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## Infrastructure and Internet Inclusiveness as Determinants of e-commerce Expansion

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### Abstract

Due to the rapidly increasing number of people around the world with Internet access, the web's global reach is affecting the growth and development of the world economy. At the macro or national level, research has been conducted to examine the growth of E-Business in Developing nations and cultural determinants of e-commerce adoption at a national level and in relation to the digital divide. In a previous study the authors focused on four particular drivers of this expansion: (1) the rapid expansion of availability of the Internet to an ever-growing number of people, (2) the increased affordability of Internet access, as technology and connection costs have plummeted, (3) the ever-widening relevance of Internet resources (function, local language access, etc.) to broad swaths of the world's population, and (4) the readiness of a nation (infrastructure, cultural acceptance) to adopt E-Commerce. Results of this study showed that, among other things, the relative importance of the "Price" and "Competitive Environment" sub-components suggest that e-commerce thrives best under a regime of inexpensive Internet connectivity available from a variety of competing suppliers. The current study expands on this analysis by examining the fifty-seven directly measurable dependent variables which constitute the 3i Index to assess which variables are the most significant as determinants of e-commerce expansion.

**Keywords:** E-Commerce, Internet Infrastructure, Internet Inclusiveness, Digital Divide

### 1. Introduction

The global reach of the Web has been greatly influenced by the increasing number of people with Internet access worldwide, and its impact on the growth and development of the world economy cannot be understated. Extensive research has been conducted to understand the growth of E-Business in developing nations and the cultural determinants of e-commerce adoption at a national level, particularly in the context of the digital divide. Previous studies have identified four key drivers of this expansion, including the availability and affordability of Internet access, the relevance of Internet resources to diverse populations, and the readiness of a nation to adopt e-commerce in terms of infrastructure and cultural acceptance.

To further investigate these drivers, this research utilizes the Inclusive Internet Index (3i) (Economist Impact, 2023), a multi-dimensional measure of the electronic infrastructure of various nations, commissioned by Facebook and covering 100 countries representing a significant portion of the world's population and global GDP. The 3i Index, based on input from over 5,000 respondents,

benchmarks countries on the availability, affordability, relevance, and readiness of people to use the Internet. In this study, the authors examine the fifty-seven directly measurable variables that constitute the 3i Index to determine which variables are the most significant as determinants of e-commerce expansion. We use (log) revenue from e-commerce, on a per capita basis, as our dependent variable measuring the size of the e-commerce economy.

The findings of this research shed light on the relative importance of different variables in driving e-commerce growth. Specifically, the study delves into sub-components such as "Price" and "Competitive Environment" to highlight the significance of inexpensive Internet connectivity and competition among suppliers in fostering a conducive environment for E-Commerce. The results of this study contribute to the understanding of the complex relationship between Internet infrastructure and e-commerce expansion, providing valuable insights for policymakers, businesses, and researchers alike.

## 2. Literature Review

Our research centered upon the following question: What is the relationship, at a national level, between the functionality of Internet infrastructure and the growth of E-Commerce. The idea that this relationship does exist is not a matter of conjecture in this study. We assume that there is a relationship between these variables such that better Internet infrastructure should facilitate e-commerce revenue growth (Dumičić, et al., 2018; Waseem, et al., 2019). One of the bases of this assumption is shown in Figure 1 which depicts the results of the 2019 Network Readiness Index analysis. This part of the analysis shows a clear relationship between the Network Readiness Index (NRI) and GDP Per Capita. This index, developed by the World Information Technology and Services Alliance was created to "provide, for the first time, a holistic framework for assessing the multi-faceted impact of ICT on society and the development of nations." Another index that attempts to measure the use of technology is the Technology Readiness Index (TRI 2.0), a 16-item scale designed to measure people's propensity to embrace and use cutting-edge technologies (Parasuraman and Colby, 2014). This tool is designed to be used at the micro level for the purposes of customer segmentation with respect to technology readiness.

