This product is part of the Pardee RAND Graduate School (PRGS) dissertation series. PRGS dissertations are produced by graduate fellows of the Pardee RAND Graduate School, the world's leading producer of Ph.D.'s in policy analysis. The dissertation has been supervised, reviewed, and approved by the graduate fellow's faculty committee.

DISSERTATION

Navigating the Information Revolution

Choices for Laggard Countries

Julius Gatune

This document was submitted as a dissertation in July 2006 in partial fulfillment of the requirements of the doctoral degree in public policy analysis at the Pardee RAND Graduate School. The faculty committee that supervised and approved the dissertation consisted of Robert H. Anderson (Chair), James Dewar, and John Engberg.

Financial support for this dissertation was provided by RAND's National Security Research Division (NSRD).

PARDEE RAND GRADUATE SCHOOL

The Pardee RAND Graduate School dissertation series reproduces dissertations that have been approved by the student's dissertation committee.

The RAND Corporation is a nonprofit research organization providing objective analysis and effective solutions that address the challenges facing the public and private sectors around the world. RAND's publications do not necessarily reflect the opinions of its research clients and sponsors.

Published 2007 by the RAND Corporation
1776 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138
1200 South Hayes Street, Arlington, VA 22202-5050
4570 Fifth Avenue, Suite 600, Pittsburgh, PA 15213
RAND URL: http://www.rand.org/
To order RAND documents or to obtain additional information, contact
Distribution Services: Telephone: (310) 451-7002;
Fax: (310) 451-6915; Email: order@rand.org

ACKNOWLEDGMENTS

The dissertation builds upon work that was previously done at RAND and I am indebted to those who sparked my interest in doing this. First it was Richard Hundley who made it possible for me to attend the Information Revolution Conference on Africa back in October 2001 and is the godfather of this project. Bob Anderson has been a source of inspiration to me ever since I accompanied him to that conference, and he raised the possibility of putting a more formal analysis into the RAND Information Revolution effort. He has been instrumental in my undertaking this effort. He has played many roles in helping me come this far and I can only acknowledge a few. As the chair of my committee he was very supportive and showed great confidence in me and was instrumental in driving me to a successful conclusion. He also played a crucial role in getting funding for this work and I am eternally grateful for his untiring efforts. My other members of my committee, Jim Dewar and John Engberg were likewise very supportive and provided prompt responses and suggestions that pointed to new directions whenever I got stuck. Their care extended to proofreading my work, for which I am greatly indebted -- English being my second language proved to be quite slippery. Special thanks to Ernest Wilson III for agreeing to be my outside reader.

I would also like to acknowledge support I got for this dissertation from RAND's National Security Division (NSRD) and in particular Phil Antón through whose intervention I was able to get the support. Many thanks to John Vogelstien whose support covered my first year of study at the Pardee RAND graduate school. I would also like to extend many thanks to

Charles Goldman and John Woodward who provided coverage for me for the better part of my stay at RAND.

I also acknowledge the support of my wife Felistas Gatune and my daughter Eva Gatune for enduring all the years and having faith and providing support from the start to the end. I thank my son Matt Gatune, who never saw the start but witnessed the end, for spicing up my life just when the going got tough. His addition to my life proved to be an inspiring force. My mother Philomena Mumbi Kariuki for her continued support and belief in me throughout my life, I dedicate this work to her.

I am also indebted that the dean of the Pardee RAND graduate school, the professors and the staff for all the support they gave me over the years.

ABSTRACT

The rapid diffusion of information and communication technologies (ICTs) during the last two decades has had a profound impact on all spheres of human endeavors, changes that are collectively referred to as the Information Revolution (IR). But the revolution has been uneven, with some countries being far ahead and others far behind in IR, resulting in the so-called digital divide. Laggard countries need means to move ahead if they are to access the benefits that IR offers and not suffer the consequences of being left out.

To navigate countries through the tempestuous waters of information revolution, policy-makers in laggard countries need to understand the drivers of IR and how they vary across the various stages of IR. But policy makers are hampered by the lack of specific studies that could provide a tool to guide their countries through the information revolution. Studies on IR drivers have either focused on drivers of adoption of ICT artifacts (long run drivers), or the market potential of the various artifacts, or on the drivers of diffusion of ICT artifacts (short term drivers) as they diffuse to their market potential after introduction.

This study identifies stages of IR, classifies countries according to their various stages, and using country-level data, identifies the drivers that are important across stages of IR. This is done at two levels: (1) drivers of diffusion of IR artifacts (short term dynamics) and drivers of the broader IR concept (long term dynamics). This study finds that at lower stages, the factors that drive the information revolution tend to be those that have to do with the development of markets. In the intermediate stages, demand factors are the key drivers. At higher stages, supply

factors are the key drivers of IR. Current use level or epidemic effects are the key drivers of the short term diffusion of ICT artifacts. The overriding drivers at all stages seem to be levels of human capital, quality of governance and the extent of urbanization. This analysis unifies long term adoption drivers with short term diffusion drivers to develop a road map that points the way for laggard countries as they ride the information revolution.

Table of Contents

1.0 BACKGROUND & CONCEPTUAL FRAMEWORK

1.1 Introduction

The rapid diffusion of information and communication technologies (ICTs) during the last two decades has had a profound impact on all the spheres of human endeavors. At the individual level, the growing income and wage inequality has been attributed to increased diffusion of ICTs in the workplace (Kruger 1993, Casseli 1999), although others are skeptical of this attribution (DiNardo and Pischke 1997). At the organizational level, huge investments in ICT have enabled business transformation, resulting in higher productivity (Bailey and Lawrence 2001). At the country level, there is anecdotal, theoretical, and econometric support for the theory that ICTs play a key role in growth and development (Kenny 2003, Oliner and Sichel 2000, Pohjola 2001). At the global level, ICTs are the principal enablers of ongoing globalization—the rapid advance in cross border integration in many areas of economic and other human activities (Hundley, et al. 2003, Avgerou 1998). The widespread use of ICTs is leading to the rise of network forms of organizations, with important implications for how societies are organized and conflicts are conducted (Arquila and Ronfeldt 1996, Ronfeldt et. al. 1998). The changes being caused by widespread use of ICTs are collectively called the Information Revolution (IR). A multi-year study on IR (Hundley et. al. 2003) concludes that the information revolution is taking the world towards a future characterized by:

I. A rise in information work and information workers;
II. New business models, for the internal organization and functioning of business enterprises and for their external interactions with customers, suppliers, and competitors;
III. The rise of electronic commerce;

IV. Challenges to the power and authority of the nation state;

V. The creation and empowerment of a wide variety of new, non-state (often global) political actors;

VI. An ever-increasing porosity of national borders;

VII. Many new winners, and also many new losers; and

VIII. New fault lines, within and between nations.

1.2 Strategic Value of ICTs

In the globalized world, nations are in competition for human resources, capital investment, trade, etc. Nations that are able to attract the best skills and capital will remain competitive. How far ahead a country is in IR is crucial in determining where skills and capital move, further consolidating their lead. The fact that globalization is underpinned by ICT infrastructure makes it imperative to have ICTs in the first place to stay relevant. A strong, flexible and modern communication system has become a strategic necessity.

