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S&T RANKINGS: DO COUNTRIES CHANGE THE LEVEL OF THEIR TECHNOLOGICAL COMPETITIVENESS?

The paper examines stability of rankings of National Technology Systems (NTS). It is shown, based on statistical analyses of data from 1993 through 1997, that rankings of NTS have remained stable over the investigated period of time. This finding validates the NTS model used in the study. The leading indicators and proxies of these indicators have been identified

1. INTRODUCTION

Questions of technology management are of crucial importance, both to governments and the private business sector, because productivity and competitiveness are often subordinated to technological progress. However, the notion of 'competitiveness' is highly disputed. For example, the 'structural' theses presented in TEP (1992, Ch.11) differ markedly from the contingency ideas offered by The Lisbon's Group Report (1993), as does Porter's (1990) 'winning/confrontational' concept differ from Krugman's (1994) call for 'cooperativeness'. The issue is complex also because of measurement and operationalization problems (Frascati Manual, 1980, 1989, 1993; Oslo Manual, 1992, TEP, 1992), and because identifying the impact of involvement in S&T upon economy is difficult (e.g., Griliches 1991). It is important to verify whether or not the World Competitiveness Report is the only and valid source of ranking S&T commitment of countries. Even more, it is warranted to search for methodologies which are more reliable, cheaper in use, and which provide for more flexibility in terms of their application.

This paper aims to contribute to some of the above mentioned dilemmas. In part two extensive description of objectives and methodological approaches used is provided. Section three of the paper reports results. Conclusions and the outline of consequences for further research are reported the final section.

2. OBJECTIVEWS AND METHODOLOGY

The World Competitiveness Report (WCR), although only a secondary source, is relatively accessible and will be used to create the data base for the study. For data not listed in the Report, unless evidence to the contrary is made available, the minimum value (according to the measurement scale in the Report) will be accepted as the value of a specific data-item. This solution is justified in order to avoid (a) missing values and (b) a value of 0, which would decrease the number of countries examined in the model. Changes to these data will be made only if documentary evidence is available to prove that WCR data is incorrect. If the missing item is

identified and cannot be explained by "a practice to report values up to a certain minimum value", one of the following approaches will be used:

- the regression model will be used to estimate the missing data-item (regression to the most closely correlated dimension); or
- the item will be calculated as an average of values reported in adjacent years (i.e. year x-1 + year x+1 / 2); or,
- extra (intra)-polation method will be used.

The model of National Technology System (Nasierowski & Arcelus, 1999) consists of the following elements:

Inputs:

- purchases of technology from abroad (PUR) – i.e., Foreign Direct Investment plus purchases of goods and commercial services;
- public investment in human development / research (public expenditures for education - EDU, expenditures for tertiary education - EDUT, and General Expenditures for Research and Experimental Development -GERD);
- commercial orientation of research project (private sector involvement) (business involvement in R&D -BRD, employment in R&D - EM).

Outputs:

- quality of outputs (publication counts - PUB, citation counts (quality of publications) - CIT, and external patents by residents – PATE);
- short term R&D results (patents by residents - PATR).

Moderators:

- culture impact on technology development (individualism - IDV, power distance - PDI, purchasing power parity - PPP, cluster membership (intense involvement in technology development vs. inadequate involvement in technology development) - CT);
- acceptance of uncertainties associated with technological change -UAV.

Tests ran in the previous studies (Nasierowski & Arcelus, 1999, 1999a) have revealed that NTS factors for different years are quite similar. This finding, however, does not imply that comparatively performance results remain constant. Based on various NTS structures, and while using different Indexes (e.g., the ones which represent I, O, M), it should be possible to rank countries on the basis of their commitment, conditions, and results of technology development. This information can be used to assess each country's relative potential as a generator and a receptor of technology. The rationale for this analysis is twofold:

- a ranking procedure represents a predictive model. Its validation can be accomplished through a statistical comparison of country ranks obtained from various factor analyses and those obtained from the WCR (with the use of Spearman Correlation Test);

- the ranking comparisons are also designed to investigate whether or not a few widely available indicators embedded in the composite NTS factors can emulate the largely experts-based and rather expensive WCR rankings. Such an approach enhances the

predictive model's range of applicability in three substantial ways. First, it expands the number of countries for which rankings are produced. Second, it generates specialized rankings obtained with different subsets of NTS components, which can be tailored to the user's specific concerns. Third, it identifies the biases inherent in the WCR rankings with respect to the various subsets of variables and weighting procedures.

