DETERMINANTS OF MOBILE BROADBAND DIFFUSION: A FOCUS ON DEVELOPING COUNTRIES

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Abstract

Past research on the broadband digital divide indicates a widening divide in which developing countries are falling further behind countries in the developed world. In response to this problem, the World Bank has advocated a "mobile first" strategy for developing countries. Unfortunately, there is little understanding of what determines mobile broadband adoption or diffusion in developing countries. In this paper, we begin to address this problem by exploring to what extent policy, regulation, government, and governance affect mobile broadband diffusion in the developing world. Our results show that when controlling for distribution and level of income, there is greater mobile diffusion in developing (i.e., non-OECD) countries that encourage competition in their telecommunication industries and practice sound governance in their public sector. Although governance is an important determinant of mobile broadband diffusion, we find no evidence that political structure (i.e., the level of democracy) matters. We also find that regulation of telecommunications licensing is associated with decreased access to mobile broadband. Further examination of our data suggest that national governments have either modernized and streamlined this regulatory measure or are performing important functions related to mobile services (e.g., spectrum allocation) without the need to regulate licenses for telecommunication service providers. We discuss these important results in light of prior literature and suggest new avenues of research that stem from our findings.

Keywords: *Mobile broadband, governance, public policy, regulation, technology diffusion*

1 Introduction

The availability of information and communication technologies (ICTs) both requires and enables economic, political, and social advances in society. ICTs create efficiencies, e.g., virtual teams, remote work opportunities, and fast communication processes within global companies as well as between companies involved in inter-organizational supply chain processes. While the potential, value, and relevance of ICTs is not debatable, past research highlights that the differences in its availability in developed and developing countries (Gulati and Yates, 2012; Rouvinen, 2006). This phenomenon is known as digital divide (Norris, 2001; Warschauer, 2004). While in this paper we do not aim to explicitly discuss digital divide-related issues, we believe that it is extremely important that the IS community shed light on factors that might lead to diffusion of and advances in ICTs in developing countries. Using diffusion data from the 2013 International Telecommunication Union report (ITU, 2013) and drawing from prior literature, we are able to formulate and test three key hypotheses involving the relationship between a country's policy initiatives, regulation, and government structure and performance (independent variables) – and the level of mobile broadband diffusion (dependent variable). These three hypotheses – discussed and operationalized below – allow us to answer the following research question: *What factors determine the diffusion of mobile broadband in developing countries?*

In answering this question, we contribute to filling a research gap surrounding broadband diffusion in developing countries. Our results show that when controlling for distribution and level of income, there is greater mobile diffusion in developing (i.e., non-OECD) countries that encourage competition in their telecommunication industries and practice sound governance in their public sector. Although governance is an important determinant of mobile broadband diffusion, we find no evidence that political structure (i.e., the level of democracy) matters. We also find that regulation of telecommunications licensing is associated with decreased access to mobile broadband. Further examination of our data suggest that national governments have either modernized and streamlined this regulatory measure or are performing important functions related to mobile services (e.g., spectrum allocation) without the need to regulate licenses for telecommunication service providers.

This study aims to address a key global issue associated with processes of ICT diffusion that are fundamental to human development. In fact, identifying factors that can promote the diffusion of such an important ICT (i.e., mobile broadband) might be helpful for governments, policy makers, and public servants, to understand current gaps and limitations and to assist service providers, promote investment, and create or modify laws and regulation that enable broadband diffusion.

The remainder of this paper is organized as follows: The next section provides an overview of diffusion of innovation theories, and then focuses on past literature on fixed and mobile broadband diffusion. Section 3 outlines the data and methods used in this study. In particular, we describe and operationalize the variables used in this study and show their link with prior literature. Section 4 presents and analyzes the findings, while section 5 discusses the implications of our findings and suggests avenues of future research.

2 Background

2.1 Diffusion of innovation theories and broadband

Innovation diffusion and digital divide theorists provide perspectives we use to inform our inquiry. For instance, Rogers (2003) argues that, using an S-curve model, early innovators and adopters are the first to embrace an innovation. Middle and late majority adopters then follow, increasing the acceptance rate. Finally, so-called laggards are the last to buy in before a saturation point sets in - at which time the current technology can drop in price, market share, and attractiveness due to the next generation of technology. With regard to the digital divide, inhabitants of developing countries who cannot afford or are unable to access new technologies may still be excluded, even after the so-called saturation level of a technology is reached in more developed countries. Furthermore, a repeating cycle of innovation diffusion perpetuates the "rich get richer" phenomenon (van Dijk, 2005). Taking a step back, it is clear that innovations in the so-called global information society are in fact innovations at different levels of technological development distributed among highly stratified societies that both reflect and reinforce existing socioeconomic disparities (Norris, 2001). In the language of van Dijk (2005), the layers in such societies reflect different levels of *material access* to ICTs. Early adopters with sufficient material access to ICTs often use emerging technologies. In contrast, laggards and those with insufficient material access often use legacy technologies, if they are available and affordable.

