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Advancement of indices assessing a nation's telecommunications development status: A PLS structural equation analysis of over 100 countries

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Abstract

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Advancement of indices assessing a nation's telecommunications development status: A PLS structural equation analysis of over 100 countries

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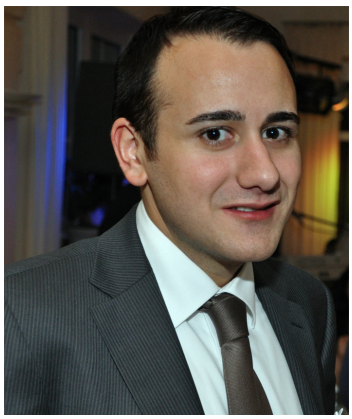

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The literature has already presented quite a number of composite metrics seeking to quantify the achievement level of countries with regard to their telecommunication infrastructures and their use by end customers. However, prior measures suffer from severe shortcomings. Therefore, this paper introduces a new second-order overall index assessing the availability, adoption and usage intensity of telecommunication networks and services at the country level. The proposed Telecommunications Development Index (TDI) integrates 11 indicators, which are grouped into three first-level subindices labeled Supply, Adoption and Usage. Indicator and subindex weights used in combining them into higher-order measures are computed drawing on Partial Least Squares (PLS) Structural Equation Modeling (SEM) techniques. The modeling rests on the assumption that TDI weights should be outcome-specific and thus constructed in a way that maximizes the indicators' and subindices' capability, respectively to predict socially desirable national performance criteria such as per capita gross domestic product (GDP) change or a country's Human Development Index (HDI) value. Based on data from 111 countries, this approach was used to calculate weights of the indicators and subindices merged into a total TDI predicting either GDP per capita change or a country's HDI. In both TDI variants the Adoption subindex variable fixed broadband subscriptions per household and the Supply subindex variable international bandwidth capacity available per Internet user achieved the highest relative weights of all indicators in the prediction of the two studied social outcome criteria. The PLS SEM results were used to calculate scores of the two TDI variations for each of the sample countries. TDI-based rankings of the countries were compared with a ranking derived from the Information and Communication Technologies Development Index of the International Telecommunication Union.

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Keywords: Adoption, composite indices, country ranking, ITU data base, Partial Least Squares Structural Equation Modeling, supply, usage.

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1. Introduction

It is widely acknowledged that the availability and use of telecommunication networks and services are strongly linked to positively valued socio-economic achievements of countries. Consequently, several studies have been carried out which strive to capture the degree of sophistication of the telecommunications infrastructure and demand status at the country level for a large number of nations in a single composite index. In the remainder of this study the term "telecommunication development index" (TDI) is used to refer to such measures of a latent construct which encompasses several features. Among others, Barzilai-Nahon (2006, pp. 274-275), Bruno, Esposito, Genovese, & Gwebu (2011, pp. 18-21) and Hanafizadeh, Hanafizadeh, & Khodabakhshi (2009b, p. 245) provide overviews of relevant index propositions.

A common key characteristic of the various TDI is that they mathematically aggregate a set of distinct indicators either in a single step or in at least two steps through the calculation of subindices. Furthermore, at the lowest level of analysis the individual indicators typically do not have a uniform measurement unit and an obvious way of weighting the indicators or higher-order subindices in the computation of the total index is missing (Saisana & Tarantola, 2002, p. 5; Vicente & López, 2006, p. 758). Politicians and executives of telecommunication firms use TDI to justify the inevitability or needlessness of a variety of public interventions as, for instance, state subsidies for the roll-out of fiber access networks in rural areas, financial aids for low income households to hook them up to the Internet or the imposition of ceilings for telephone line installation fees paid by residential customers (Almutawkkil, Heshmati, & Hwang, 2009, pp. 176-177). Scholars focusing on the telecommunications sector are more interested in the conceptual underpinnings and in methodological aspects (dimensionality, weighting algorithm etc.) of composite measures assessing the telecommunications development (TD) level of countries.

Regardless of who relies on TDI and of what is intended to be achieved through TDI analysis, capturing the status of the availability and use of telecommunication infrastructures and services at the country level in a single composite index is a highly complex endeavor. This holds even more if the index designer strives to base the measure on raw data which are accessible not just for a few (developed) nations but for a large number of countries. In particular, the selection of variables ("indicators") to be entered in a TDI and the weighting of indicators or of subindices introduced at intermediate levels between the basic variables and the overall index raise a number of intriguing questions. Although these questions have been addressed in quite a number of publications there is still room for improved responses to them. The present work intends to contribute to such improved answers. It extends the literature mainly in three ways.

First, we develop a proposal of a more comprehensive set of 11 indicators and their summary in three first-level subindices which in turn are merged in a (second-order) overall TDI. The set includes variables describing the supply of telecommunication infrastructures and services in a country as well as the intensity of usage of access lines. Both facets are not sufficiently accounted for in earlier measures assessing a country's TD status. Second, this study considers that first-order TD subindicies constructed in earlier research (e.g., Al-mutawkkil et al., 2009; Hanafizadeh, Saghaei, & Hanafizadeh, 2009a; ITU, 2013; Waverman, Dasgupta, & Rajala, 2011) are linked in means-end-chains. For instance, a subindex measuring the take-up rate of network access options has impacts on the values of another subindex capturing a country's use situation. Hence, in deriving appropriate weights of TDI indicators or subindices such functional relationships need to be taken into account. Third, this investigation makes the point that weights of indicators or subindices entered into an overall TDI should vary depending on the socio-economic target criterion, which is to be predicted by the index. The criterion-related weighting is achieved by applying a variance-based structural equation modeling (SEM) technique – Partial Least Squares (PLS) – to empirically estimate TDI scores of 111 countries for two societal outcome criteria.

The remainder of this article is organized as follows: The next section reviews the literature on assessing a country's TD level in a composite index in order to explain potential areas of improvement with respect to the content areas covered in a TDI, the consideration of relations between its first-level subindices and the derivation of weights at the detailed indicator and at the subindex level. Section 3 describes the structure of the subindices merged in the TDI proposed here. Furthermore, it details the data sources and indicators used in the empirical construction of three subindices for two TDI each of which aims at predicting a specific desirable societal outcome criterion. Section 4 reports the results of the empirical estimation of indicator and subindices weights in the overall TDI based on a PLS SEM modeling approach. Final conclusions and suggestions for future research are presented in section 5.