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Institutional variety and internet infrastructure development: The net and the internet: emerging markets and policies

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INSTITUTIONAL VARIETY AND INTERNET INFRASTRUCTURE DEVELOPMENT

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THE NET AND THE INTERNET: EMERGING MARKETS AND POLICIES

INTERNATIONAL TELECOMMUNICATIONS SOCIETY
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Abstract

This paper analyzes if and how the design of telecommunications regulatory institutions has influenced the evolution of Internet connectivity in approximately 100 countries between 2007 and 2014. While most advanced and developing countries have adopted policies and regulations intended to enhance private sector incentives for the provision of Internet access infrastructure, there is little consensus about the optimal design of telecommunications policies and regulations, how they should reflect differences in endowments and institutional settings across countries, or their impact on network infrastructure development. Using measurements of network connectivity speeds and cross-country institutional differences this article presents and analyzes patterns of regulatory design and their possible impact on the evolution of Internet access infrastructure capacity around the world. We find that sector specific indicators of formal rules and institutional arrangements do not vary significantly with income or indicators of the evolution of connectivity. General and sector specific indicators of perceived institutional quality are positively associated with cross-country differences in Internet connectivity speeds, but do not help explain differences in their growth rates. We further explore the implications of the apparent dichotomy between formal and perceived institutional quality for public policy and private sector participation in the development of Internet access infrastructure.

Keywords: Internet, infrastructure, institutions, regulation, development, digital divide

I. Introduction

Given the perceived importance of public policy and regulation for the development of Internet access infrastructure, a growing body of studies tries to quantify cross-country institutional differences and evaluate their impact on indicators of network development such as fixed and mobile diffusion (Bouckaert et al. 2010; Lee et al. 2011), capital expenditures in fixed assets (Grajek & Roller, 2012), and the quality of service in terms of connectivity speeds and users experience (Berkman Center, 2010; Rajabiun & Middleton, 2015). Focusing primarily on the experience in advanced economies with the diffusion of high-speed broadband networks (i.e. OECD, EU), previous studies generate an empirical puzzle that captures key dilemmas in the design of institutional arrangements for the operation of Internet Protocol (IP) based communications networks. Since competition is not always feasible or desirable and structural

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dominance is the norm, market forces do not always generate desirable outcomes and therefore demand for regulatory remedies. Some studies have found that the “density” or “intensity” of regulation is negatively associated with capital expenditures on network infrastructure and take this to imply forbearance from regulation represents an optimal policy strategy (Grajek & Roller, 2012). However, there is some evidence documenting advanced economies with relatively credible third party access/essential facilities regulations have managed to develop relatively high quality broadband networks (Berkman Center, 2010; Choi, 2011; Rajabiun & Middleton, 2015). This indicates rules and institutions that fit local/national needs and conditions can complement market incentives and efficiency in the provision of Internet access infrastructure.¹

While poorly designed public regulations may reduce private sector investments and/or deter potential competition, the experience in advanced economies indicates rules and institutions that promote cooperation and risk sharing can enhance private sector capacity to meet growing demand for Internet connectivity. Furthermore, cross-country studies of telecom regulation have found that higher income countries tend to have a wider array of formal regulations, more resources, and enforce the rules relatively more intensively (Waverman & Koutroumpis, 2011; Perkins, 2014). The fact that regulatory formalization and engagement increase with income lends further support to the hypothesis that public regulation can complement the capacity of private market mechanisms to deploy and manage Internet access infrastructure. Whether public regulation represents a substitute or complement to private participation in delivery of Internet connectivity infrastructure is an important question, particularly for middle and lower income countries where access to fixed and mobile connectivity remains relatively limited, especially beyond a small number of densely populated urban centers. High income countries may be able to afford directing public funds to subsidize access and transport facilities when market outcomes do not seem satisfactory, for example in addressing market failures in the provision of broadband in high-cost rural areas (Rajabiun & Middleton, 2013). Due to the relative scarcity of public funds and potentially more important policy priorities such as health and education, stimulating private sector incentives to extend Internet connectivity beyond small pockets of urban elites in developing countries is likely to be the only option for reducing the extent of the global digital divide in the future.²

