E C O N O M I C S   B U L L E T I N

Assessing the information content of the technology achievement index in the presence of the human development index

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Abstract

This paper supports the proposition that the indexes of technological achievement and of human development exhibit similar information validity and similar country rankings, thus questioning the need for the existence of two indexes rather than one.

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1. Introduction

The 2001 Human Development Report (UNDP, 2001) presented a new eight-factor measure of technological innovation, called the Technology Achievement Index (heretofore, *TAI*). The stated purpose (UNDP, 2001: 39) of the *TAI* was to capture the ability of countries to create new products and processes through research and development, to diffuse new and old technology in production and consumption and to develop the human skills for technological learning and innovation. Simultaneously, UNDP (2001) also issued the yearly Human Development Index (*HDI*), a composite measure of health, knowledge and wealth, widely used as a barometer of a nation's progress in human development. The purpose of this note is two-fold, namely to evaluate (i) whether the *TAI* has any information content over and above that provided by the more comprehensive *HDI*; and (ii) whether all eight factors included in the *TAI* are really needed for its composition or there exists enough redundancy among them to justify some factor pruning.

The organization of this note is as follows. A brief description of the computational procedure to construct both indices appears in section 2. This is followed by a series of statistical tests designed to test the two propositions embedded in the dual purpose of the note. A Conclusions section completes the note.

2. The nature of the TAI and of the HDI

The process to calculate the *TAI* appears in Technical Note 2 of UNDP (2001). Two equally weighted indicators measure each of the four equally weighted dimensions used to generate the *TAI*. The components of technology creation (*TC*) are *PGR* (the number of patents granted per capita) and *RRL* (the receipts of royalties and license fees from abroad per capita). *IH* (the number of Internet hosts per capita) and *TEX* (high and medium technology exports as a share of all exports) measure *DN*, the diffusion of new technology. *TMC* (logarithm of telephones per capita, mainline and cellular) and *ELC* (logarithm of electricity consumption per capita) do likewise for *DO*, the diffusion of old technology. Finally, *MYS* (mean years of schooling in the population aged 15 and above) and *TSR* (gross tertiary science enrolment ratio) determine *HS*, the human-skills dimension. Details on data sources appear on UNDP (2001, p. 47). These eight indicators yield their respective achievement indexes, obtained by subtracting from each observed value the minimum for the respective indicator and then dividing the difference by its range (maximum – minimum). The average of the eight achievement indexes measures the *TAI* and the average of their corresponding pair of achievement indexes yields each dimension's index.

It should be pointed out that justification for considering the *TAI* as an index of technological progress does not yet exist. Irrespective of the extant gamut of theoretical and empirical evidence for the selection of one or more of the eight indicators, no study still exists corroborating the UNDP (2001) assertion of *TAI* as a comprehensive measure. Hence, doubts about the claim exist, especially when considering that all indicators are input related and none measure technology performance.

On the other hand, the *HDI* reflects the mean achievement of a country in three basic dimensions of development – longevity, knowledge and purchasing power. The first relates to the attainment of long-life expectancy in good health, as measured by the life expectancy at birth. The second quantifies a country's educational attainment through a knowledge index composed of "the adult literacy rate (with two-thirds weight) and the combined primary, secondary and tertiary gross enrolment ratio (with one-third weight)." (UNDP, 2004: 259). The third calculates the gross domestic product (*GDP*) per capita of each country, in US$, with the purchasing power parity used to convert the various national currencies into US$. Such index operates "as a surrogate for all the dimensions of human development not reflected in a long and healthy life and in knowledge." (UNDP, 2004: 259). As before, each index is obtained as the ratio of the observed value minus the minimum divided by the range. The sum of the three indexes yields the *HDI*.