A variety of research studies have approached the global aspects of e-commerce at the micro level, dealing with firms and industries in terms of issues such as consumer behavior (Shiu-Li, et al., 2019), socialization (Xintian & Xiangdong, 2019), technology use, business factors (Gorla, et al., 2015), e-commerce intensity (Kuresova & Eger, 2017) and web site globalization (Augustine, et al., 2008). At the macro or national level, research has been done to examine e-commerce and economic growth (Hibner, 2012), the growth of e-commerce in Developing nations (Dumičić, et al., 2018), and cultural determinants of e-commerce adoption at a national level and in relationship to the digital divide (Makame, et al., 2014).

Our previous research extended this line of inquiry. Specifically, we examined the relationship between e-commerce revenue and infrastructure at the national level using a multifaceted assessment of Internet participation, the Inclusive Internet Index (3i Index).

## 2.1. The Inclusive Internet Index

According to Business Standard (2020), the Inclusive Internet Index “benchmarks countries on the internet's availability, affordability, relevance, and the readiness of people to use it. The annual report is commissioned by Facebook. In its fifth year, the index covered 100 countries, representing 99% of the world's population and 97% of global GDP.” This index represents a multi-dimensional measure of the electronic infrastructure of various nations. The 3i Index, which polled more than 5,000 respondents from 100 countries, was developed as an approach to measure the effectiveness of existing Internet Infrastructures.

The overall index score is produced based on scores assigned for the Availability, Affordability, Relevance and Readiness categories. The Availability category “examines the quality and breadth of available infrastructure required for access and levels of Internet usage”. Affordability “examines the cost of access relative to income and the level of competition in the Internet marketplace.” Relevance “examines the existence and extent of local language content and relevant content” and Readiness “examines the capacity to access the Internet, including skills, cultural acceptance, and supporting policy.” (Economist Impact, 2023)

These four indexes are based upon both measurable values (such as the number of Internet users or Smartphone cost) and assessed perceptions on how the Internet use impacts individuals (such as the availability of basic information in the local language or social level of trust in online privacy). Each of the four main categories is further broken down into sub-categories. For example, Availability is expressed as a combination of Usage, Quality, Infrastructure and Access to Electricity. Each sub-category, in turn, is composed of various baseline statistics. As an example, the Readiness sub-category of Literacy consists of the following measures: Level of Literacy, Educational Attainment, Support for digital literacy and Level of web accessibility.

## 2.2. Previous Research

Our previous research examined the basic relationship between e-commerce and infrastructure at the national level (Augustine, Rasp, and Nguyen, 2020). In this paper we examined the relative importance of the four drivers of e-commerce adoption and expansion identified in the Inclusive Internet Index as driving the expansion of Electronic Commerce. These drivers are (1) the rapid expansion of availability of the Internet to an ever-growing number of persons, (2) the increased affordability of Internet access, as technology and connection costs have plummeted, (3) the ever-widening relevance of Internet resources (function, local language access, etc.) to broad swaths of the world's population, and (4) the readiness of a nation (infrastructure, cultural acceptance) to adopt E-Commerce.

This analysis examined the relationship of eleven sub-component variables in the Index (Usage, Quality, Infrastructure, Electricity, Price, Competitive Environment, Local Content, Relevant Content, Literacy, Trust and Safety, and Policy), with (log) e-commerce Revenue per Capita. Correlations between each subcomponent, and Log Revenue per Capita generally show moderate to strong correlations (ranging from .897 for Usage to .497 for Policy. The exception is the Trust & Safety variable, which is essentially uncorrelated with Log Revenue per Capita. The t-scores and p-values for

all the subcomponents were highly significant except for the “Trust and Safety” variable. The results of the regression of the eleven sub-component (dependent) variables to (log) Revenue per Capita shows that four of the variables (Usage, Price, Competitive Environment and Literacy) were significant based on their (one-tailed) p-values.

The number of dependent variables and the multicollinearity between the variables, combined with the preliminary and exploratory nature of the research, convinced us that it was premature to posit definitive interpretation of these results. Nevertheless, the findings did offer several insights, and suggest various lines of further inquiry.