Over the past decade most developing countries have replicated various elements of formal rules and administrative mechanisms for the governance of telecom infrastructure common in high income jurisdictions, including legal obligations to interconnect with third parties at the wholesale level, allocating spectrum, and protecting consumers. Concerns about the potential for regulation to inhibit private sector incentives to deploy increasingly affordable fixed and mobile Internet access platform technologies limit the scope for their implementation in many developing and advanced countries (i.e. “forbearance”). Relative scarcity of resources for enforcing formal regulations in developing countries accentuates disincentives to apply formal rules that may have adverse consequences on private sector investment (i.e. false positive errors). In some countries there is increasing interest in understanding which institutional arrangements are conducive to balancing competition, coordination, and investment incentives that ultimately shape the pace of progress in Internet infrastructure development.

Previous studies on the determinants of network development focus primarily on the experience in high-income countries. Growing interest in the broader international experience has motivated the development of a variety of quantitative indicators that try to capture telecom regulatory variation across a large number of countries (Waverman & Koutroumpis, 2011; Perkins, 2014; World Economic Forum (2014)). Previous studies analyze interactions of these indicators with each other and more general quantitative measures of institutional quality. This article extends the discussion by exploring potential links between indicators of institutional variety and indicators of cross-country differences in the development of Internet connectivity. Understanding the relevance of quantitative indicators of institutional quality and variety is important because such measures are routinely employed by decision makers such as policymakers and investors to assess risk.

The article provides the next step in the analysis with a preliminary assessment of potential links between quantitative indicators of regulatory variation in the telecom sector and network development that includes a wide range of high-income and developing countries. The next section characterizes the extent of the global digital divide and the evolution of connectivity using indicators of the quality and capacity of Internet access infrastructure between 2007

¹ This insight from telecom sectors in advanced economies can be viewed as another example of broader debates about the interaction between state and market mechanisms. See Hall & Gingerich (2009) for an empirical analysis of institutional complementarities in advanced economies.

² See James (2010) for a discussion of low cost mechanisms for extending Internet access in developing countries. See World Bank (2010) for an overview of regulatory and strategic issues associated with technological change and platform convergence in Information and Communication Technologies (ICT) facing developing countries.

and 2014 from around 100 countries. Section 3 explores potential associations between these network outcome measures and a wide range of quantitative cross-country institutional and governance indicators. Section 4 concludes.

2. Internet Infrastructure Development: 2007-2014

There is a wide range of indicators that are potentially relevant for capturing Internet access infrastructure development, including supply side measures such as the diffusion of particular technologies (e.g. dial-up, DSL, fibre, mobile wireless) or demand side ones such as Internet use intensity of individuals and organizations. Which of these indicators are appropriate depends partly on the questions that are being asked, the context of discussion, and availability of the data. For example, fibre penetration rates to homes/businesses/individuals are a relevant policy outcome variable for high-income countries where access to legacy DSL and cable platforms is already widespread. In developing countries where more end users may be sharing more end point interfaces on the edge of the network (e.g. Internet cafes, community wireless, etc.), demand side indicators such as the intensity of Internet use might be more appropriate. This article employs measurements of Internet connectivity speeds detected by Akamai Technologies' global Content Delivery Network (CDN) to construct four indicators that help capture international differences in service quality/connectivity speeds end users experience (in Mbps) and their growth (in % average annual). Measures of connectivity speeds from Akamai are collected while its servers are attempting to deliver content and application services for a variety of clients that employ Akamai's CDN to reach end users around the world. Consequently, they offer a relatively consistent and realistic view of the end user quality of experience when deploying more advanced applications.³ Based on speed measurements between 2007 and 2014 we explore cross-country variations at the end of the period (AvgS, PeakS) and their growth rates (AvgG, PeakG) for a sample of 99 countries.⁴ Table 1 summarizes these indicators.