But beyond trying to survive, nations need to be competitive to improve the circumstances of their people. The competitiveness of nations has traditionally been analyzed on the basis of comparative advantage, i.e. the ability to produce a good or services on the basis of lower opportunity cost. But ICTs can erode or further consolidate whatever comparative advantage a country has. So, for example, it is not enough to have beautiful scenery, great beaches and abundant wildlife to attract tourists. Having the necessary ICT infrastructure to make the potential tourist find you, know more about your offerings, make bookings online and also

guarantee the tourist first class communication facilities during their stay may tip the balance of where the tourist dollars will flow. When used wisely, ICTs can be used to leverage the comparative advantage a country already enjoys. ICTs also provide opportunities to link sectors and coordinate commercial activities much like ICTs in a business setting provide opportunities for cross-selling based on customer profiles. Therefore, with better knowledge of potential tourists, policies in sectors like agriculture can be tailored to grow foods that tourists like. Thus while ICTs may not provide new comparative advantages (except where their diffusion will spawn new industries), failure to use them to leverage existing advantage will lead to erosion of these advantages.

ICTs are seen as having a great potential for improving the human condition by creating new economic and educational opportunities, improving health delivery, improving governance, and improving the general provision of services (Rodriguez & Wilson 2000). The potential of IR has been appreciated by many nations and great efforts to acquire ICTs have been made, but the results have been mixed - with some nations far ahead and others far behind - resulting in the so-called digital divide. This is a problem of great interest to the general policy community and bridging the digital divide is one of the 10 Millennium Development Goals that has been agreed to by the heads of state of over 180 nations in the United Nations[1].

[1] Goal 8 includes a target to make available the benefits of ICTs to all the world's inhabitants. http://millenniumindicators.un.org/unsd/mi/mi_goals.asp

1.3 Policy Problem

There is a lack of specific studies that could provide a tool for policymakers to guide their countries through the information revolution. Studies on drivers have either focused on drivers of adoption level (market potential) of ICTs (long run drivers) or on the drivers of diffusion of ICT artifacts (short term drivers). But full justice requires a distinction between adoption, which makes the assumption of equilibrium of the system (i.e., market potential), and diffusion, which assumes that the system is not in equilibrium, (i.e., market potential not yet attained). The study of adoption thus aims to investigate what factors determine the equilibrium level (market potential) of IR while the study of diffusion is about understanding what drives the systems to their market potential. While both perspectives are useful to policy makers they need to be unified into a coherent policy framework that harmonizes long term drivers with short-term drivers. In this way, short-term policy actions are not taken at the expense of long-term goals and vice versa.

Though IR studies have acknowledged that drivers change across countries, the traditional approach has been to divide countries into developing and developed, and then perform an analysis to see how drivers change. But this approach fails to recognize that countries with similar income can show very divergent IR postures. Thus Korea may be classified in middle-income countries but Korea has the highest broadband use in the world and is ranked up there in IR posture. A more appropriate level of analysis is classification based on IR posture. However studies that focus on the broader IR concept tell policymakers where they are with respect to other countries but fail to point out what they need to do to move to the next stage of IR. These

studies also fail to address all the factors that determine IR posture. Overall, policymakers in laggard countries lack the means to chart their countries through the tempestuous waters of the information revolution.

1.4 Objectives and Outline

The objective of this study is therefore to contribute to our understanding of the drivers of the information revolution and propose appropriate strategies to move forward. Specifically, the study uses available country data to:

I. Further develop the notion of IR Stages, building on previous studies. This includes identifying stages of the information revolution (IR) and mapping countries to their respective stage.
II. Identify drivers that are important at the various stages of IR, thus providing pointers to what matters and when.
III. Identify drivers of ICT artifact diffusion, thus identifying short-term dynamics as countries adjust to the equilibrium levels.
IV. Unify long-term adoption drivers with short-term diffusion drivers to identify differences and generalities between diffusion and adoption, between artifacts and across stages. This will thus identify pointers to the most effective actions in moving ahead in IR and accelerating the diffusion of ICT artifacts.

V. Policy Choices: identify policies that are most effective for the countries that are left-behind in IR, in particular the policies required in the short-, medium-, and long-term, thus providing a road map for moving along the various stages of IR.

The next section explores the concept of IR from historical, theoretical and empirical research and develops a conceptual framework for studying drivers of IR. Section 3 develops an IR scale and classifies countries into IR stages using this scale. This classification forms the basis of analytical work that follows in section 4 and section 5. Section 4 introduces the data used and focuses on identifying long run drivers of the information revolution. Section 5 focuses on short term dynamics of ICT artifacts diffusion, identifying drivers that hasten diffusion at various stages of IR. Section 6 unifies findings of sections 4 and 5, identifying patterns and differences. These differences are then used to identify policy implications. Policies that would be most efficient in moving forward in IR are then identified in section 7.

2.0 CHARTING THE COURSE OF INFORMATION REVOLUTION

The Information Revolution posture of a nation is defined by two dimensions; The first is the level of penetration of ICT technologies (e.g. telephone lines, computers, Internet access, Internet hosts, etc.) and the second is the capacity of a nation to produce ICT products and devices as defined by intellectual property developments - e.g., protocols, algorithms; artifacts production - i.e., cell phones and computers; and ICT services - e.g., business applications, e-learning, telemedicine (Hundley, et al. 2003). There is great variation in the IR posture of nations. Some are far ahead in the information revolution—the vanguard nations, while others are far behind—the left-behind nations, and many fall in between the polar positions (Hundley, et al. 2000). "The forces that shape a nation's IR posture are more or less the same across the world but they interact in a variety of ways, subject to the circumstances of the country, thus leading to different national manifestations of IR" (Hundley, et al. 2003). A useful framework in understanding the forces driving IR is to look at those forces from four different aspects:

I. Technology diffusion theories
II. History of innovations/technology diffusion
III. The economic framework of supply and demand
IV. Empirical studies of ICT diffusion

2.1 Technology Diffusion Theories

Diffusion of innovations and technology is a subject that has been studied extensively[2] and is still an area of great research interest, mainly to identify the barriers to adoption of innovations. The diffusion of innovations has been observed to follow an S-shaped pattern. The S-shaped or ogive distribution was noted from the earliest work on diffusion, e.g., Zvi Griliches' (1957) work on hybrid corn.

While innovation provides new opportunities to inventors, adopters, and to society in general, innovations have inherent risks to both inventors (as innovations do fail) and to adopters (as adoption entails sunk costs). The inherent risk arises mainly due to a lack of information about the costs and benefits of an innovation. Learning is the process by which diffusion is driven and a number of models can arise depending on various assumptions regarding the learning process.