While van Dijk (2005) critiques Rogers' use of the S-curve, he adopts a revised version of the same. Van Dijk, while supporting the logic underlying an S-curve diffusion model, believes that "there may be different S-curves for particular social categories of people" (p. 65). Still, he suggests that governments and targeted policies and regulation are necessary to enable access to both fixed and mobile broadband services. Both cross-national statistical studies and case studies from across the globe have shown that material access to ICTs has differed mainly on income (Chinn and Fairlie, 2007; Norris, 2001) and income inequality (Fuchs, 2009), with the majority of the population in developing nations excluded from today's information society. Previous research on the broadband digital divide has focused on fixed line broadband in developed countries and the role of several

factors in bridging this divide, including different forms of broadband industry competition (Cava-Ferreruela and Alabau-Muñoz, 2006; Distaso, Lupi and Manenti, 2006; Grosso, 2006; Lee, Marcu and Lee, 2011). While these studies and others provide many insights into fixed broadband diffusion, there are a handful of studies that explore mobile broadband service, and we explore this issue next.

2.2 Mobile broadband

Besides the very scant literature on mobile broadband in developing countries, here we narrow our focus to mobile broadband for two reasons: First, mobile broadband diffusion allows wider access by citizens (e.g., using smart-phones and other wireless devices); and second, less infrastructures is required for its diffusion – since mobile 'hot spots' can cover even rural areas and its diffusion does not necessarily involve citizens (e.g., WiMax – see Andrews, Ghosh and Muhamed, 2007). However, to date there is little diffusion of broadband in developing countries (World Bank, 2012). Figure 1 (below) clearly shows the relationship between per capita income and mobile broadband diffusion. While it is interesting to note that some countries with a UN Income Index between 0.4 and 0.6 (United Nations, 2010) have little or no mobile broadband diffusion, some countries are providing greater access to mobile broadband in the presence less affluence.

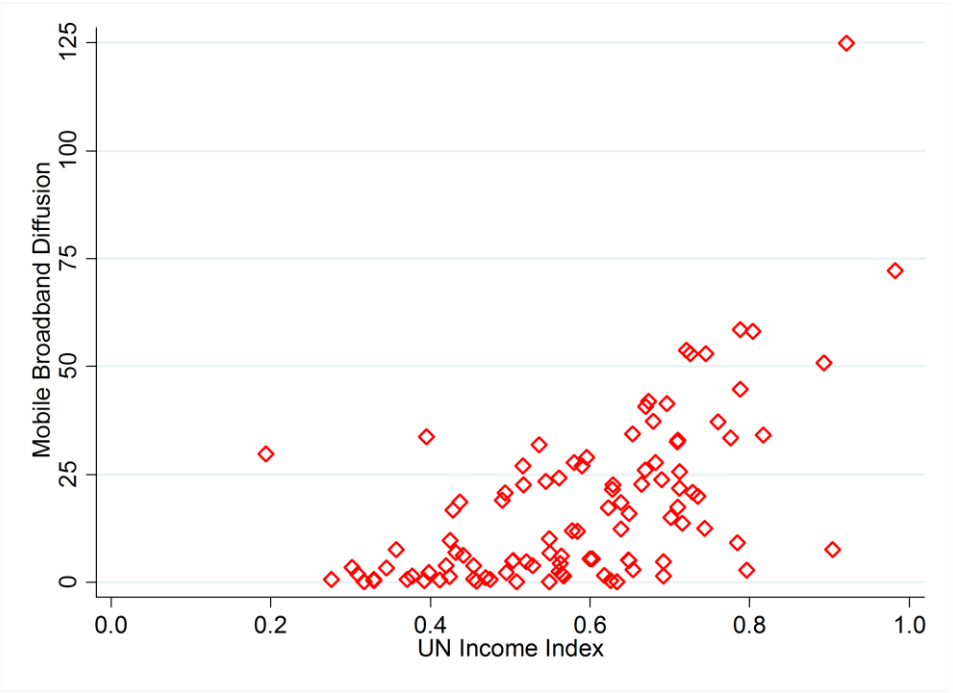

Figure 1. Mobile broadband diffusion versus United Nations Income Index for developing countries.