	Avg. Growth in Speeds (2007-2014, annual %)		Speeds (Mbps, 2014)	
	AvgG	PeakG	AvgS	PeakS
Mean	43	82	6	29
Median	34	71	5	26
STDEV	30	51	4	14
Min	-8	1	1	7
Max	138	371	23	69

Peak connectivity speeds represent maximum connectivity speeds detected by Akamai's servers, capturing network capacity when demand for network resources is relatively low.⁵ Consequently, peak measures partly control for potential differences in demand relative to indicators of average connectivity speeds end users experience and can be viewed as an indicator of installed network capacity.⁶ On average peak capacity grew at around two times the rate of average connectivity speeds, highlighting that operators had to install increasingly more excess capacity to meet growing demand for network resource by end users. In more successful countries peak connection speeds grew at

³ For example viewing content rich websites, voice, multimedia, cloud applications, etc. There is however a number of limitations to this type of data as it captures network performance when deploying relatively more network intensive applications for Akamai's clients and is therefore not a general picture. For example, 1st generation Internet applications (e.g. email/text, browsing simple sites) do not require high speed connectivity and can be deployed by anyone that can access increasingly affordable mobile devices in developing countries. Regardless of the end user devices on the edge of the network, as more end users start to move from 1st generation to more network intensive Internet applications emergent congestion on local links, routers, and transport facilities degrades average service quality and imposes a negative externality on the ability of others in the vicinity to deploy advanced applications.

⁴ The sample covers countries with the highest volume of communications with Akamai's servers.

⁵ And therefore congestion is relatively limited.

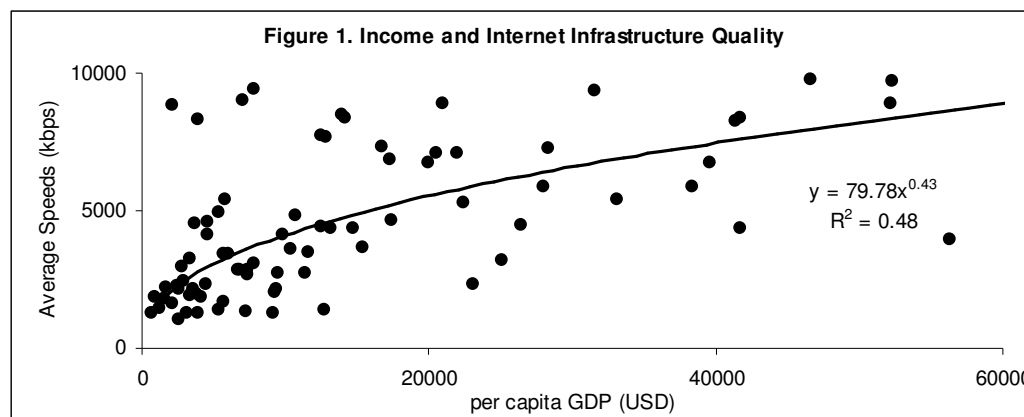
⁶ If operators do not increase network capacity at a sufficiently fast rate, growing demand for network resources associated with low cost end user devices will lead to congestion and reduce average service quality/speeds.

relatively higher rates than average (nearly three times at the sample Max).⁷ In a small number of countries network investments apparently did not keep up with growing demand as average service quality actually declined over time.⁸ Median rates of growth in connectivity speeds are below the average rates, indicative of an asymmetric distribution in the evolution of connectivity around the world: There were a large number of countries where network quality did not improve very fast and a small number where it did. Average and peak speeds also have a similarly skewed distribution, reflecting the fact that there is a relatively small number of high-income countries with very fast broadband networks and a large number of developing ones where service quality remains relatively poor in absolute terms. As documented in Table 2, there is a strong positive correlation between average and peak growth rates (AvgG, PeakG), as well as between our quality/capacity indicators in absolute terms (AvgS, PeakS). There is little association between rates of growth in the past and network outcomes at the end of the period.

Table2. Internet Connectivity: Correlation Matrix

	AvgG	AvgS	PeakG	PeakS
AvgG	1.00			
AvgS	-0.14	1.00		
PeakG	0.77	-0.07	1.00	
PeakS	-0.12	0.89	0.11	1.00

The fact that the rate of network improvements is not correlated with outcomes may partly reflect a process of convergence as lower income countries starting from a lower base are likely to be improving connectivity faster than advanced economies with relatively higher quality networks. To explore any evidence of convergence, we study the impact of income on our indicators of network development. As depicted in Figure 1 there is a statistically significant (non-linear) positive association between income and cross-country indicators of connectivity speeds. Differences in income account for around half of the observed variation in connectivity speeds.⁹