Demand side learning occurs as potential users learn about the new technology. This learning can be through interaction with users - i.e. word-of-mouth, or from common information sources - e.g. mass media (news, advertisements etc.). Word-of-mouth learning generates epidemic effects where use increases as users "infect" non-users. Initially there will be a few users, then users grow rapidly as each new user "infects" a potential user. This process then slows down as the market potential is approached, thus tracing the S-curve. This is the basic epidemic model of diffusion.

[2] Diffusion research can be traced to rural sociology research traditions, which began in the 1940s, mainly in connection with new hybrid seeds in agriculture. Since the 1960s, the diffusion model has been applied in a wide variety of disciplines such as education, marketing, communication and economics (Rogers and Scott 1997).

Demand side learning need not be through word-of-mouth. Firms can learn by buying information or experimenting, thus incurring information search costs. When firms learn, uncertainty is lowered and they can thus revise the perceived benefits of technology and find it profitable to adopt. If the firms are heterogeneous, their search costs will differ, and depending on their distribution, an S-curve can be traced. Heterogeneity of users is thus the driver of diffusion and this forms the basis of Probit diffusion models.

The supply side can learn by doing, thus becoming better at producing, and further user feedback helps in improving features and quality. Therefore as suppliers learn, cost is expected to go down, thus increasing the pool of users. Users buy technology because they get a certain benefit, but will only acquire the technology once the benefits exceed the cost. The S-curve can then be traced by making the assumption about the distribution of users' benefits. If the benefit obeys a normal distribution, then as price falls, more and more users acquire the technology and a cumulative normal curve is traced which is an S-curve. This is the alternative motivation of the Probit diffusion model.

Diffusion models can also be motivated by assumptions that are not based on learning. Stoneman (2002) and Geroski (2002) describe such models. Stoneman (2002) further classifies diffusion models into two categories, equilibrium models and disequilibrium models. Disequilibrium models are derived from the fact that the process of diffusion at any stage is not at equilibrium and the diffusion path is traced as the system moves to equilibrium level. Disequilibrium models are self-perpetuating where use of technology today generates further use tomorrow. An internal stimulus drives the process. Epidemic models fall into this class. In

equilibrium models there is an equilibrium number of users at any time that is determined by exogenous factors, e.g. price, firms' location, interest rates etc. But over time, these factors change. Thus the equilibrium level changes, tracing out a diffusion path. The Probit model is an example of an equilibrium model.

2.2 History of Diffusion of Innovations

History provides a useful tool for understanding the factors that drive diffusion. The challenge is to find innovations that provide a good historical analogy. One way is to see where ICT innovations fall in the general classifications of innovations and then look for compelling historical examples that could be useful for each class. ICTs generally fall into two classes, communication technologies and general-purpose technologies (GPT).

As communication technologies, Dewar (1998) sees the printing press as the best candidate for historical analogy. While printing press technology had its origins in East Asia around 700 A.D.[3] it didn't diffuse widely for a long period. But when introduced in Germany around 1450 it quickly spread to the rest of Europe (Katz 1995). The reason advanced for the rapid diffusion of the printing press in Europe was the great demand for information as the Reformation brought with it an insatiable appetite for religious books and the Renaissance brought a great appetite for newly discovered classics (Eisenstein 1983). This great demand for books provided a business opportunity for entrepreneurs, and the result was rapid diffusion of the printing press as entrepreneurs looked for ways to satisfy this demand. Culture, religion,

[3] Wood block printing or xylography was first developed in China, movable type was later developed around 1041 (Reed 2000). Korea was the first to develop the movable metal type, which was the precursor to the modern printing press in the 13th century (Kang 2000).

instability, corruption (lack of meritocracy) and low demand were the key factors in the failure of printing press diffusion in Korea and China (Kang 2000). Religion was the key obstacle in the Islamic empire (Dator 2004) while political instability (BBC 2003) and illiteracy (Deveneaux 1976) were the culprits in Africa. The history of the printing press suggests that market size, culture, religion, governance and entrepreneurship impact adoption of technology.

ICTs as General Purpose Technologies (GPTs)

As GPTs Rosenberg and Trajtenberg (2001), David (1999), Casselli (1999), and Jovanovich and Rousseau (2003) point to the steam engine and the electric dynamo as the GPT equivalents of ICTs.

The initial slow diffusion of electricity has been attributed to high capital investments that had already been made in the older power technologies, lack of skilled personnel, slow learning (David 1990) and the difficulty of restructuring organizations around the new technology (David and Wright 1999). The subsequent rapid diffusion of electricity in the 1920s was due to technological improvement in power generation and political and institutional changes that allowed utilities to escape regulation and facilitated the flow of investment capital. The favorable investment climate of the 1920s also helped (David and Wright 1999). The rise in wages in the period after 1914 was a factor as organizations sought new technologies to cut costs (David 1990). The education system played a key role in providing manpower attuned to working in the new organizational environment that resulted from the adoption of electricity (David and Wright 1999).

The history of GPTs suggests that adoption is impacted by investment in existing technologies, inability to adapt to accommodate new technologies, competition from old technologies, availability of skills, technology improvements, credit availability and politics (regulatory policies).

2.3 Supply and Demand Framework

The economic framework of supply and demand is also a useful tool for understanding the determinants of diffusion. Hall and Khan (2003) suggest such a framework. They argue that diffusion can be seen as the aggregate demand resulting from a series of individual/firm decisions to use the new technology, which is the result of the comparison of the uncertain benefits of using new technology with the uncertain costs of adopting it. The supply side can greatly influence the benefits and costs. Both supply and demand factors are modified by environmental factors.

Demand Side Factors

Economic theory tells us that demand is determined by income, prices, consumers' tastes, complementary goods, and substitute goods. Income is a key determinant as consumers have a budget constraint: higher income means higher demand. Gibbs, et al. (2002) point out that distribution of wealth is also important as it determines the proportion of a population that can afford ICTs. Consumers' taste is mostly determined by demographics, e.g., education level, age, rural/urban location, and culture. The market size is a function of industry sectors; certain types

of firms (e.g., financial organizations and retailers) are heavy users of ICTs and their predominance will affect the rate of diffusion (Gibbs, et al. 2002). Availability of complementary inputs like electricity, software, education, etc., will determine how useful ICTs will be. The availability of substitute goods reduces demands for ICTs, mass media, e.g., newspapers, television, and radio, are alternative sources of information. Network externalities - where perceived value derived from a network increases with an increasing number of users - also play a key role in determining demand (Gurbaxani 1990). Awareness increases demand of a product, providing another channel where mass media affects demand for ICTs. The wage level will also drive demand of ICTs as organizations faced with higher wages adopt technology to cut costs (David 1999).

Supply factors

The key supply factor is innovation. Innovation includes both development of new products and improvements of the products to improve quality and usability. Improvements after a technology has been developed have the greatest impact on diffusion (Hall and Khan 2003), as these improvements are mostly the result of user feedback. Mukoyama (2001) finds that the key determinants of technology improvements are learning and R&D investment, while the speed of quality improvement depends on the distribution of skills in the economy. Production costs (and thus prices) fall as learning-by-doing occurs, further emphasizing the importance of learning.