Even though Figure 1 confirms that per capita income is an important driver of mobile broadband diffusion, the scatter in this figure shows that factors other than income must be at work. For instance, political structure (Guillén and Suárez, 2005), regulation and governance (Waverman and Koutroumpis, 2011), financial investment (Gulati and Yates, 2012) have been found to be important explanatory variables, in particular with respect to diffusion of narrowband and broadband Internet access.

Factors that have been shown to influence mobile broadband diffusion in developed countries include different forms of competition, level of income, fixed broadband price, national policy, standards, and infrastructure (Cabral and Kretschmer, 2007; Gruber and Koutroumpis, 2010; Lee, Marcu and Lee,

2011; Rossi, 2012; Smith, 2010). Gruber and Koutroumpis (2010) argue that multiple wireless standards and various types of services using different technologies facilitate competing systems that can provide for increased and improved mobile services. With regard to public policy and competing standards, Cabral and Kretschmer (2007) found that mobile diffusion levels in the U.S. (where multiple standards are used) are similar to Europe (where mostly single standards are used). Cava-Ferreruela and Alabau-Muñoz's (2006) study of OECD countries found that technological competition, low costs of deploying infrastructure, and predisposition to invest in new technologies are key factors for fixed broadband access and use. Finally, Lee, Marcu and Lee's (2011) study showed that for 30 high-income OECD countries, having multiple standards in the market is associated with a high level of mobile broadband penetration.

Earlier studies in the literature, e.g. (Chinn and Fairlie, 2007; Norris, 2001; Rouvinen, 2006), focus primarily on gaps in penetration of ICTs that predate but are closely related to mobile broadband, namely the Internet and mobile telephony. These studies show that competition to provide telecommunication services lowers the cost of access to ICTs, and that higher income results in higher usage of these services. Rouvinen (2006) found that market competition increases mobile telephony diffusion in developing and developed countries; but that standards competition hinders diffusion in the developing world.

2.3 Gap identification and hypotheses

The literature review above shows that several factors have the potential to positively or negatively contribute to broadband diffusion in the developing world. Policy initiatives, regulation, and the national context in which these are collectively reduced to practice are the most likely determinants of mobile broadband diffusion (Rossi, 2012). However, as previously noted, to our knowledge there are no previous studies that discuss these factors with respect to broadband diffusion in developing countries. Nor have previous studies focused on mobile broadband diffusion, which is believed to be one of the most relevant technological components for promoting economic development, social inclusion, and thus reducing the global digital divide (Warschauer, 2004; World Bank, 2012). Therefore, we formulate three hypotheses that draw from the literature and also shed light on factors related to targeted regulation, political structure, and government performance. In particular, here we focus on policy (first hypothesis), targeted regulation (second hypothesis), and government structure and performance (third hypothesis). Specifically, our three hypotheses are:

(H_1): National policy initiatives to promote information and communication technologies (ICTs), including competition among service providers and financial investment in ICTs, increase a nation's mobile broadband diffusion;

(H_2): Regulatory measures that engage governments in the telecommunication standards process and empower governments to manage licenses for telecommunication service providers increase a country's mobile broadband diffusion; and

(H_3): A more democratic political structure and sound governance in the public sector increase the diffusion of mobile broadband services.

While previous research provides rich detail on the connection between public policy initiatives and technological development as well as the challenges to realizing specific policy objectives, it is impossible to make any valid generalizations on the contribution that policy and other factors (both related and contextual) have on bridging the mobile broadband digital divide in the developing world. In the next section, we operationalize the dependent and independent variables (see Section 3.1), and also the control variables (see Section 3.2). The subsequent section, Section 4, is devoted to testing the three research hypotheses described above.

3 Methods, Variables, and Operationalization

3.1 Data and methods

We test our hypotheses that national policy initiatives to promote ICTs, targeted regulation, and government structure and performance increase mobile broadband diffusion with OLS multiple regression analysis on data from 103 countries. Although mobile broadband data were available for 121 developing (i.e., non-OECD) countries, there were 18 countries with no mobile diffusion, which prevented these countries for being included in the log-linear regression model described in Section 4. In other words, the multiple regression model developed in this study applies only to countries with mobile diffusion that is strictly greater than zero.