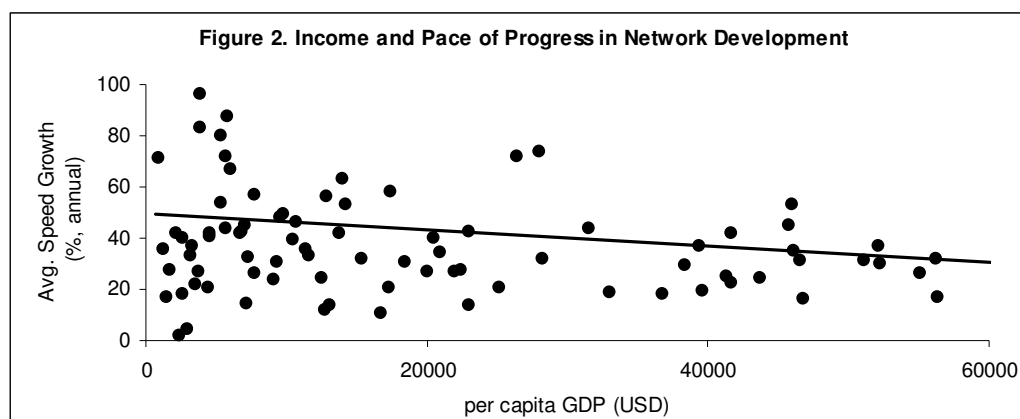
While there appear to be a negative correlation between income levels and rates of growth in quality/capacity, as documented in Figure 2 this association is not statistically significant. On average lower countries have not been improving network connectivity at a higher rate than advanced economies, explaining the extent and persistence of the global digital divide in terms of average connection quality (Figure 1). A cluster of lower and middle income countries

⁷ Highest rate of growth in average connectivity speeds was in Armenia, followed by a number of other countries in the Former Soviet Union; highest growth in peak/maximum detected connectivity speeds was in Uruguay. The Appendix to this article provides a list of countries in our sample in descending order of the rate of growth in peak connectivity speeds they experienced from 2007-2014.

⁸ As was the case for two countries in our sample (Nepal and Tunisia). Highest rate of growth in average connectivity speeds was in Armenia, followed by a number of other countries in the Former Soviet Union; highest growth in peak/maximum detected connectivity speeds was in Uruguay.

⁹ While not reported here, peak speed and growth (PeakS, PeakG) appears to be less sensitive to differences in income than average speed and its growth (AvgS, AvgG). To account for the non-linear nature of the relationship in the discussions that follow we take the natural log of GDP in exploring the relevance institutional indicators on network development.

have experienced a substantially higher rate of progress in the development of Internet connectivity, which can be identified in the Appendix to this article. In most others the quality of Internet connectivity has improved at rates that are similar or below those of higher income countries that already have substantially higher quality networks. Identifying institutions and strategies that explain the success of those who have improved connectivity at substantially higher rates than others could be particularly valuable for countries lagging behind and help mitigate the global digital divide.



3. Institutions and Connectivity

A variety of factors can potentially explain cross-country differences in the evolution of Internet connectivity, including variations in endowments, institutions, demography (e.g. young v. older populations), geography (e.g. low v. high cost of network deployment), financial strategies of operators (e.g. to retain/reinvest earnings), culture (e.g. beach going v. video gaming), etc. In this study we abstract away from many of the potentially relevant factors and instead focus on indicators of telecom governance institutions and network outcomes documented in the last section. This is a preliminary step and future research can extend the discussion in a number of directions, such as adding relevant controls or other informative proxies for institutions and outcomes. Developing a richer body of international datasets that help capture inputs, controls, and outcome variables in the telecom and ICT sectors will be a prerequisite for extending the analysis beyond the set of relatively high-income countries for which a larger set of reliable cross-country data is available (e.g. for OECD, EU).¹⁰