Jovanovic and Macdonald (1997) model diffusion of technology in firms and conclude that information barriers are key to explaining diffusion of technology. Patents are the key

barriers to the flow of information. Supply of new technology is thus limited due to monopolies that patents provide. But patents, by providing this monopoly to innovators, do provide further incentive to innovate (Benhabib and Spiegel 2002).

Network effects have an impact on supply, as they are important in determining which competing standards embodied in various technologies will dominate, thus establishing the *de facto* standard. This has an effect of creating a monopoly for the supplier of the winning standard.

Nelson and Phelps' (1966) human capital-growth model shows that the rate at which technological latecomers realize technological improvements is a positive function of educational attainment and the gap between the latecomer and the leader.

Environmental Factors

The main environmental factors are governance (government laws and regulations, trade policies etc), geography and socio-cultural factors. Environmental factors can impact either supply or demand.

A market characterized by many suppliers has higher rates of adoption due to lower prices caused by competition. Trade openness allows new technologies to diffuse via foreign investments and imports, and such imports are accompanied by technology spillovers that further enhance diffusion (Casselli and Coleman 2001). Foreign Direct Investments (FDI) via Multi-National Corporations (MNCs) will also push suppliers and business partners to adopt

compatible systems as well as transferring technology and knowledge (Gibbs, et al. 2002). Trade liberalization also introduces an element of global competition, forcing local business organizations to seek technology to remain competitive The importance of openness of the economy is underscored by the fact that ICT are manufactured in a few countries and thus ICTs in most countries are a result of importation (Casseli and Coleman 2001).

Government laws and regulations determine the structure of the financial markets and the quality of institutions that govern the market. Well-developed and regulated financial markets that provide adequate returns on investments attract capital that is important to both supply and demand of ICTs. In particular venture capital is a major enabler of innovations, and availability of credit is important in acquiring ICTs. A legal environment that protects both investors and consumers allows entrepreneurship, a driver of innovations, to develop and thrive. Government mandated standards reduce users' uncertainty and increase competition—both of these increase technology diffusion (David and Steinmueller 1994). ICTs are primarily communication media and therefore tools for expression of political speech and civil liberties among other things. Political regimes that suppress freedom of speech may want to control the diffusion of technology, and indeed their fears are well founded as Kedzie (1997) shows that democratization is positively impacted by the spread of ICTs.

Physical geography plays an important role as technology spillovers are higher in those regions that are nearer to the innovation, and also FDI flows are higher to countries neighboring richer countries (Keller 2001). Geography has an impact on patterns of past colonization, religion and culture. While these factors may not be relevant in diffusion now, they are important

as they determined the type and quality of institutions that were developed and thus the starting point of diffusion (Schoffer 2004). Geography also embodies some aspects of the history of past innovations adoption, which plays a major role in how future innovations diffusion will fare (Comin and Hobijn, 2003).

Culture and values held by a society are important for both the supply and demand of new technology. Culture determines whether society members are responsive to new ideas (tolerance), independence and their attitude toward taking risks, factors that are important in diffusion of new technologies (Hundley, et al. 2003). Trust is the grease that makes a market operate and determines whether individuals will engage in innovative activities or not. Innovators must trust that their innovations will be taken up and buyers need to have trust to try new innovations (Volken 2002). Societies where free market ideas of competition, merit pay and ownership are valued are likely to see more innovations, as entrepreneurship will thrive. But entrepreneurship also requires attitudes that value hard work, challenge and initiative.

2.4 Review of Empirical ICT Diffusion Studies

Empirical studies of diffusion of ICTs have focused on the indicators that the economic framework of supply and demand deems important in diffusion, though few studies have focused on a comprehensive number of indicators and even fewer have based their selection of indicators on a comprehensive theory. Studies adopt either an adoption framework that assumes market potentials are reached, i.e. equilibrium, or a diffusion approach that assumes market potentials not attained, i.e. system moving towards an equilibrium (market potential) along an S-shaped diffusion path.

In a comprehensive study, Chinn and Fairlie (2004) investigated the determinants of cross-country disparities in personal computer and Internet penetration for 161 countries over 1999-2001 based on an adoption approach. They used a set of explanatory variables derived from an economic demand and supply framework, they concluded that public investment in human capital, telecommunications infrastructure and the regulatory infrastructure can mitigate the gap in computer and Internet use between rich and poor countries. They also found that region-specific factors were similar. This study, though comprehensive, fails to consider epidemic effects and cultural values. It also uses the developed vs. developing countries paradigm rather than actual IR posture to investigate the impact of the various drivers across countries.

Rouvinen (2004) studied the factors determining diffusion of digital mobile telephony across 200 developed and developing countries using the Gompertz formulation of an epidemic diffusion[4]. Network effects were found to play a more important role in developing countries. Technological and market uncertainties were found to have more detrimental effects on diffusion in the developing world. Complementary innovations, especially microfinance and payment systems, hasten diffusion in developing countries. Using a similar framework Kiiski and Pohjola (2001) used Internet hosts per capita as a measure of diffusion and found that for OECD countries, GDP and Internet access cost can best explain diffusion. Competition in the telecommunications market and investment in education did not seem to matter. However, when the sample was expanded to include developing countries, investment in education became significant.

[4] This formulation assumes an asymmetric S-curve rather than symmetric S-curve and will be discussed in section 4.

Beilock and Dimitrova (2003) investigated the factors that explain global inter-country differences in Internet usage across 102 countries, including both developed and developing countries using an adoption approach. Income was found to be the most important determinant and further income impact was greater at lower levels of income than at higher levels of income. Openness of society, infrastructure and religious affiliations were also important.

Casselli and Coleman (2001) used computer imports per worker as the measure of ICT adoption using data from 90 countries. They found that computer use is strongly influenced by a high level of human capital and trade with Organization for Economic Co-operation and Development (OECD) countries. It is also enhanced by high investment rates, good property rights protection, and a small share of agriculture in GDP. On the other hand, computer use is reduced the larger the share of government expenditure in GDP. English language skills did not affect the outcome either.

Baliamoune-Lutz (2003) focused on 47 developing nations using a diffusion framework. The study included economic freedom and civil and political rights indicators, in addition to the traditional indicators of income and human capital. Four ICT indicators: cellular mobile subscribers per 100 inhabitants, personal computers per 100 inhabitants, Internet hosts per 10,000 inhabitants, and Internet users per 10,000 inhabitants were used. Factors found to be important were income and trade policies. Political and civil rights were important indicators for mobile phones and Internet hosts indicators while GDP seemed to have no effect. Education was found not to be important.

Gibbs, et al. (2002) examined the determinants of e-commerce diffusion using a systematic case study of 10 countries from both developed and developing worlds. They found that Business-to-Business (B2B) e-commerce is primarily driven by global competition via "push" from Multi-National Corporations (MNCs) to the customers, suppliers and subsidiaries. Business to Consumers (B2C) is driven by local consumer markets. Trade policies and telecommunication liberalization were seen as having the biggest impact on e-commerce, while e-commerce legislation was not important.