That the “Usage” variable is the sub-component most highly correlated with E-commerce revenue, and with most significant contribution in the multiple regression analysis, suggests that it is the prime driver of the E-commerce economic boom. This makes good sense – for E-commerce even to exist, individuals must, of necessity, be using the Internet. It also suggests a policy priority: that simply getting people connected is the first order of business, in terms of fostering E-commerce growth. We further noted that, in the multiple regression, the “Infrastructure” and “Electricity” variables were not significant once other factors were considered. This stands rather in contrast to the “if you build it, they will come” mantra of some development theorists. Here, it seems, simply having the structures in place for e-commerce to exist is not enough to drive revenue; the populace must be moved to “Usage” of the Internet resource. The issues in developmental economics suggested here are well worth further study.

Relative importance of the “Price” and “Competitive Environment” sub-components suggested other policy priorities as well. The implication is that e-commerce thrives best under a regime of inexpensive Internet connectivity available from a variety of competing suppliers. These issues appear to trump more nationalistic concerns, such as the availability of locally sourced or culturally relevant content. Matters of localism versus globalism are becoming increasingly prominent in contemporary economic policy debate. Computer professionals likewise deal with the dynamics of local control versus the worldwide scope of the Internet. These matters are worthy of much greater study, but this finding does lean toward the global-competitive rather than local-protectionist approach.

It was clear to us that three of the four first-level variables (Availability, Affordability and Readiness) contribute to the economic value of e-commerce at a national level when expressed per capita. It appears that there is a significant relationship between the Overall 3i Index measure and Per Capita e-commerce revenue. It also appears that there is a basic threshold needed, in each of the four first-level component areas, before meaningful economic growth for e-commerce occurs. This phenomenon also occurs for each of the four constituent measures. It appears that all four first-level components are highly significant predictors of economic activity. However, there is multicollinearity and Relevance does not add significant explanatory power, once the other three variables are in the model.

### **2.3. Overview of the Current Research**

The current study expands upon this research. Each of the top-level constructs (Availability, Readiness, Relevance, Affordability) in the 3i Index is in turn composed of multiple constituent

variables. The result is a huge number of possible predictors. Fitting a single model to these data would result in massive problems with overfitting and multicollinearity. To forestall these problems, we divide the problem by conducting four separate multiple regression models, one for each main component of the 3i Index. Further, we restrict the analysis by using as predictors only those constituent variables that are directly measurable. Thus, there are 21 independent variables in our model for the relationship of "Availability" to e-commerce, 17 for the "Readiness" model, 11 for "Relevance," and 7 for "Affordability." By looking at multiple models in greater detail, we provide more finely-grained insights into the factors driving e-commerce growth.

### **3. Results**

The data were analyzed using four separate multiple regression models. In each model, the dependent variable is the Log of Per Capita e-commerce measured in US dollars. Findings from each model are discussed separately below.

#### **3.1. Availability**

(Log) Ecommerce per capita is highly correlated with the "Availability" measure of the 3i index. "Availability" explains 78.7% (r-square) of variation in the Ecommerce variable. There are four second-level variables in this category, Usage, Quality, Infrastructure, and Electricity. All four of these predictors are highly correlated with per capita E-Commerce. However, they are also highly correlated with one another, indicating a high degree of multicollinearity. The use of One-tailed p-values are in order, as we have a priori reason to believe in a positive relation for all variables. In this case, "Usage" is the only statistically significant predictor of per capita E-Commerce. However, other variables are marginally significant. That is, the "Usage" variable captures the greatest explanatory power. Once it is in the model, the other variables contribute only marginally. These four second-level variables can be represented by twenty-two third-level variables.

This analysis suggests that Internet Users and Fixed-line broadband subscribers are the variables that matter most in contributing to per capita E-Commerce. However, all the variables are statistically significant. It seems that getting users connected is the most important factor in the expansion of E-Commerce. It is possible that some of the results may be a result of proxies for national wealth. So, for example, rural electricity access matters more than urban, but it is the wealthy nations that feature high rural electric access.

#### **3.2. Readiness**

As noted in our initial study, (Log) Ecommerce per capita is correlated with the "Readiness" measure of the 3i index. "Readiness" explains 48.4% (r-square) of the variation in the Ecommerce variable. This is the lowest of the four top-level categories. But it's still exceedingly statistically significant. There are three second-level component variables that compose the Readiness category, Literacy, Trust and Safety, and Policy. The regression analysis of these variables indicates that only the Literacy category is significantly related to per capita E-Commerce. The analysis of the third-level component variables (Level of literacy, Educational Attainment, Trust in online privacy, Trust in Government websites and apps, Trust in Non-governmental websites and apps, Trust in information from social media, and e-commerce safety) shows only one variable "Educational Attainment"

(measured by average years of schooling of the population) to be statistically significant. It seems that the more education people have, the more Ecommerce there is. This is not particularly surprising - education is a 'wealth' measure. The results of this analysis are shown in Table 1.