Before comparing the ranks two problems must be resolved. The first deals with the appropriate statistical test to compare ranks presented in a nominal scale – the Spearman correlation coefficients (SCC) between any two pairs of ranking schemes test (e.g. Siegel & Castellan, 1988) was selected. The statistical null hypothesis is that of independence of rankings produced by any two schemes. The second question refers to the weighting scheme needed to combine the different factors into an overall index. The WCR scheme is undisclosed. Thus, it can be neither evaluated nor applied to the factors obtained in this study. The approach utilised in this study accepted that each factor is weighted in terms of its importance and contribution to explaining the variation in the data. The second factor weighting approach assigns equal weights to each factor, regardless of its PVE. The N at the end of an index label identifies this approach. Whereas the second approach appears less desirable, its inclusion has a dual purpose, namely (i) to test whether the ranks are substantially affected by the weighting scheme utilised; and (ii) to identify, which scheme resembles more closely that utilised by the WCR.

There are three main objectives / questions of the current report:

- **Question 1** - are ranks of WCR S&T Competitiveness and ranks of NTS stable? – an answer to this question is important because stability would justify the use of the same model for different years, which simplifies research procedure. Certainly, it remains an unresolved query, whether or not such an approach can be followed into the future? Again, however, for the investigated period of time stability brings simplification, and can serve as a starting model to investigate future. The examination of this aspects will be accomplished by the use of an overview of ranks of WCR and current study ranks over the five years period and the Spearman correlation coefficients for these comparisons;

- **Question 2** – do ranks of NTS obtained in the current study replicate WCR rankings? – the positive answer to such a question would provide a validation of the model used by us. Nevertheless, we may claim that our approach is "better" or "more scientifically grounded", but the only available benchmark for assessment, i.e., the WCR, is widely recognized. Thus, in order to validate our model Spearman correlations coefficients between WCR and our Indexes will be calculated. High, and statistically significant, values would constitute "validation" of our approach;

- **Question 3** - what are the leading variables that can be used as 'indicators' of factors which describe NTS? – this question addresses demands (constraints, requirements) of envisaged issues of further studies – namely the assessment of efficiency of NTS and the search for "best" NTS solutions. This issue will be addressed by examining correlations between identified Indexes and items of these Indexes – items with highest correlation coefficient (unless other criteria, such as stability or data availability are examined) will be suggested as proxies of our Indexes.

3. ANALYSIS AND RESULTS

Altogether, 16 ranking schemes and the WCR ranking were evaluated (the ranking for I, M, 0, (and PUR), each time weighted by POPU and by GDP, for Indexes weight by PVE – "w", those not weight - "n". Because there is no universally accepted measure of comparability, the only recourse is to evaluate them against each other. When doing so, the issue becomes one of information content - do the different ranking schemes result in statistically significant differences in rankings and therefore measure different aspects of a country's NIS structure?

Question 1

Table 1 shows Spearman correlation coefficients (SCC) for WCR for 1994-1998. Table 2 identifies SCC for the sample Indicators developed in the current study[1]. In all cases coefficients are high: SCC is at the level of .8 and above with $p < .000$. Thus, we conclude, that rankings of S&T competitiveness by WCR and rankings of NTS, as identified in the current study, are stable over the examined period of time.

Table 1. Spearman correlation coefficients (SCC) for ranks for 1994-1998 (upper triangle coefficients – lower triangle p values

	WCR94	WCR95	WCR96	WCR97	WCR98
WCR94	-----	.962	.916	.874	.823
WCR95	.000	----	.903	.892	.825
WCR96	.000	.000	----	.935	.901
WCR97	.000	.000	.000	----	.946
WCR98	.000	.000	.000	.000	----

Table 2. An example of SCC for ranks for IpxxW

	IP93W	IP94W	IP95W	IP96W	IP97W
IP93W	----	.955	.965	.952	.931
IP94W	.000	----	.978	.966	.940
IP95W	.000	.000	----	.971	.958
IP96W	.000	.000	.000	----	.961
IP97W	.000	.000	.000	.000	----

Results of tests show similarities between rankings arrived at based on the model presented in this report and those reported in WCR, as well as ranks for different ranking schemes are shown in Table 1 and in Table 2 (only a sample test). This outcome permits to conclude that ranks are not different from one year to another – these ranks are stable. Consequently, one may use the same NTS model for different years. This observation validates the model.