Volken (2002) investigated the cultural dimension of Internet diffusion using trust as the key determinant of ICT adoption. He used a sample of 47 countries using country data on values, corruption, economic freedom, civil rights, and political rights. Two types of trust were investigated—trust in systems and generalized trust. Trust was found to display both a positive and a significant effect but not in the same way. In advanced democracies both types of trust have the same impact, while in emerging democracies trust in systems is much more important. Tertiary education was found to be significant in advanced democracies but the effect disappears in the pooled sample of all countries. Access cost was a significant and negative factor for poorer countries, although insignificant for advanced democracies.

Rodriguez and Wilson (2000) explored the ICT gap between the rich and poor countries and the trends in the gap. They found that the gap is growing though there are a few developing countries that are surging ahead. They found that countries enjoy greater technological progress when there is a respect for civil liberties, respect for rule of law and security of property rights,

low levels of government distortions, and investment in human capital. They caution that these links are complex and that there are tradeoffs. For example, investing in public health is associated with negative technology growth, which reflects short-term choices that poor countries face, a decision termed as a choice between Pentiums and Penicillin.

The empirical studies on ICT diffusion have mostly investigated a subset of the determinants so that a number of studies need to be consulted to determine the impact of various factors. When there are missing variables - as is the case in many studies - then the results could be biased due to omitted variable bias. Studies also tend to focus on differences between developed and developing countries, but using income as a way to partition countries when studying ICT diffusion is not the right approach as countries with similar incomes can show great variation in ICT diffusion. Studies also tend to focus on either long-term drivers (adoption studies) or short-term drivers (diffusion studies). I have not yet come across a study that investigates both long-term and short-term drivers, thus providing a more complete picture.

2.5 IR Drivers: A Conceptual Framework

The literature review shows that a number of factors are at play in the ICT diffusion process. These factors impact on the diffusion process directly or indirectly through other factors. In particular, environmental factors impact diffusion directly and through their impact on demand and supply factors. Time affects all factors and the diffusion process directly through learning and technology advancement. Diffusion has a number of stages and the current stage determines

the next stage. We would also expect the impact of indicators to vary across stages. Diffusion of ICTs can thus be modeled as shown in fig 2-1.

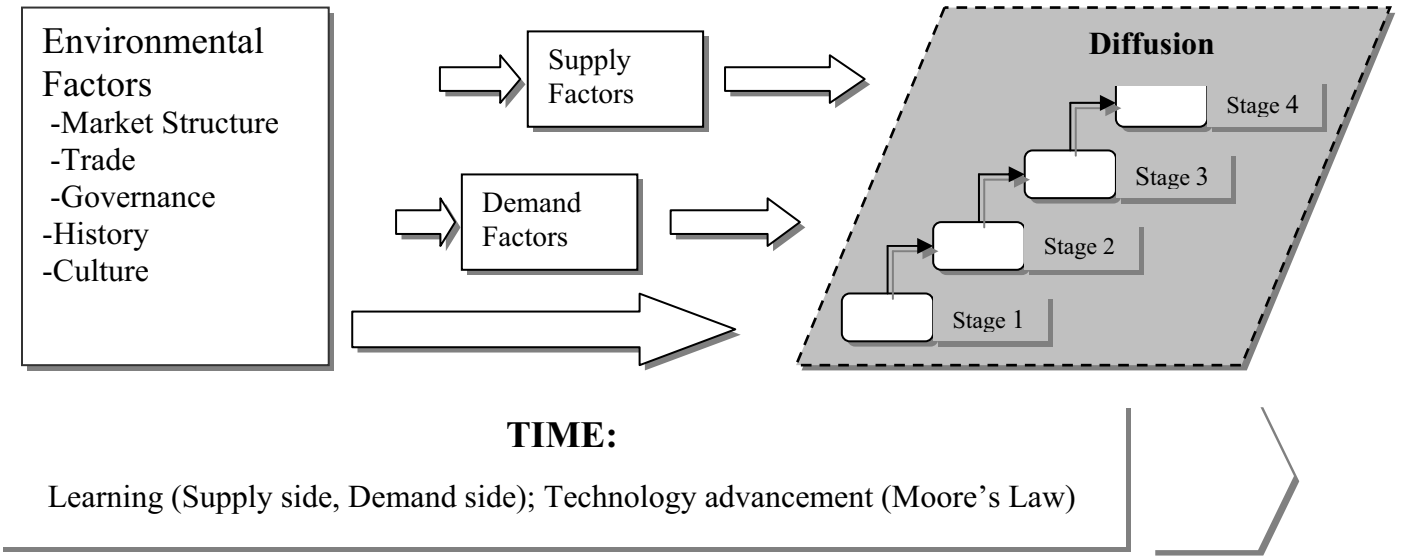

Fig 2-1: IR Drivers Conceptual Framework

Demand factors

- Wealth and Income: ICTs are relatively costly and income reflects the ability to acquire them
- Demographics: They determine the size of the market, also, since tastes vary with age, certain age groups have higher taste for ICTs and thus higher demand
- Education: Use of ICTs require some level of education though the level depends on the specific ICTs in question e.g.; using computers in design (CAD) may require university level education while using a mobile phone requires basic literacy.
- Network externalities: ICT's value increases with the number of people using them, so a mobile phone is more valuable if others, especially those you need to communicate with, join the network. Therefore the number of people already in the network impacts current demand.

- Substitute products/services: ICTs are in competition with other products/services though the general-purpose nature of ICTs makes it hard to pinpoint a single product/service that competes with them in all dimensions. For example, mass media as an alternative source of information competes with ICTs on this aspect.
- Complementary products/services: Availability of electricity increases demand for ICTs as all of them need electricity to operate.
- Promotion: Awareness through suppliers' advertisements, government policy and mass media news increases demand.

Supply factors

- Research and Development (R&D) personnel: This reflects the capacity available to develop and improve ICTs.
- Research and Development (R&D) funding: This reflects the resources devoted to developing and improving technology which complements R&D personnel.
- Tertiary education (Science and Engineering enrollments): This primarily reflects the capacity to adapt technology to local needs, in particular developing ICT services.

Environmental factors (impact both supply and demand)

- Governance: Regulatory environment, political freedom and civil liberties are important in diffusion of new ideas. Regulation determines the numbers and types of players in the ICT market place, i.e. competition, and thus ultimately the prices charged and range and quality

of services offered. ICTs are primarily an information media and regimes that want to control the flow of information may suppress their spread.

