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Digital divides in the world and its regions: A spatial and multivariate analysis of technological utilization

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ABSTRACT

The research purpose is to identify the correlates of technology utilization for the world and major world regions, while screening for spatial bias. Conceptual theory is induced which posits that levels of technological utilization are based on social, economic, government, and societal openness factors, while recognizing that geographic proximity can be influential for this utilization; the model's endogenous factors are posited to account for proximity. Regression findings worldwide for broadband internet subscribers indicate that the important correlates are tertiary education and innovation capacity. The disaggregated findings provide a more refined view. For Europe, significant determinants are judicial independence and innovation capacity, while for Asia they are tertiary education, foreign direct investment, and innovation capacity. For combined Africa–Latin America, higher education, press freedom, and foreign direct investment are most significant. The empirical findings lead to a more complex theoretical model that distinguishes determinants for developed and developing nations. The study suggests that a nation's governmental policies be tailored to the distinctive factors that apply for that nation's developed or developing region and/or its continental region. For planners and policy makers, the study suggests that use of spatial analysis can contribute to greater understanding and more accurate investigation of digital divides.

1. Introduction

The world has a digital divide that represents differences among countries in technology utilization, technology accessibility, economic level, and government support. The importance of national technology differences is evident in such phenomena as grass roots political unrest, economic export capacity, provision of sourced technology services, platforms for e-commerce, and structures for virtual collaboration. At the same time, geographical differences remain and might even be greater with increasing levels of technology. High intensity of technology use is associated with creative and economically productive cities and regions [1–3]. It is also correlated with countries or regions having high social and economic levels, and intensive government R&D [2–4]. Technology comprises the largest portion of the capital investment of many organizations and of some nations.

Because of the growth in technology worldwide, it is essential to understand better the influences and associations of underlying social, economic, and governmental, and societal openness attributes of a country with its technological utilization. With this understanding comes greater potential for national governments to plan for and stimulate productive use of technologies.

There have been many studies of the influences on technology utilization at the country level [5–18], but few have included both socioeconomic determinants and locational agglomeration. The prior research mostly utilized ordinary least squares (OLS) regression, with sample sizes ranging from 30 to 90 nations.

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The contributions of this study are to include geographical proximity and clustering in the theory and practice of researching the digital divide of nations. The theory introduced includes both socio-economic determinants of levels of technology utilization and the tendency of high-technology nations to locationally group together, and of low-technology nations to do so. When nations form geographic agglomerations of similar technology levels, it is possible to assess whether or not the socio-economic determinants explain the agglomerations. If they do explain the groupings, then the model is working without spatial bias. However, if the model determinants do not explain the high-tech or low-tech agglomerations, then the model is considered spatially biased. It is missing an important aspect of explaining digital differences.

The challenge of assessing these geographical aspects can be addressed by measuring spatial autocorrelation, which is the tendency of model estimation errors to be non-randomly distributed in space. For instance, if high-tech companies all cluster together in one place, and another place has only low-tech firms, then geography is playing an influential role in the association of the attributes with tech level of firms, but geography would be ignored in standard OLS regression, so the importance of determinants may be misstated with spatially autocorrelated estimation errors present, compared to a random spatial error pattern [19].

This study's exploratory empirical analysis assesses the determinants of technology utilization for the world and then disaggregates the study sample to assess the determinants in developed/developing and continental regions. The model is first tested empirically for a sample of 110 nations. OLS stepwise regression is applied, and tested for multi-collinearity, normality, heteroscedasticity, and joint influence of all the independent variables. In addition, testing is performed for spatial autocorrelation, which reveals the extent to which the estimation errors are spatially non-random. If estimation errors are randomly distributed spatially, then the worldwide regression findings can be relied on. If there is significant spatial autocorrelation of residuals at the world level and the visual map indicates that the continental regions have reduced spatial autocorrelation, then separate continental-region regressions are run, or to eliminate or seek to lower spatial autocorrelation of residuals.

The practical contributions of the study are, first, to demonstrate to researchers and planners a technique to screen for extent of spatial bias in modeling the technological level of nations. Second, for national policymakers, the findings point to distinctive determinants for developed vs. developing nations and between continental regions. Hence, a policymaker can better benchmark what national initiatives are appropriate based on that country's world region.

The objectives of the research are to develop a conceptual model of the social, economic, governmental, and societal-openness correlates of utilization of technologies for the world and its regions that includes geography; to empirically test the model, screening for the spatial autocorrelations of model error terms; to examine the implications of the findings for the planning and policies of national governments; and based on findings, to consider revisions to the conceptual model.

The paper is organized into sections on conceptual model development, research questions, methodology, findings, discussion, theoretical implications, limitations, and conclusion.

2. Conceptual model development

Prior research provides a basis for induction of a conceptual model for technology utilization in nations. Studies of countries have posited and demonstrated that social, economic, governmental, political, legal/regulatory, and other factors can jointly influence indicators of technology utilization, access, or rate of adoption [3,5–10,12,14–18,20]. Other approaches that have been followed are Gompertz model of internet diffusion which quantifies impacts of demand-side independent factors on technology adoption, based on an S-shaped curve [20], structural equation modeling [3], and purely conceptual path model [8].

The present conceptual model (see Fig. 1) proposes that, for countries, social, economic, and governmental and societal openness factors are associated with technology utilization outcomes. In addition, the model takes into account the influence of spatial clustering by level of technological utilization.

This model of technology utilization among nations is one similar to the intermediate stage in the framework of a cycle of digital divide models developed by James [21]. That framework considered, in sequence, generation of information and communication technologies (ICT), diffusion of ICT, impact of ICT on digital divide, and policy towards the digital divide. Our conceptual model analyzes roughly the stage two, how national characteristics are related to the diffusion of ICT. It should be noted that the reverse could also be conceptualized, i.e. how diffusion of ICT influences country characteristics, but this study only addresses the former. Also, this model does not study the impact of the utilization of technologies on societies, such as through technology influencing economic growth, and political change [21]. There is consideration of the impact of the conceptual model on national policies, which is the final stage in the framework of James [21].

Since there is not a widely accepted conceptual model for nations of how their characteristics affect ICT diffusion, the present model is exploratory and the characteristics influencing technologies are induced from many studies at the national level [22]. The induction of four main categories of characteristics is given later in this section.

The conceptual model also incorporates geographical proximity in two ways. First, based on a dependent technology factor, it determines whether or not nations cluster together in groupings of high technology levels or of low technology levels. For instance, does a high broadband nation such as the U.S. have proximate neighbors that are also high broadband? Or, alternatively are a nation's neighbors randomly distributed, so the neighbors would have random relationship to that nation's technology level?

In digital divide studies, this geographical clustering can be influential in the diffusion and magnitude of divide differences. For instance, Scandinavia is considered a high broadband clustered region, so it is likely that there is some diffusion of technologies from each nation to its neighbors. The concept of spatial diffusion of innovations has been investigated [21,24,25]. Rogers [23] emphasized it as a small but important line of research on spatial diffusion of innovation. He identified prior studies in which innovations were clustered, for example the early adoption of window air conditioners in clustered locations in suburbs of Philadelphia

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