Before evaluating the relevance of telecom sector governance indicators, it is important to highlight the potential limitations of aggregated indices that try to quantify institutional differences across heterogeneous countries. Previous research focusing on aggregated governance indicators compiled by the World Bank suggest that they do not necessarily have that much informational value that allows for causal analysis as they tend to be measuring the same general concept in quantitative terms (Langbein & Knack, 2010). Since many of such indicators tend to employ arbitrary weights to add up the existence of this or that rule/element of the system into some form of an index and higher income countries have more developed/extensive formal regulatory institutions, the measures can be highly correlated with income levels. Perceptions based measures using surveys of “experts” or business managers also tend to be highly correlated with existing endowments/income levels as places that are already doing well can appear to also have good policies and institutions. Consequently, aggregated and perceptions based governance indicators may not necessarily be adding that much information to cross-country regressions beyond that can be accounted for variations in income levels. Nevertheless, such indicators are routinely employed to evaluate public policy and the potential impact of the institutional environment on risky investment decisions. As such, how the indicators are constructed and used by policymakers and market participants can have an effect on policy and strategic choices with real social and economic implications for development (Davis et al. 2012). If perceived regulatory quality is higher than it should be and overestimates real institutional quality, lawmakers may be less inclined to adopt efficiency enhancing institutional arrangements that fit local needs and conditions. In such a case investors in fixed assets might underestimate certain regulatory risks and therefore “over-invest” in those markets. Analogously, overly pessimistic

¹⁰ See Martin & Jayakar (2013) for an analysis of the relevance of telecom governance indicators in OECD countries.

indicators of institutional design can create an impetus to adopt policies that may not fit local conditions and/or deter private sector investment. Since international governance indicators tend to be strongly correlated with income and poorer countries are generally ranked lower, utilization of uninformative indicators by policymakers and risk averse investors represents a general concern for developing countries hoping to adopt public policies and legal arrangements that attract domestic and international capital.

The informational value and political economy implications of quantitative cross-country indicators of governance institutions is particularly relevant in industries such as telecoms where future returns to irreversible capital expenditures in fixed network assets can be particularly sensitive to changes in the regulatory environment for the operation of the market. Given uncertainties about the value of simplifying complex institutional arrangements into cross-country quantitative indicators, we explore the relevance of a number of telecom/Information and Communications Technology (ICT) sector specific indicators constructed using distinct methodologies. Specifically, we build on contributions by Waverman & Koutroumpis (2011) and Perkins (2014) who have compiled indicators of approximately 10 aspects of de jure/formal design of telecom regulations for a large sample of advanced and developing countries (hence WK & SP respectively). Their sector specific indicators are derived by identifying and adding the presence/absence of certain formal institutional features, using arbitrary or relatively systematically derived weights. Besides these measures of telecom regulation, we include a number of other indicators derived from surveys that aim to quantify perceived political transparency in general terms (Transparency International, TI) and effectiveness/quality of laws relating to ICTs (WEF), as well as an aggregated indicator of readiness/propensity of countries to exploit ICTs in general terms (WEF, 2014; Network Readiness Index, NRI).¹¹ Table 3 documents correlations between this wide range of institutional and network outcome indicators.¹²

Table 3. Telecom Governance and Internet Connectivity						
Indicators (sources)	AvgG	AvgS	PeakG	PeakS	GDP	
Per capita GDP (UN)	-0.26	0.57	-0.14	0.52	1.00	
Number of Regulatory Elements (WK)	-0.14	0.07	-0.22	0.03	0.16	
Telecom Regulatory Transparency (WK)	0.03	0.03	-0.06	-0.06	0.17	
Telecom Regulatory Independence (WK)	-0.06	-0.04	-0.12	-0.07	-0.02	
Resources (WK)	-0.21	0.22	-0.18	0.19	0.24	
Enforcement (WK)	-0.09	0.14	-0.08	0.08	0.29	
Institutional Stability (SP)	-0.36	0.36	-0.26	0.31	0.45	
Standards Rules (SP)	-0.22	0.25	-0.14	0.24	0.10	
Governance Structures (SP)	0.15	-0.21	0.06	-0.19	-0.17	
Entry Barriers Rules (SP)	-0.09	0.10	-0.08	0.10	-0.08	
Political Appointment Process (SP)	-0.06	0.03	0.09	0.06	0.02	
Market Structure Rules (SP)	0.07	-0.16	0.11	-0.18	-0.11	
General Political Transparency (TI)	-0.29	0.63	-0.12	0.62	0.79	
Effectiveness/Quality of ICT Laws (WEF)	-0.17	0.54	-0.06	0.53	0.65	
Telecom Regulatory Governance Index (TRGI, WK)	-0.19	0.28	-0.19	0.19	0.51	
Network Readiness Index (NRI, WEF)	-0.21	0.72	-0.03	0.71	0.78	

Waverman & Koutroumpis (2011) aggregated various aspects of formal sector specific regulations into the Telecommunications Regulatory Governance Index (TRGI) and found that it is positively associated with both income

¹¹ Interested readers in the details of methodologies for compiling the indicators should turn to the original sources. Please note that the exact results in this table and the analysis below are likely to differ to some extent because they are based on different samples of countries due to data availability. These differences do not influence the direction and interpretation of the results.