- Market/Industry Structure: Sectors like financial services are intensive users of ICTs while agriculture makes little use of ICTs. Thus the industry structure will impact on demand.
- Trade: Trade facilitates diffusion through transfer of expertise especially when imports have high ICT components. Diffusion also occurs through unintended knowledge spillovers. Exports to some markets may require use of ICTs -- e.g., e-commerce, barcodes etc. In general participation in global trade requires linkages to global markets through ICTs.
- Geography: Regional factors like religion, history of colonization, etc., determine types of political systems, education systems and other institutions that impact on diffusion. Knowledge spillovers also occur due to proximity to countries that produce ICTs.
- Culture: Trust or social capital is key in driving ICT diffusion as the epidemic model is premised on contagion. Adoption requires more than just information, it requires persuasion and trust is central in persuasion. Attitudes towards risk and conformity are also important and they reflect the ability to adopt new ideas, i.e., entrepreneurship.

Diffusion Stage

- Diffusion theories postulate that different units adopt at different times due to differences in capabilities, taste etc. Therefore there is heterogeneity that results in different stages of adoption (see next chapter for details). The earliest adopters are those of highest capability and the later adopters of less capability. Thus the stage of adoption will determine what products and services will be demanded.

Time

- Supplier learning: Improvement in usability, performance, features and reliability is an ongoing endeavor by suppliers. Learning by doing and feedback from customers is the primary means by which this occurs.
- Users learning: With time, users make better use of the technology as they learn by doing. Users also make adjustments to make technology work better, e.g., organizational redesign.
- Technology advancement: Improvement in price/performance by Moore's law and related similar technological development trends makes ICTs more affordable over time, increasing both supply and demand.

2.6 ICTs Adoption Versus ICT Diffusion

In identifying drivers of information revolution there is need to reiterate the distinction between adoption drivers and diffusion drivers as used in this study. Adoption drivers determine the equilibrium level of adoption while diffusion drivers determine how fast the equilibrium is reached.

Structural constraints as defined by demand, supply and environmental factors (political and cultural factors) define the capacity of an economy to adopt ICTs. Thus, income means that only some people can afford ICTs. Adoption drivers define the efficient (or equilibrium) level of adoption under the prevailing circumstances. Changing this equilibrium level entails relaxing the structural constraints faced by the economy. ICT adoption study is concerned with the impact of changes in structural constraints on the equilibrium level.

But it has been noted that innovations are not always adopted quickly and some adoption times can be long. So adoption can be sub-optimal when the equilibrium level of adoption is not attained. The reason for this has been attributed to the fact that innovations tend to be risky because the benefits are uncertain due to lack of information. But as innovators adopt, the benefits become apparent and thus adoption rates increase as information spreads until the optimal level is reached where all those who can acquire have acquired. ICT diffusion drivers determine how fast the equilibrium is reached.

Adoption and diffusion are thus two sides of the same coin. One is concerned with defining the equilibrium level and the other is concerned with the process by which the equilibrium level is attained.

3.0 IR STAGES CONSTRUCTION

3.1 Information Revolution (IR) Stages

While it is acknowledged that countries are at different stages of IR there are few studies that have attempted to define the various IR strategies and classify countries into stages. The RAND IR conference (Hundley et. al. 2000) identified 10 IR postures[5] and gave typical countries in each classification. While this classification is appropriate for case studies and general discussion it is not appropriate for quantitative analysis due to the fact that some groups will have too few countries, given that there are at most 100 countries for which comprehensive data on IR exists. A different method of classifying IR posture is thus required for the purposes of this study.

Rogers' (1985) model of innovation diffusion classifies adopters of innovations into five categories; (1) innovators, (2) early adopters, (3) early majority, (4) late majority, and (5) laggards. The demarcation line is the percentage of the unit of adoption, e.g., households or individuals that have adopted a technology after a given time. The percentages assigned to various classes are shown in table 3-1:

Table 3-1: Rogers (1985) Diffusion Groupings

Group	Percent	Merged*	Cumulative
Innovators	2.5%		
Early Adopters	13.5%	16%	16%
Early Majority	34%	34%	50%
Late Majority	34%	34%	84%
Laggards	16%	16%	100%

* The grouping is where Innovators and Earl Adopters are merged into one category

[5] The stages were IR Rejectionists, IR Left behind; IR Veneer; IR Transition societies; IR Late starters; IR Conflicted societies; IR Slow movers; IR Modifiers; IR Strivers; IR Vanguard.

We can combine the innovators and early adopters, as this is the group that is critical to getting the diffusion process started and sustaining it. Rogers (1985) calls this group the critical mass. Using this framework we can then propose four stages of IR. Countries in the 1st stage of diffusion are those with less than 16% of the relevant population group adopting. The 2nd stage are those countries with between 16% and 50% of relevant population adopting the technology, the 3rd stage are those with between 50 and 84 % of potential adopters adopting while those in 4th stage have over 84% of the potential adopters adopting. This is summarized in table 3-2.

Table 3-2: Modified Rogers Diffusion Groupings

IR stage	Penetration
4th Stage	> 84%
3rd Stage	50% - 84%
2nd Stage	16%– 50%
1st Stage	< 16%

The four stages of IR have also been proposed in literature. Desai, et al. (2002) propose four stages when classifying countries on capacity to create and use ICTs. The Global Diffusion of Internet (GDI) framework (Wolcott et al. 2001) proposes five stages of Internet development - namely levels 0 through 4. Level 0 signifies non-existence of Internet, i.e., no diffusion, so technically they really have four stages of diffusion. It is therefore reasonable to divide IR into four stages.

3.2 Classifying Countries to IR stages

A number of rankings of ICT diffusion that combine a number of ICT indicators to some index have been developed by both academic and non-academic organizations. They rank countries

using some criteria that depend on their score in various measures. The indexes tend to combine both quantitative measures and qualitative measures. They also tend to combine IR posture measures with measures of factors that cause IR. This makes many of them inadequate for empirical analysis (Da Rocha and Teixeira 2003, Choucri, et al. 2003). Another major shortcoming of many indexes is that there is a lack of data necessary to calculate the values for a reasonable number of countries. Further, indexes vary significantly depending on the type of organization in which they are developed. The objectives and the methodology used make comparison across indexes hard (Dutta et. al., 2003). Producing a single index with which to measure IR is still an area of active research interest. A survey of these indexes can be found at www.bridges.org (2001) and by Dutta et. al. (2003).

Hundley et al. (2003), upon which this report is building, proposes that a measure of IR posture should have two key dimensions; (1) the capacity to generating innovations as measured by ICT technology, artifacts and services produced and (2) the capacity to absorb or use technology as measured by teledensity, computers per capita etc. The indexes that best capture this concept are the United Nations Development Program (UNDP) Technology Achievement Index (Desai et. al. 2002), and the Global Competitive Report-Technology Index (Schwab et. al. 2002). The Network Readiness Index (Kirkman et. al. 2002, Dutta et. al. 2003, Dutta et. al. 2004) captures this concept but the capacity to produce is captured indirectly by assessing the enabling environment.