The indicator for broadband diffusion and dependent variable is the number of mobile broadband subscriptions per 100 inhabitants in 2012, as reported by the International Telecommunication Union (ITU, 2013). The large number of countries with very little mobile broadband service yields a long tail of small values in the distribution of the number of subscribers per 100 people. We therefore take the natural logarithm of this diffusion variable to be the dependent variable in our analysis. The ITU standardized on using the number of subscriptions to a telecommunication service per 100 inhabitants as the measure of service adoption since it defined the ICT Development Index for almost 200 economies in 2009/2010 (ITU, 2010).

All independent variables used in our multiple regression model were sampled from prior years (i.e., 2007-2010), reflecting the fact that their effects are delayed with respect to their value in a given year. The independent variables described in the remainder of this section, and the control variables described in Section 3.2, were chosen either because they were important for theoretical reasons (e.g., per capita income) or were shown to be significant in studies of fixed broadband diffusion (e.g., competition) or mobile broadband diffusion (e.g., telecommunication standards development), or in bridging other dimensions of the digital divide (e.g., shared financial investment).

3.1.1 Competition, financial investment, and universal service

We test hypothesis H_1 using three different variables, calculated for each of the non-OECD countries, which together reflect policy initiatives important to mobile broadband. The first is a broad measure of competition among telecommunication service providers. The second is a measure of financial investment in ICTs shared by the private sector, the public sector, and consumers. The third is the presence or absence of telecommunications universal service strategy that addresses broadband services.

Because broadband technologies have been deployed by service providers in different industries, we use six indicators to measure the extent of competition in the telecommunications sector. In addition, relying on multiple indicators gauges a country's general commitment to privatization, deregulation and promoting market competition in key industries. We aggregate several indicators into an index of competition that takes into account the level of competition in the industries that provide:

(C1) Basic telephone service;
(C2) Mobile services;
(C3) Narrowband Internet service;
(C4) DSL-based Internet service;
(C5) Cable modem-based Internet service; and
(C6) Cross-platform competition.

2010 data for each of these variables were obtained from the International Telecommunication Union's ICT Eye database (ITU, 2012). The variables (C1) through (C5) were all coded as follows:

"0" if data were not available in the ITU ICT database;
"1" if the country has a state-owned or private monopoly;
"2" if there is partial competition in a country's industry; and
"3" if there is full competition in the industry.

The last variable, (C6), cross-platform competition, is coded as a "1" if variable (C4) is greater than zero and variable (C5) is greater than zero; otherwise variable (C6) is set to "0". These six variables were subjected to a factor analysis with varimax rotation to confirm that all the items loaded on a single factor. One component was extracted that included all six items, with factor scores ranging from .67 to .87. A factor score coefficient was computed for each country using the regression method. In our analysis, we refer to the single value that captures the overall competition in these industries as the *telecommunications competition index*.

We reviewed a number of indicators in the World Bank's World Development Indicators (WDI) database that could measure the financial investment and economic activity within and around the telecommunications sector. No single indicator provided a comprehensive picture of investment and related activity, but focused on only a small segment of such investment. To address this concern, we constructed an additive index of seven indicators of a nation's investment related to technological development. These seven indicators are: Telecommunications revenue (as a percentage of GDP); ICT expenditures (as a percentage of GDP); telecommunications investment (as a percentage of revenue); research & development spending (as a percentage of GDP); natural log of international Internet bandwidth (bits per second per person); high-technology exports (as a percentage of manufacturing exports); and, computer, communications and other services (as a percentage of service exports).

Of the nearly 240 variables available in the WDI database, we selected these seven because of their connection to financial investment and induced economic activity in information or communication technology. Because most of the benefits of such investment may not be realized until a few years into the future, we measure investment over a number of years by averaging the data available between 2000 and 2007. Once averages were computed for each indicator, we computed an aggregate *financial investment index* based on an average in the form of Z-scores of the seven indicators for each country.

From a policy perspective, a critical indicator of whether a country is committed to putting mobile broadband in the hands of all citizens is a universal service policy that directly addresses broadband Internet access (FCC, 2010; ITU, 2013). We use an indicator variable to capture whether or not such a national policy has been formulated for either fixed line or mobile broadband based on data available in the International Telecommunication Union's (ITU's) ICT Eye database (ITU, 2012). Of the almost 200 countries for which the ITU reports data, only 43 of these countries had a universal broadband service policy in place in 2010.