¹² Given the sample sizes coefficients higher than (+/-) .2 is significant at a 10% and (+/-) .3 at 1% significance levels for a two tailed test.

and general indicators of institutional quality such as the Transparency International (TI) measure. They also find resources available for enforcing the rules are particularly sensitive to general political transparency, even after controlling for differences in incomes. This suggests countries with more political transparency tend to invest more in implementing formal rules. They take the result to imply “those countries whose regulatory governance relatively lags general governance should be able to quickly improve telecoms specific regulation as general economy-wide institutions are in place” (p. 465). Although this hypothesis might be correct, it does not help explain what improved telecom regulations might look like across countries with diverse needs and conditions. In the presence of uncertainty about what type of rules and enforcement procedures would help improve the institutional environment for the operation of the market, policymakers may choose to not to adopt them or forebear from enforcing formal regulations in order not to deter private investment (i.e. to avoid false positive errors).

As documented in Table 3 the aggregated TRGI has a significant positive correlation with income.¹³ The direction of interactions between TRGI and the network development indicators is also similar to those associated with cross-country variations in income levels. However, TRGI’s interaction with the outcome variables is substantially weaker and is significant only in the case of cross-country variation in average speeds (AvgS). In terms of the components of TRGI which are weighted equally to construct the aggregated index, sector specific aggregations of institutional design (telecom regulatory transparency and independence) do not vary with connectivity indicators or income very much. The two components of TRGI relating to resources available to regulators and intensity of enforcement are positively correlated with income, reflecting the fact that higher income countries tend to have more resources to devote to enforcing formal regulations. Resources/enforcement components of TRGI have a stronger correlation with network outcome indicators than formal/de jure institutional design features relating to regulatory transparency and independence.

Perkins (2014) constructs a set of alternative indicators that aggregate specific elements of formal telecom regulatory arrangements by reducing around 30 variables into six dimensions and evaluates the extent of variation within them. She finds higher income countries tend to have a broader array of sector specific regulations and institutions for enforcing them are more stable. She takes this to suggest “that regulation is a key factor in the efficient functioning of markets” and that “this fact is also particularly important for foreign investment managers to better understand the likely patterns of regulatory variation in the industry globally so as to be able to effectively adapt their strategies accordingly” (p. 161). She finds that most of cross-country variance in regulatory arrangements is due to the “institutional stability” indicator, which includes age, sources of funding, organizational type of the regulator, and changes in statutory provision and regulatory structure. Since advanced countries have a longer history with telecom regulation and most developing countries have adopted or reformed their regulatory arrangements more recently, the strong positive association between this measure of institutional stability and income is not surprising. The other five dimensions of governance Perkins (2014) constructs appear uncorrelated with cross-country differences in income levels, or with the network development indicators. The exception to this is the aggregated indicator of “standards rules” which includes a variety of elements such service provider quality standards, as well as how social, environmental, and safety considerations are incorporated in policymaking. The other four indicators of governance structures, entry barrier rules, the political appointment process, and market structure rules have relatively limited cross-country variation and do not appear to be associated with income or network outcomes. This is somewhat surprising in the sense that these aspects of telecom regulation are usually at the center of policy debates at domestic and international level. Nevertheless, these observations should not be taken to imply that such formal/de jure elements of telecom regulation are unimportant as the lack of variation might be a function of the inadequacy of the aggregated indicators. Furthermore, many lower and middle income countries have increasingly replicated formal rules and procedures for the regulation of telecommunications and information industries common in more advanced economies. Increasing homogeneity in formal aspects of telecom regulation would also help explain why their quantitative characterizations do not appear to be related to income levels or network outcome.