3.2.1 Technology Achievement Index (TAI)

The technology achievement index (TAI) (Desai et al. 2002) aims to capture how well a country is creating and diffusing technology and building human skills. The index has four dimensions:

i) Technology creation dimension using two indicators: (1) patents granted per capita to reflect current level of invention activities, and (2) receipts of royalties and license fees from abroad to reflect the stock of successful innovations.

ii) Diffusion of recent innovations as captured by (1) the export of high and medium technology products as a share of all exports and (2) the diffusion of the Internet measured by number of hosts.

iii) Diffusion of old innovations as captured by (1) electricity consumption[6] and (2) telephone penetration.

iv) Human skills as captured by (1) years of schooling in the population aged 15 and above and (2) the gross enrollment ratio of recent science, mathematics and engineering graduates. These two measures captures the ability to create technology (tertiary education) and the ability to absorb technology (basic education)[7]

[6] The values are capped at OECD levels to reflect the importance of these technologies at early stages of development. The values are also transformed to logarithms so that they contribute less to the index as the level increases.

[7] This is a measure of capacity as opposed to outcome or capability which the TAI purports to measure.

Each of the four dimensions is given equal weight. The data used is mostly from years 1998 to 2000[8] and included are 72 countries for which data are available and of acceptable quality. Desai et al (2002) further classifies countries into four groups based on their TAI score.

- *Leaders:* These are countries that are at the cutting edge of technological innovation, where innovation is self-sustaining. Diffusion of ICTs is widespread.
- *Potential Leaders*: These countries have invested in high levels of human skills and have diffused old technologies widely. However they innovate little, though they have skill levels comparable with those in the top group.
- *Dynamic Adopters*: These countries are dynamic in the use of new technologies and have important high technology industries and technology hubs, but the diffusion of old inventions is slow and incomplete.
- *Marginalized*: Technology diffusion and skills have a long way to go in these countries. Large parts of the population have not benefited from the diffusion of technology

3.2.2 Global Competitiveness Index- Technology Index (GCI-TI)

The Global Competitiveness Report (Schwab et. al., 2002) provides a technology index that aims to capture the capacity for innovation and diffusion of technology. The index is constructed using hard data from country statistics and soft data from executive opinion surveys. The technology index is a composite of three subindexes:

i) The innovation subindex seeks to explain the factors that underlie innovation using
   - Data on patents granted

[8] Some country data goes as far back as 1995 if more recent data could not be obtained

- Tertiary education enrollment data
- Executive opinion on innovation

ii) Technology transfer sub-index aims to measure of ability to transfer technology using the following data:

- Technology trade
- Executive opinion on importance of trade

iii) The information communication technology subindex is a measure of access to technology. It uses data on:

- Mobile telephone users
- Internet users
- Internet hosts
- Telephone mainlines
- Personal computers
- Executive opinion on competition (markets), laws, regulation, Internet in schools, and government ICT priorities

This index was developed by Harvard University Centre for International Development (CID) for the World Economic Forum (WEF). The technology index ranks 75 countries representing 80% of world population and 90% of economic output. The report divides countries into two groups, a core group where innovation matters more than diffusion and non-core group where diffusion matters more.

3.2.3 Network Readiness Index Framework

The Network Readiness Index (NRI) is a collaborative effort of the INSEAD school of management, the World Bank (Infodev) and the World Economic Forum. It builds on the earlier work by Harvard University Centre for International Development, European Foundation for Quality Management (EFQM) and IAP (Information Age Partnership) Frameworks.

NRI assesses countries' capacity and potential to participate in the networked world. On this index the country with the most highly developed ICT networks and the greatest potential to exploit these networks is ranked first. In its current edition (Dutta et. al. 2004) the index attempts to capture creation, usage of ICTs and the enabling environment for both creation and use of ICTs. Both hard data and survey data are used in calculating the index. The current report ranks 102 countries. A modified NRI index was created to only capture creation and usage aspects and not the enabling environment.

3.2.4 Modified Technology Achievement Index (M-TAI)

Using data provided by the current United Nations Development Programme (UNDP) Human Development Report (UNDP 2004) on technology creation and diffusion, a modified Technology Achievement Index has been constructed by the author[9]. The indicators used for the two dimensions of ICT creation and use are shown in table 3-3. Data on personal computers per

[9] The Modified Technology Achievement Index (M-TAI) was developed to further enrich the set of available indexes and also as an index that explicitly tries to capture both creation and use dimensions of IR posture. It follows the approach and data sources used by TAI index, thus the naming of the index.

1000 people was extracted from the World Development Indicators (WDI) while the rest of the data was obtained from the Human Development Report (UNDP 2004).

Table 3-3: Modified Technology Achievement Index (M-TAI) Dimensions.

USAGE DIMENSION (USE INDEX)	**CREATION DIMENSION (CREATION INDEX)**
Personal Computers per 1000	Patents granted to residents per million people
Telephones mainlines per 1000 people	Receipts of royalties and license fees (US$ per person)
Mobile phones subscribers per 1000 people	Research and Development (R&D) expenditures as % of GDP
Internet users per 1000 people	Researchers in R&D per million people

Note that Desai *et al.* (2002) did not use R&D expenditure and R&D personnel in creating the TAI index as they felt that these are inputs rather than outputs in the creation dimension, but their approach does penalize countries that are not yet producing any patents or earning royalties but are creating ICTs products and services not at the cutting edge. Production of ICT services is especially difficult to capture through royalties and patents data. They also did not include data on personal computers (PCs), yet PCs are the core of the information revolution.

The modified TAI is created using the same procedure adopted by *Desai et. al*. (2004) in imputing missing data on patents and royalties and in calculating the index[10]. The index for, say, the PCs dimension for country *i* is calculated as

$$PC_{i\_index} = (X_i - X_{min}) \div (X_{max} - X_{min})$$

Where X_i is the score of country *i* and X_{max} and X_{min} are the maximum and minimum values in that measure so that the highest scoring country gets a value of 1 and lowest scoring a

[10] Desai, et al., imputed a value 0 for non-OECD countries that had missing data on patents and royalties, the argument being that missing data for this countries is an indication of no activity.

value of 0. The usage index is then the average of the four use sub-indexes and the creation index is the average of the four creation sub-indexes. The modified TAI is then the average of the creation and use indexes.

Use_Index = (PC_index + Telephone_index + Mobile_index + Internet_Index)/4

Creation_Index = (Patents_index + Royalties_index + R&D expenditure_index + R&D Personnel_Index)/4

Modified TAI = (Use_index +Creation_index)/2

Since simple averages are used, each dimension contributes equal weight to the Modified TAI. The resulting modified index has 97 countries. (see appendix table A-1).

3.3 Assigning countries to IR stages

The four indexes (NRI, TAI, TI and M-TAI) are relative rankings of countries on some construct that purports to measure the information revolution. The objective, however, is to group countries into the four stages of IR identified earlier. Though the four indexes have many countries in common there are many countries not covered in all the indexes and some countries are covered in only one index. To use information contained in all indexes so that the list of countries can be as large as possible, there is a need to determine whether the indexes are comparable. The four indexes differ in a number of ways that may make their comparison or compatibility problematic:

- Underlying variables are not the same, so we need to worry whether they are measuring the same construct

- The indexes use data from different years, so that even if they were measuring the same phenomena we need to worry whether this construct is unchanging from year to year
- The number of countries covered by each index is different, though a majority of countries are common. So if they are measuring the same construct what happens if the relative rankings of some countries are not the same across indexes, which index is closest to the "truth"?

