nevertheless increasing in time. In 2007 about half of the countries have a volatile ranking position (vis à vis 1998 when only 7 out of 27 countries were considered volatile). The two main sources of volatility in all datasets considered are the use of PCA weights with a dataset with a different number of indicators and the normalization of sub-domain scores. The increase over time of the number of volatile countries in the PMR ranking is probably a reflection of the convergence of regulatory environments. Small changes in underlying methodology are likely to reshuffle countries' rank the smaller is the difference in countries' score.

The analysis of the datasets 1998, 2003 and 2007 show a correspondence between the structure of the composite indicator (i.e. it division in sub-domains and domains) and the pattern found in the data. Finally the analysis of the relationship between the PMR composite indicator and its components (indicators, sub-domains and domains) shows a discrepancy between the theoretical "worth" of each component, i.e. the weight, and the actual influence of each component in the composite. The CI is rather imbalanced towards the domains *state control* and *barriers to entrepreneurship* which count the double or even the triple of the domain *barriers to trade and investment*. This in spite of the fact the weighting scheme takes into account the disparity in the number of indicators belonging to each sub-domain.

The importance of certain low-level indicators might however provide some guidance in view of possible future "interim" updates of the PMR based on working a subset of "core" low-level indicators.

Acronyms: structure of the PMR

State Control (SC)

Public Ownership (PUO)

- *SC1. Scope of public enterprises*
- *SC2. Direct control over business enterprise*.
- *SC3. Government involvement in infrastructure sector (NEW, 2003)*

Involvement in business operations (IBO)

- *SC4. Price controls*.
- *SC5. Use of command and control regulation*.

Barriers to entrepreneurship (BE)

Regulatory and administrative opacity (RAO)

- *BE1. Licenses and permits systems*.
- *BE2. Communication and simplification of rules and procedures*.

Administrative burdens on start-ups (ABS)

- *BE3. Administrative burdens for corporations*.
- *BE4. Administrative burdens for sole proprietors*.
- *BE5. Sector-specific administrative burdens*.

Barriers to competition (BAC)

- *BE6. Legal barriers*.
- *BE7. Antitrust exemptions*.
- *BE8. Barriers to entry in services*
    - *BE8a. Entry regulation in infrastructure sector (NEW, 2003)*
    - *BE8b. Vertical integration in infrastructure sector (NEW, 2003)*
- *BE9. Barriers to entry in services (NEW, 2003)*

Barriers to trade and investment (BT)

Explicit barriers to trade and investment (BTI)

- *TI1. Ownership barriers*.
- *TI2. Tariffs*.
- *TI3. Discriminatory procedures*.

Other barriers (OBA)

- *TI4. Regulatory barriers*.

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Abstract
The construction of a composite indicator (CI) involves stages where choices have to be made: the structure of PMR in domains and sub-domains, the normalization of the original data, the weighting of indicators, domains and sub-domains, and the aggregation method. All these choices will affect both the ranking and the message brought by the CI in a way that deserves analysis and corroboration. Robustness analysis is a powerful tool to test the sensitivity of PMR ranking to the different methodological assumptions. In particular we are interested in three questions. Does the use of one construction strategy versus another provide actually a partial picture of the countries' performance? Which countries have large uncertainty bounds in their rank (volatile countries)? Which are the factors that affect the countries rankings? We employ two strategies to answer to these questions. We consider each methodological choice individually and we study its effect on PMR ranking and we consider all the possible sources of variability together and study its joint effect on the PMR ranking.

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