3.1.2 Regulation of technical standards and telecommunication licenses

We test hypothesis H_2 using two indicator variables, sampled for each of the non-OECD countries, which together reflect important regulatory measures. The first variable is whether or not technical standards are regulated by the central government. The second is whether or not the government has the authority to grant and maintain telecommunication licenses. Data indicating whether or not each country's government had these regulatory measures in place in 2010 were obtained from the ICT Eye database (ITU, 2012). These indicator variables were coded "1" if the respective measure was employed by the national regulatory authority or sector ministry and "0" if it was not.

3.1.3 Political structure and government performance

We test hypothesis H_3 using two variables chosen to capture and distinguish the impact of government structure and government performance (i.e., governance) on mobile broadband diffusion in developing countries.

To account for the impact of political (or government) structure and a culture of democratic politics, we included the Unified Democracy Scores (UDS) for 2008 as an independent variable. The UDS is derived through a Bayesian latent variable approach and draws from 10 frequently used indicators of democracy (e.g., Polity IV and Freedom House) to produce a single composite scale (Pemstein, Meserve and Melton, 2010).

We use the rule of law and control of corruption indicators from the Worldwide Governance Indicators (WGI) project (Kaufmann, Kraay and Mastruzzi, 2011) to assess governance practices in each country. These indicators of national governance measure perceptions by experts in the public and private sectors and NGOs worldwide and also citizens in individual countries regarding the ability of a nation's government to govern according to the law and control political corruption. Rule of law and control of corruption, in combination, have been shown in many cases to be essential for having national policy and regulation be effective in advancing private sector development. This has been demonstrated for telecommunications policy and law in both the pre-Internet era (Levy and Spiller, 1996) and the Internet era (Waverman and Koutroumpis, 2011). Since these WGI variables are standardized, we use a simple average to combine them.

3.2 Control variables

We include two control variables in our regression model that have a theoretical link to ICT diffusion or an empirical link shown in previous research.

Previous cross-national studies of technology adoption have assumed that countries with an affluent population will be in a stronger position to spend more on emerging ICT technologies. Furthermore, people who have a higher level of income are more likely to demand that more services be made available over the Internet (van Dijk, 2005). We use the United Nations' Income Index for 2010 (United Nations, 2010) to capture the impact of the affluence of a nation's citizens on the dependent variable in our regression model.

Nations that have less of a disparity among its citizens in income, and the distribution of other resources, more generally, also should have less of a disparity in access to mobile broadband service and other forms of ICTs. Past research shows income inequality does predict inequalities in Internet access and use (Fuchs, 2009). We measure the level of income inequality with the commonly-used Gini coefficient (Dorfman, 1979). These data were obtained from *The CIA World Factbook* [see https://www.cia.gov/library/publications/the-world-factbook/ (CIA, 2012)] and (United Nations, 2010).

4 Data Analysis and Findings

The results of the multiple regression analysis of the log-transformed value for the number of mobile broadband subscriptions per 100 inhabitants based on three policy variables (rows labeled **[P])**, two regulatory variables (labeled **[R])**, and government structure and performance variables (**[G])**, as well as two control variables, are reported in Table 1. The nine independent variables sampled for 99 countries together explain 35% of the variance in mobile broadband diffusion. Although mobile broadband data were available for 121 developing countries, there was either no mobile broadband or missing data for at least one independent variable for 22 countries.

The first seven rows of data in Table 1 report the coefficients for variables specific to policy (see H_1), regulation (H_2), and governance (H_3). Since the dependent variable has been log-transformed, the unstandardized beta coefficients (***b***) should be interpreted as the percentage change in the dependent variable associated with a .01-unit change in the independent variable. Thus for a one-unit increase, the percentage change would be 100 * ***b*** (see, for example, http://www.ats.ucla.edu/stat/).

	Unstandardized Coefficients			
	b	Std. Err.	Standardized *Beta*	Sig.
Policy, Regulation, Governance				
[P] Telecommunications competition index	.424	.206	.211	.042
[P] Financial investment index	-.153	.340	-.042	.653
[P] Universal broadband service (1=present)	.303	.308	.086	.328
[R] Technical standards development (1=present)	.537	.445	.103	.231
[R] Telecommunications licensing (1=present)	-1.059	.488	-.196	.033
[G] Democratic political structure (UDS)	-.254	.222	-.109	.257
[G] Rule of law and control of corruption (WGI)	.533	.267	.215	.049
Control variables				
Affluence (UN Income Index)	4.750	1.150	.443	.000
Income inequality (Gini coefficient)	-.013	.016	-.068	.434
(Constant)	.340	1.162		.770
Dependent variable: Natural log of mobile broadband subscriptions per 100 residents. N = 99; Adjusted R Squared = 0.348; Std. Error of the Estimate = 1.325.				