In addition to sector specific measures of formal regulatory arrangements, we include two sector specific indicators compiled by the World Economic Forum (WEF) and one relating to general political transparency for comparison. WEF’s Network Readiness Index (NRI) represents a good example of the type of aggregated quantitative indicators based on a large number of sub-components that have become popular in public policy and international business discussions. NRI incorporates a wide range of perceptions based and more concrete components reflective of supply and use conditions in order to assess “the performance of...economies in leveraging information and communications

¹³ One reason for this is the inclusion of GDP/income as one of the components of the aggregated TRGI indicator.

technologies to boost competitiveness and well-being” (WEF, 2014). WEF survey results pertaining to the effectiveness/quality of laws relating to ICT sector represents one of NRI’s components and reflects perceptions of executives in large multinational firms about of de facto institutional quality of the digital ecosystem in broad terms. All three indicators are highly correlated with income and their coefficients have similar signs as that of GDP with respect to the network outcome indicators.

To the extent that countries that are already doing relatively well/poorly also appear as if they have high/low quality institutional arrangements, these correlations should not be viewed as causal. We control for variations in income levels with the log of per capita GDP using ordinary least squares and find that association between the three indicators with average connectivity speeds remains statistically significant.¹⁴ More general NRI and political transparency indicators improve the fit of the log-linear regressions more than the sector specific perceptions based indicator relating to ICT laws of those relating to particular dimensions of formal telecom regulations. The positive association between TRGI and connectivity speeds becomes statistically insignificant after controlling for income levels. This is not surprising since GDP is one component of TRGI and two of the index’s components (resources and enforcement) that vary more are also correlated with income levels. In general terms Table 3 illustrates that sector specific formal rules and institutional arrangements tend to vary less with network development outcome than more general governance indicators that capture perceptions of de facto institutional quality or more aggregated governance indices. This does not imply that formal telecom rules do not matter or that perceptions are causal, but might be simply a reflection of the relative homogeneity of formal institutional arrangements across a heterogeneous set of countries with distinct needs and conditions.

To extend the discussion other indicators of institutional variety and infrastructure development might provide alternative perspectives and help identify rules and procedures that enhance private sector incentive to build and administer Internet access infrastructure. For example, it would be interesting to explore the interactions between various institutional indicators and capital expenditures on network infrastructure.¹⁵ Beside macro-level studies, micro-level explorations of the experience in countries that have done particularly well in the past might help others in their search for rules and procedures that stimulate private sector incentives to supply Internet access infrastructure. Business strategies of operators in these countries may also have important lessons for others. The Appendix provides a list of countries in our sample ranked in descending order of the rates of growth in peak connectivity speeds in order to promote further research into policies and strategies that explain success and failure in delivering Internet connectivity.

4. Summary and Implications

A recognition that the design of institutional arrangements for the operation of market systems matter for how they evolve has led to the development of a variety of general and sector specific indicators that try to quantify institutional variety and evaluate its impact on social and economic outcomes. This article uses measurements of the quality/speed of Internet connections and their growth in around 100 countries and evaluates their associations with a wide range of quantitative indices that aim to capture institutional variety or quality. We find a significant positive (non-linear) connection between cross-country measures of the network quality/speeds and the level of income. We fail to find a statistically significant connection between the rates of growth in average and peak connectivity speeds (AvgG, PeakG) and income levels. The analysis subsequently explores if various telecom governance indicators help explain observed differences in network outcome and capacity growth. We find relatively weak correlations between indicators of institutional variety and the evolution of Internet connectivity, particularly quantitative indicators of formal rules and institutional design. Formal elements of telecom regulatory arrangements tend vary less with network performance indicators than perceptions of the quality of de facto institutional arrangements. The fact that aggregated indices of formal arrangements seem uncorrelated with outcomes should not be taken to imply that such institutional are irrelevant. It might be the case that aggregated and perceptions based indicators are not that informative in their attempt to simply and quantify complex institutional arrangements. For example, particular aspects of regulatory arrangements such as the credibility of essential facilities obligations or the presence of a vertical separation mandate might have much larger implications for private sector incentives than other rules. Aggregating such subtleties into

¹⁴ At a 10% significance level.

¹⁵ Unfortunately disaggregated data on fixed capital expenditures on network infrastructure is not available for a large sample of countries, despite efforts by the International Communications Union (ITU) to address this important gap in cross-country telecom datasets.

country-wide quantitative measures makes it difficult to evaluate what elements of regulatory regimes promote or inhibit the pace progress in network infrastructure development.