Justification for considering *HDI* as a potential index of technological progress reflects the strong nexus between human development and technology, irrespective of the doubts about *TAI*. Such nexus is clearly stated in the rationale given by UNDP (2002) to create the *TAI*: "digital, genetic and molecular breakthroughs are pushing forward the frontiers of how people can use technology to eradicate poverty. These breakthroughs are creating new possibilities for improving health and nutrition, expanding knowledge, stimulating economic growth and empowering people to participate in their communities." (UNDP, 2001: 27)

In addition, innumerable studies evidence the important influence of technological advancements, especially in information systems, upon global development. Mention of three manifestations of this impact suffices to make the point. First, there are indications (e.g. Nasierowski and Arcelus, 2003) that innovation has allowed countries leapfrogging (e.g. Barro and Sala-i-Martin, 1995) into modern service sectors without having to go through the normal manufacturing stage. In addition, high levels of technological development act as strong magnets in attracting foreign direct investment (Gani and Sharma, 2003; Sharma and Gani, 2004). Further, the development divide between rich and poor countries may be partially attributable to the quality of each country's information base (e.g. Rodriguez and Wilson, 2000). Gani and Sharma (2003) present a recent review of this rather voluminous literature.

3. The empirical evidence

This section presents an empirical evaluation of the two hypotheses subject of this note. In terms of the magnitude of the information content of *TAI*, given *HDI*, the evidence indicates that the ability of the *TAI* to provide additional information over and above that provided by the *HDI* is questionable at best. This can be readily seen by observing that the Spearman correlation coefficient between the two indexes is .958 and between *TAI* and the three *HDI* dimensions, life expectancy, educational attainment and wealth, .873, .919 and .948, respectively. Further, the p-values are under 10^{-4} in all cases. Hence, the hypothesis of differences in the country rankings provided by these indexes can be rejected

Further, the evidence in favour of a great degree of redundancy embedded in the computation of the *TAI* is also overwhelming. Three types of statistical tests substantiate this assertion. First, the Spearman correlations between the *TAI* and its eight components, *PGR, RRL, IH, TEX, TMC, ELC, MYS* and *TSR*, .862, .802, .928, .784, .958, .956, .882, and .891, respectively; between *TAI* and its four dimension, *TC, DM, DO* and *HS*, 0871, .894, .970 and .948. The corresponding p-values are also under 10^{-4} in all cases. These results underscore once again the similarity in country rankings obtained with either *TAI* or through any of their components. Second, the regression results of Table 1, with one of the *TAI* indicators as dependent variable and the remaining as explanators, reveal a great degree of multicolinearity among them. This suggests the advisability of some pruning in the set of indicators selected for the construction of the index. Third, further unsuccessful efforts to single out distinguishing factors led to a principal components analysis of the eight *TAI* indicators. Only one factor exhibited an eigenvalue greater than 1 (5.08 in this case) and explained at least 10% of the variation (63.5%) in the data, the usual two criteria for factor selection (e.g. Hair, et.al., 1998). However, this factor included all the eight indicators, since all had factor loadings in excess of .85.

Table 1: Stepwise regression results (p-values in parenthesis)

TAI indicators	Dependent Variable							
	PGR	RRL	IH	TEX	TMC	ELC	MYS	TSR
Constant	-1.08 (.017)	-.032 (.100)	-.032 (.648)	-.187 (.056)	.174 (.000)	-.103 (.001)	-.039 (.487)	-.248 (.000)
PGR				.477 (.006)				
RRL			.666 (.000)	.327 (.097)				
IH		.403 (.000)			-.072 (.085)		.311 (.000)	.346 (.000)
TEX	.225 (.001)	.130 (.004)						
TMC			-.264 (.073)	.647 (.000)		.959 (.000)	.728 (.000)	.634 (.000)
ELC					.790 (.000)			
MYS	.146 (.085)		.402 (.002)			.142 (.023)		
TSR			.297 (.007)		.142 (.003)			
R^2	.545	.739	.812	.732	.968	.966	.875	.810

4. Some concluding comments

The analysis of this note has produced two basic insights. First, the *HDI* and the *TAI* exhibit similar information validity and yield similar country rankings. Hence, both indexes provide equivalent measures of social and economic well-being and the *TAI* does not add information to *HDI*. This insight does not question the usefulness of either index. Rather, it merely questions the need to use both. Second, the eight indicators are not needed in the creation of the *TAI*, given the high degree of redundancy among them. As a result, a natural suggestion for further research includes additional work on improving the *TAI*, before it can be accepted over the *HDI* as a proxy for technological achievement.

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