Table 1. Multiple regression model explaining mobile broadband diffusion in non-OECD countries.

The coefficients in the first row indicate that there is a connection between competition to provide telecommunication services and the diffusion of mobile broadband in the non-OECD countries. When holding all other variables constant, a 0.10 unit increase in a country's *telecommunications competition index* increases the number of broadband subscribers per 100 by 4.2% (***b*** = .424). The coefficients are statistically significant at the .05 level and provide support for the widespread view that countries with higher levels of competition will have a larger proportion of its population using ICTs. To further illustrate, a country that has the mean value (-0.18) on our index of competition would have 75% more residents with mobile broadband access than a country that has the minimum value (-1.95) on our index. And a country that has the maximum value (1.18) would have 58% more residents with mobile broadband than a country with the mean value on our competition index. This result for developing countries provides partial support for hypothesis H_1, that national policy initiatives to promote information and communication technologies, specifically those that develop and sustain healthy competition among service providers, increase a nation's mobile broadband diffusion. This result is consistent with results showing a similar positive impact of telecommunications competition on mobile telephony diffusion (Rouvinen, 2006) and fixed line broadband adoption, e.g., (Distaso, Lupi and Manenti, 2006; Grosso, 2006).

Surprisingly, the level of shared financial investment in telecommunications did not have an effect on mobile broadband diffusion. As evident in the second row of data, the coefficients for the *financial*

investment index are not statistically significant. It was expected that in countries where there is more investment, there would in turn be greater access to and use of mobile broadband technology. As we will discuss below, an economic variable with broader scope, the Income Index, is the most significant factor in this model and perhaps is masking the effect of variables like our financial investment index, which has a narrower scope.

The presence of a universal service policy for broadband also did not have an effect on mobile broadband diffusion. The coefficients for the universal broadband service variable in the third row of Table 1 are not statistically significant. It was expected that in countries where there is such a policy in place, there would be greater material access to mobile broadband products and services. Approximately 25% of the countries in the developing world have a broadband strategy that addresses universal service. Even so, the presence or absence of a plan to achieve universal access to broadband does not explain differences in broadband diffusion. Although beyond the scope of this study, it is possible that universal broadband policies in the developing world have either faced challenges in their implementation or have not been in place long enough to yield measurable positive outcomes.

Referring to hypothesis H_2, row four shows findings for government structure and process whereas row five shows findings for government performance, or governance. The coefficients in row four suggest that government engagement in developing and regulating technical standards does not have a measurable impact on mobile broadband diffusion. Even though more than 81% of non-OECD countries engage in developing and regulating technical standards, whether or not a country does so appears to have no effect on the number of mobile broadband subscriptions. Governments in these countries typically adopt technical standards put forward by mostly-OECD countries and depend heavily on the private sector to recommend appropriate standards and to worry about their implementation and their interoperability with other standards. Since the variable used in row four focuses on public sector (and not private sector) activities, it is possible that factors directly related to technical standards development are not captured in our regression model for developing countries.

The findings in row five suggest that the practice of granting and maintaining licenses for telecommunication service providers *decreases* access to mobile broadband. This result is particularly surprising since more than 80% of non-OECD countries manage licenses for operation, spectrum use, right of way, etc. Figure 2 shows mobile broadband diffusion for countries that do manage telecommunication licenses above the one (1) on the *x*-axis and those that don't above the zero (0). [Recall that the ITU (2013) measures mobile broadband diffusion (the units of the *y*-axis) in each country as the number of subscriptions per 100 residents.] Figure 1 confirms that the vast majority countries in this study practice telecommunications licensing as one of their regulatory measures. Furthermore, this group of countries includes those that perform the best and the worst in terms of mobile broadband diffusion.