While aggregated indicators of institutional variation may not be that informative in explaining global network development patterns, it is important to reiterate they can have a real impact on decisions by policymakers and investors. If such indicators underestimate institutional quality, using them can lead risk averse investors to ask for a relatively high premium and/or not to invest in markets that are perceived to have low quality regulatory institutions. Even if some countries managed to identify and adopt regulations that fit their local needs and conditions, governance indicators that are simply capturing current development levels or are uninformative for other reasons can reduce private sector investment incentives.¹⁶ Analogously, governance indicators that overestimate institutional quality can lead to too much investment in markets that appear to be safe relative to expected returns. In terms of policy evaluation gaps between perceptions and reality can also lead to sub-optimal decisions, such as replicating formal regulatory arrangements that do not necessarily fit local needs in order to appear less risky to investors or maintaining ineffectual policies that are perceived to be working.

¹⁶ The potential impact of uninformative indices of governance/institutional quality on investment decisions seems particularly important when we consider that such indices can be incorporated into quantitative finance models as a measure of institutional risk facing firms in particular markets, and therefore influence capital allocation and pricing.

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Appendix: Network Performance Growth

(Based on measurements from Akamai, 2007-2014, ranked in descending order of average annual growth in peak speed, in %)

Country	AvgG	PeakG	Country	AvgG	PeakG	Country	AvgG	PeakG
URUGUAY	114	371	LATVIA	42	84	CHILE	32	55
ARMENIA	138	236	IRELAND	53	83	DOMINICAN R.	44	54
KAZAKHSTAN	132	228	MACEDONIA	41	83	BOLIVIA	40	54
QATAR	39	185	MEXICO	49	83	GERMANY	25	53
MOLDOVA	110	161	BRAZIL	36	83	ROMANIA	26	52
AZERBAIJAN	131	157	CHINA	67	82	COSTA RICA	30	52
SINGAPORE	37	155	ECUADOR	72	82	SOUTH AFRICA	32	51
UKRAINE	83	152	FINLAND	45	81	LUXEMBOURG	23	51
SYRIA	42	145	PHILIPPINES	18	75	ESTONIA	20	50
SRI LANKA	110	135	PANAMA	48	75	SWEDEN	26	50
UAE	42	129	SPAIN	32	75	ICELAND	23	49
PARAGUAY	96	126	COLOMBIA	57	74	EGYPT	33	49
RUSSIA	53	123	NETHERLANDS	35	74	SAUDI ARABIA	21	49
GEORGIA	109	122	ALGERIA	54	72	GREECE	28	48
ISRAEL	44	121	ARGENTINA	33	72	NORWAY	23	48
TRINIDAD	58	119	UK	37	72	KENYA	71	47
BULGARIA	45	117	AUSTRIA	31	71	ITALY	19	45
LITHUANIA	63	117	HUNGARY	24	71	HONG KONG	18	44
BAHRAIN	43	114	VIET NAM	28	70	PERU	43	44
MAURITIUS	123	114	BOSNIA & Hert.	42	70	JORDAN	21	43
SERBIA	80	114	AUSTRALIA	33	69	EL SALVADOR	27	42
THAILAND	88	113	KUWAIT	17	68	FRANCE	20	41
CYPRUS	72	107	MACAO	31	67	SLOVAKIA	11	41
POLAND	56	107	BELGIUM	24	67	JAPAN	16	40
BELARUS	42	100	CANADA	30	65	INDIA	17	39
TURKEY	46	96	CZECH R.	31	65	VENEZUELA	12	38
INDONESIA	22	96	DENMARK	32	61	CROATIA	13	36
TAIWAN	34	95	PORTUGAL	27	61	IRAN	14	34
PUERTO RICO	74	92	SWITZERLAND	31	61	SOUTH KOREA	14	27
MALTA	40	90	SLOVENIA	27	59	MOROCCO	4	11
MALAYSIA	39	90	NEW ZEALAND	29	58	NEPAL	-7	10
LEBANON	24	89	U.S	31	56	PALESTINE	2	6
PAKISTAN	36	87	GUATEMALA	37	55	TUNISIA	-8	1