[1] Only an example is provided because of space limitations. If there is a departure from the observed (reported) norm, it is reported in the text.

Question 2

Table 3 provides results of the SCC for the sample of WCR and an Index obtained in the current study. Again, coefficients are high and statistically significant. This permits us to conclude that the model presented in this report is not 'inferior' to the one reported in WCR. In our opinion it is better – it takes into account different importance of items, it is easier to calculate it, and it expands the number of countries which can be considered.

Table 3 – WCR Spearman coefficients for WCR and Indicators of NTS (signifiance levels are .000 and are not reported)

	WCR94	WCR95	WCR96	WCR97	WCR98
IpxxW	.750	.732	.755	.707	.661
OpxxW	.810	.796	.804	.790	.788
MPxxW	.726	.740	.737	.687	.650
IgxxN	.770	.756	.609	.703	.747
OgxxN	.724	.746	.744	.679	.703
MGxxN	.735	.712	.732	.728	.650

Question 3

The correlation between the variables which constitute an Index and the Index was verified. In all cases (not surprisingly) coefficients are very high (above .8 with statistical significance $p<.001$). This observation permits us to accept that any (in these case a variable which is) may represent an Index. The selection of the leading variable is based upon the following criteria: (i) the variable is not a constant, (ii) the variable has the highest loading in factor analysis, (iii) the variable is a stright-forward representation of the meaning of the factor.

Table 4 **Correlation coefficients between factors and items of the factors – weighting by "p"** (not significant correlations are marked with "*")

	IP93W	IP94W	IP95W	IP96W	IP97W
EDU	**.912**	**.897**	**.899**	**.874**	**.906**
EDUT	.925	.938	.933	.928	.933
GERD	.717	.660	.697	.687	.752
BRD	**.925**	**.892**	**.934**	**.930**	**.945**
EM	.574	.626	.686	.629	.672
	OP93W	OP94W	OP95W	OP96W	OP97W
PUB	.912	.915	.918	.925	.926
CIT	.899	.899	.899	.902	.902
PATE	**.788**	**.752**	**.762**	**.841**	**.840**
	MP93W	MP94W	MP95W	MP96W	MP97W
CT	.916	.945	.916	.899	.898
PDI	.851	.864	.857	.866	.868
IDV	-.868	.-874	-.865	-.849	-.844
PPP	**-.844**	**-.831**	**-.848**	**-.834**	**-.859**

Table 5 **Correlation coefficients between factors and items of the factors – weighting by "g"** (not significant correlations are marked with "*")

	IG93W	IG94W	IG95W	IG96W	IG97W
EDU	**.856**	**.830**	**.845**	**.837**	**.842**
EDUT	.911	.916	.830	.895	.909
GERD	.773	.817	1.000	.812	.764
BRD	**.926**	**.919**	**n/a**	**.939**	**.948**
	OG93W	OG94W	OG95W	OG96W	OG97W
PUB	.847	.865	.855	.878	.875
CIT	.900	.896	.897	.894	.893
PATE	**.867**	**.872**	**.866**	**.881**	**.880**
	MG93W	MG94W	MG95W	MG96W	MG97W
CT	.947	.945	.946	.943	.943
PDI	.857	.864	.862	.869	.871
IDV	-.878	-.874	-.875	-.874	-.869
PPP	**-.824**	**-.831**	**-.828**	**-.799**	**-.829**

Table 4 provides results of analyses of correlation coefficients between factors and items of factors for 1993 though 1997. For example, results suggest selection of the following variables as proxies of factors: factor Input 1 - EDUP; factor Input 2 - BRD; Moderator 1 – PPP; UAV – the only choice for the factor Moderator 2; PATE – for factor Output 1; PATR – the only choice for the factor Output 2. Results for items weight by "g" are presented in Table 5.

4. CONCLUSIONS

Ranks identified in the study are relatively stable, thus either countries do not change policies or the distance between countries remains similar. Although ranks reported by WCR and these obtained in the current study are highly correlated, some differences are evident. These originate primarily from differences in variables used to assess "S&T factor". Nevertheless, it has been proven that our methodology is valid.

One item to be underlined regarding the current report is related to high collinearity of items (factors) used. It calls for further study, which will allow to examine joint impacts of identified factors upon outputs, and thereafter upon economy (e.g., as measured by productivity and levels of competitiveness at the macro-economic level). Such an approach is expected to produce more precise results as opposed to those when separate items are advanced as the means for assessing the appropriateness and efficiency of technology development/transfer.

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