**Table 1. Analysis of Third-Level Readiness Variables**

	<i>Coeff.</i>	<i>Std Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>
Intercept	0.0425	0.3145	0.1350	0.8930	-0.5850	0.6700
4.1.1) Level of literacy	0.0031	0.0044	0.6991	0.4869	-0.0058	0.0120
4.1.2) Educational attainment	0.0244	0.0042	5.8232	0.0000	0.0160	0.0327
4.2.2) Trust in online privacy	0.0020	0.0034	0.5919	0.5558	-0.0048	0.0088
4.2.3) Trust in Government websites and apps	0.0051	0.0039	1.3115	0.1941	-0.0026	0.0128
4.2.4) Trust in Non-government websites and apps	-0.0082	0.0067	-1.2245	0.2249	-0.0216	0.0052
4.2.5) Trust in information from social media	-0.0005	0.0051	-0.0953	0.9243	-0.0107	0.0098
4.2.6) e-Commerce safety	0.0024	0.0033	0.7167	0.4760	-0.0042	0.0089

### 3.3. Relevance

(Log) Ecommerce per capita is correlated with the "Relevance" measure of the 3i index. "Relevance" explains 55.5% (r-square) of the variation in the Ecommerce variable. Once again, it isn't as high as Availability, but is still exceedingly significant. For the Relevance category, there are two second-level variables, Local Content and Relevant Content. Here, again, One-tailed p-values are in order, as we have an a priori reason to believe in a positive relation for all variables. Both variables are statistically significant. It appears that the more local content there is, and the more relevant content there is, then the more e-commerce there is. This is not especially surprising, since this is correlation, not causation. What may be interesting is the development cycle here: perhaps this is simply reflecting robust and broad-based development of the national internet ecology reveals only one statistically significant variable, "e-Commerce content." This variable "seeks to measure the availability - and extent of - electronic commerce ... in the country" and is based on a B2C E-commerce index developed by a U.N. agency (UNCTAD). Note that the "Value of e-Commerce" variable is NOT at all significant. Data value based upon a survey ("How often do you purchase goods via the internet?") so it's a frequency measure not a value measure. The results of this analysis are shown in Table 2.

**Table 2. Analysis of Third-Level Relevance Variables**

	<i>Coeff.</i>	<i>Std Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>
Intercept	0.8069	0.5296	1.5236	0.1320	-0.2508	1.8646
3.1.1) Availability of local news in local languages	-0.0048	0.0059	-0.8067	0.4230	-0.0166	0.0070
3.1.2) Concentration of websites using country-level domains	-0.0006	0.0013	-0.4535	0.6520	-0.0031	0.0019
3.1.3) Availability of e-Government services in the local language	0.0015	0.0017	0.8854	0.3790	-0.0019	0.0050
3.2.1) e-Finance content	-0.0031	0.0025	-1.2397	0.2200	-0.0080	0.0019
3.2.2) Value of e-finance	-0.0011	0.0024	-0.4548	0.6510	-0.0058	0.0036
3.2.3) e-Health content	0.0014	0.0022	0.6211	0.5370	-0.0030	0.0057
3.2.4) Value of e-health	-0.0017	0.0028	-0.5911	0.5570	-0.0073	0.0039
3.2.5) e-Entertainment usage	0.0039	0.0035	1.1019	0.2750	-0.0032	0.0109
3.2.6) e-Commerce content	0.0247	0.0028	8.9457	0.0000	0.0192	0.0303
3.2.7) Value of e-Commerce	-0.0015	0.0037	-0.3994	0.6910	-0.0088	0.0059
3.2.8) Open data policies	0.0015	0.0012	1.2289	0.2240	-0.0009	0.0039