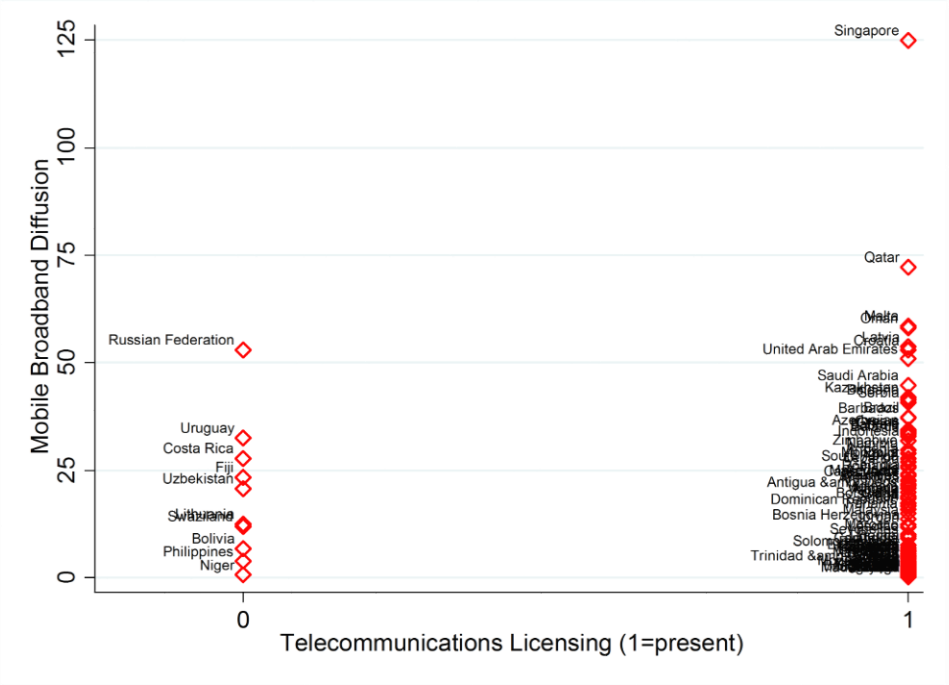

Figure 2. Mobile broadband diffusion versus telecommunications licensing for non-OECD countries.

There appear to be two factors that explain the clustering of countries in Figure 1 and, in turn, that having regulators manage licenses for telecommunication service providers decreases mobile broadband diffusion. First, of the many countries that manage telecommunication licensing, few have streamlined or modernized this regulation to promote recently developed ICTs such as mobile broadband. This explains the dense cluster of countries that sit immediately above the one (1) on the right hand side of this figure. Countries such as Singapore, Qatar, Malta, Oman, Latvia and Croatia, however, appear to have made such adjustments in their regulation. Second, a handful of countries (about seven, including Russia, Uruguay, etc.) that do not practice licensing as a regulatory measure, have nonetheless seen significant mobile broadband diffusion within their borders. These countries have the largest mobile diffusion values above the zero (0) on the *x*-axis and have an average mobile diffusion value of 17.5 subscribers per 100 inhabitants. In contrast, the countries above the one (1) on the *x*-axis have an average mobile diffusion value of less than 15 subscribers per 100 inhabitants.

Rows six and seven refer to hypothesis H_3, and suggest that a more democratic government does not have an impact on mobile broadband adoption but that sound governance does. That a more democratic government is not related to mobile broadband diffusion is consistent with previous research that also has been unable to find a relationship between democratic institutions and technology diffusion even though there are strong theoretical reasons to believe that this should be the case (Norris, 2001). While a democratic society may create a positive environment and potential demand for mobile broadband access, it is not enough, at this point, to spur adoption in the developing world. The results in row seven, however, show a positive relationship with governance that is statistically significant at the .05 level. When holding all other variables constant, a 0.10-unit increase in a country's governance score increases a country's score on the online service index by 5.3%. A country that has the mean value for rule of law and control of corruption (-0.37) would have 92% more mobile broadband subscriptions than a country that has the minimum governance score (-2.09). And a country that has the maximum value (1.94) would have 123% more subscriptions than a country with the mean value. These results are consistent with other cross-national studies, e.g., those

summarized by Waverman and Koutroumpis (2011), which suggest that rule of law and control of corruption are important for national telecommunications policy and regulation to be effective. These results strongly suggest that an administrative culture of sound governance increases the diffusion of mobile broadband services, thus providing partial support for hypothesis H_3. Moreover, the standardized beta coefficients show that a country's rule of law and control of corruption (*Beta* = .215) is the most important of the policy, regulation and governance variables in explaining mobile broadband diffusion within that country.

Row eight shows that higher levels of income have a substantial effect on the number of mobile broadband subscriptions per person. A .01-unit increase on the UN Income Index (the first of two control variables) increases the percentage of broadband subscriptions by 4.75% when controlling for all other variables. The coefficients for the Income Index control variable are statistically significant at the .01 level. Countries with a more affluent population may face a greater demand for mobile broadband services from governments, businesses and consumers. The data also suggest that the public and private sectors have responded to meet this demand. The standardized beta coefficient in row eight shows that a country's per capita income (*Beta* = .443) is the most important factor in explaining mobile broadband diffusion in our regression model.