### 3.4. Affordability

(Log) Ecommerce per capita is correlated with the "Affordability" measure of the 3i index. "Affordability" explains 56.2% (r-square) of the variation in the Ecommerce variable. This isn't as high

as Availability - but is still exceedingly significant. There are only two second-level variables associated with Affordability (Price and Competitive environment). One-tailed p-values are used here, as we have an a priori reason to believe in a positive relation for all variables. We see an interesting result here. The "Price" component of Affordability is what's driving things here; "Competitive Environment" is not at all significant (and hence not particularly relevant). This would seem to argue against a strong influence of free markets. However, if low prices are driven by government subsidies, this may not be sustainable and may not be economically efficient. Third-level variables are Smartphone cost (handset), Mobile phone cost (prepaid tariff), 2.1.3) Mobile phone cost (postpaid tariff), 2.1.4) Fixed-line monthly broadband cost, 2.2.1) Average revenue per user (ARPU, annualized), 2.2.2) Wireless operators' market share, and Broadband operators' market share). These variables can be classified as either consumer costs or provider measures. We have not used one-tailed p-values here, as not clear there's an a priori reason to presume a positive (or negative) slope. In the case of these variables, it is not intuitively obvious why any of these variables might 'matter.' The only two that are statistically significant are 'Smartphone cost' and 'Average revenue per user'. 'Smartphone cost' has a positive impact on per capita e-commerce revenue which may indicate that in places where individuals buy more expensive smartphones, they may also buy more e-commerce goods. This may simply indicate that wealthier places have more disposable income, and more of it is spent online. Finally, the 'Average revenue per user' displays an inverse relationship with per capita e-commerce spending. This variable (per the data description given in the data source) is overall consumer spending on mobile services (both pre-paid and post-paid). Along with the previous result, this seems to suggest that high-end phones along with cheap cost of usage drives per capita e-commerce spending. The results of this analysis are shown in Table 3.

**Table 3. Analysis of Third-Level Affordability Variables**

	<i>Coeff</i>	<i>Std Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>
Intercept	-1.2513	1.1498	-1.0883	0.2802	-3.5451	1.0424
2.1.1) Smartphone cost (handset)	0.0197	0.0035	5.5943	0.0000	0.0127	0.0267
2.1.2) Mobile phone cost (prepaid tariff)	0.0247	0.0173	1.4253	0.1586	-0.0099	0.0592
2.1.3) Mobile phone cost (postpaid tariff)	-0.0025	0.0093	-0.2710	0.7872	-0.0211	0.0161
2.1.4) Fixed-line monthly broadband cost	0.0051	0.0122	0.4171	0.6779	-0.0193	0.0295
2.2.1) Average revenue per user (ARPU, annualized)	-0.0080	0.0031	-2.5887	0.0117	-0.0141	-0.0018
2.2.2) Wireless operators' market share	-0.0023	0.0039	-0.5991	0.5510	-0.0101	0.0054
2.2.3) Broadband operators' market share	0.0034	0.0023	1.5102	0.1356	-0.0011	0.0079

#### 4. Conclusions

Out of a total of fifty-seven third-level predictor variables analyzed in this study, only twenty-six had a statistically significant effect on per capita e-commerce spending. Of these, twenty-two were Availability measures, followed by two Affordability, and one each in the Readiness and Relevance categories. The coefficient of determination (adjusted R<sup>2</sup>) for the level-one categories was .906 for Availability, .786 for Affordability, .714 for Readiness, and .549 for Relevance. The analysis of Availability suggests that Internet Users and Fixed-line broadband subscribers are the variables that matter most in contributing to per capita E-Commerce, suggesting that ensuring that users are

connected is the most important factor in the expansion of E-Commerce. The analysis of the third-level component variables of the Readiness category shows only one variable "Educational Attainment" (measured by average years of schooling of the population) to be statistically significant. The conclusion here is that the education-wealth correlation is important as an e-commerce driver. The "Price" component of Affordability seems to be the major factor influencing per capita e-commerce spending. What is not clear is the effect of government subsidies. Finally, the analysis of the third-level Relevance variables reveals only one statistically significant variable, "e-Commerce content." This variable "seeks to measure the availability - and extent of - electronic commerce ... in the country" so its significance is not surprising.

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