Within the 99 non-OECD countries analyzed in this study, income inequality had no significant effect on broadband diffusion. While there is a strong relationship between economic and technological development, less income inequality does not seem to translate into greater diffusion of mobile broadband. The results in rows eight and nine suggest that in many developing countries mobile broadband services are so expensive that increases in the number of subscriptions may, in part, be predicted by higher per capita income, but not by lower income inequality.

5 Discussion and Conclusions

Our research assesses the impact of policy, regulation, political structure, and public sector performance on mobile broadband diffusion in the developing world. We showed that countries that encourage competition among telecommunication service providers and have more effective public sector governance have greater access to mobile broadband services. Specifically, these two factors have a positive and significant relationship with the number of mobile broadband subscribers per 100 inhabitants of a given country (ITU, 2013). Two additional findings also demonstrate that accepted regulatory practices in developed countries are not directly applicable in the non-OECD countries. First, we showed that the practice of granting and maintaining licenses for telecommunication service providers decreases mobile broadband diffusion in the developing world. This appears to be because some developing countries have streamlined their licensing process to facilitate the adoption of mobile broadband and other countries have found alternative mechanisms to perform functions that are critical to the deployment of mobile services (e.g., spectrum allocation). Second, we presented evidence that it is not necessary for national governments in the developing world to engage directly in the development of technical standards, but instead to depend on private sector activities moderated by government agencies in highly developed countries. For this evidence to be conclusive, however, a more in-depth investigation of technical standards development for mobile broadband and related ICTs is needed.

This is the first cross-national study of mobile broadband in the developing world to assess the impact of regulation and public sector performance using a broad range of indicators. Previous studies have relied on single indicators, e.g. (García-Murillo and Rendón, 2009), and, thus, omitted measurement of important public sector activities. It is not surprising that we found that governance has a strong positive impact on the extent of a country's mobile broadband diffusion since there were strong theoretical reasons for expecting this to be the case (e.g., see Norris, 2001; van Dijk, 2005; Warschauer, 2004). It was not anticipated, however, that governance would have the largest impact of any variable in our model. This indicates, moreover, that the culture and practices within the public

sector are important enablers of the adoption of emerging ICTs such as mobile broadband. It is therefore unlikely that the promise of mobile broadband will become a reality in laggard nations without transformations first occurring in their public sectors. Elected officials and policymakers are not powerless to make a difference, however. We also found that specific policies matter. Because the policy initiatives we evaluated are intended to support the ICT sector as a whole and telecommunication industries more specifically, some of these initiatives, e.g., competition among telecommunication service providers, will have a positive impact on mobile broadband diffusion.

There are of course other factors that contribute to understanding the diffusion of mobile broadband services across the globe. There may be more precise activities or norms within the public sector that explain greater access to mobile broadband that also can be measured. Wilson and Wong (2006), for example, demonstrate the importance of "information champions" in explaining variation in Internet diffusion across African states. The appointment of a chief information officer could indicate an even stronger commitment by a nation to advancing the use of emerging ICTs. External leadership also may influence transformations in the public sector. Finnemore (1993) shows how the United Nations Educational, Scientific, and Cultural Organization (UNESCO) provided valuable educational assistance to nations in creating science bureaucracies after World War II. Nations can learn from each other as well, and there are studies which suggest that governments adopt policy innovations from nations seen as their socio-cultural peers and from neighboring states that have demonstrated past success with new policies (Simmons and Elkins, 2004).

Still, the global broadband digital divide characterized by inequalities in fixed line broadband Internet diffusion (Gulati and Yates, 2012) seems to be perpetuating in mobile broadband diffusion. If mobile broadband is to follow the trajectory of mobile telephony in developing countries (Rouvinen, 2006), and be more inclusive, we believe significant cooperation between governments, service providers, and other stakeholders is necessary (Marsden, 2011). Such cooperation will promote healthy competition among telecommunication service providers and help produce effective regulation. These efforts, as well as complementary policy initiatives, will be essential in bridging the mobile broadband digital divide in the developing world.

We hope that our findings will guide decision makers in capitals across the globe to take an active role in improving public sector performance, and also developing a healthy ICT sector. If properly guided, such changes should reduce inequalities in access to mobile broadband services and thereby allow the ongoing information and communication revolution (World Bank, 2012) to improve the lives of those in developing countries who have yet to benefit.

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