Plotting the indexes can reveal patterns that may indicate a shift from one stage to another and also how the indexes compare. The plot of the indexes' in Fig. 3-1 shows no clear point at which one can say there is a significant jump to indicate moving from one stage to another. The graph shows the indexes falling smoothly from the highest to the lowest scoring country.

Note that only countries that are in all indexes are included in fig 3-1 and the NRI and GCI-TI indexes are scaled to the same scale as TAI for better visualization. The graph shows that the indexes have a similar pattern, though the M-TAI shows a much sharper decline especially for countries at lower scores. This can be explained by the fact that M-TAI gives equal weight to use index and creation index but since only a few countries create ICTs as measured by patents, royalties and R&D data, the index falls rapidly after the countries that create ICTs are ranked.

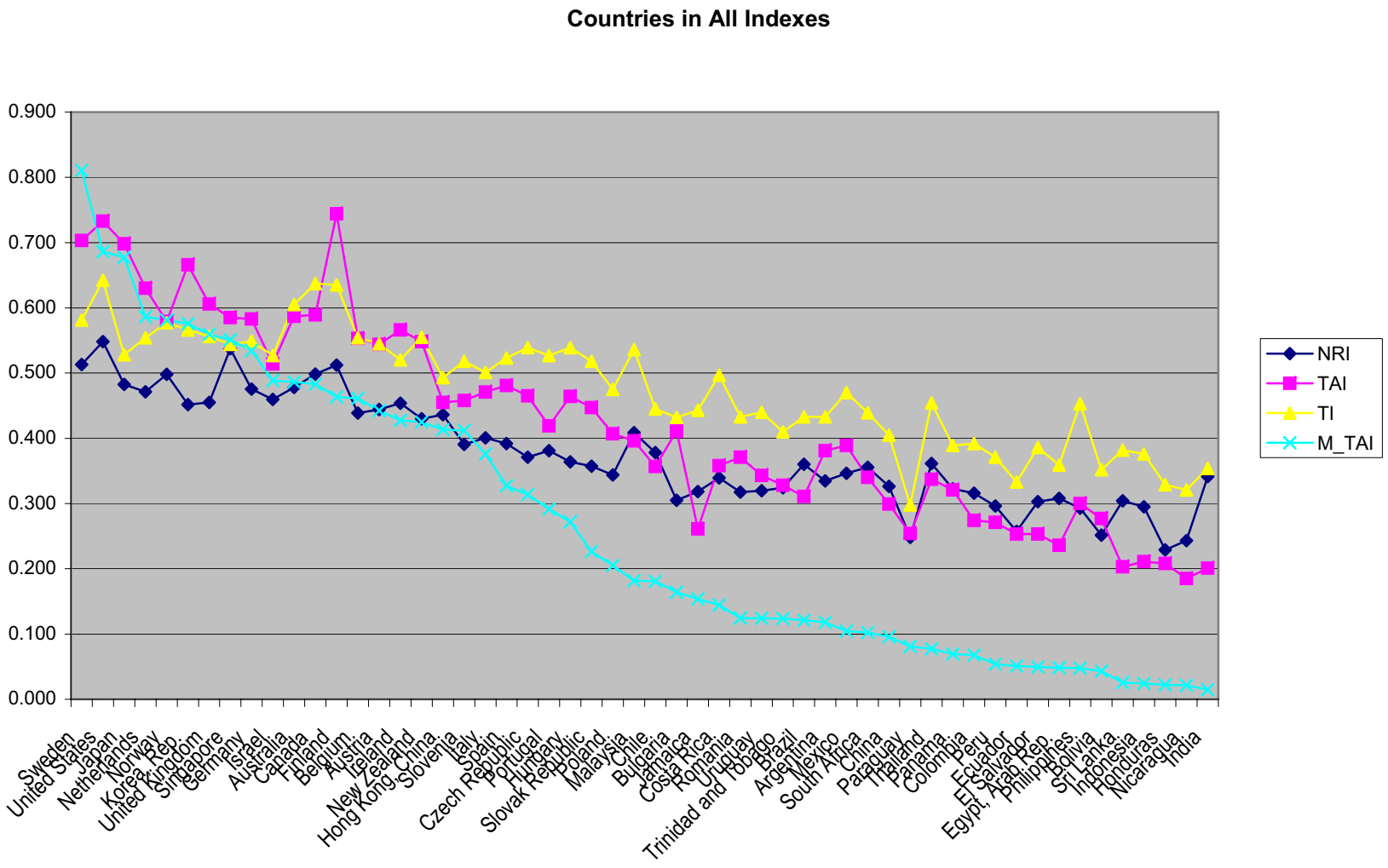

Fig. 3-1: Plot of Countries on the IR indexes

The correlations of the four indexes are very high as we can see below. (The number of countries common in each index is also shown together with the correlations).

	TAI	NRI	GCI-TI	M-TAI
TAI	1.0000			
	72			
NRI	0.9207	1.0000		
	67	103		
GCI-TI	0.9154	0.9018	1.0000	
	58	75	75	
M-TAI	0.9518	0.8732	0.8482	1.0000
	61	78	68	96

Thus from the correlations we have confidence that the indexes are measuring the same construct, which presumably is a measure of the degree of adoption of and participation in the information revolution (IR) by country. We can have more confidence in using all the indexes since our objective is not to rank countries *per se* but to group them in stages of IR. Therefore, the precise rank of individual countries does not matter. The stage of IR a country is in is also not expected to change quickly so indexes from different years can be used if the years are not too distant.

Assuming that the indexes are capturing a common construct that is the information revolution (IR), we can use the indexes to recover it. This construct can be extracted using the factor analysis technique, which aims to reduce a large number of dimensions to a few that capture the common variance among them. This is the method used in creating the IR scale. Factor analysis was done using the 55 countries that had data on all the indexes and it showed that the four indexes can be captured by one factor that explains the common variance.

Variable	Factor Loadings 1	Uniqueness
nri_score	0.95812	0.08201
tai_score	0.98056	0.03850
ti_score	0.93385	0.12792
m_tai_score	0.96965	0.05979

Using the score function in factor analysis each country (the 55 core countries) was then scored creating a scale (call it IR) based on this factor. The new scale has a very high correlation with the 4 indexes as is expected.

	IR
IR	1.0000
nri_score	0.9665
tai_score	0.9891
ti_score	0.9420
m_tai_score	0.9781

The rest of the countries that had data missing on one or more indexes were then fitted on this new scale by imputation. The imputation strategy used a regression strategy that utilized the available data points to create relationships between the various indexes by regressing a particular index on the other indexes. These relationships were then used to impute the missing data. Thus if the TAI data is missing for a given country the relationship obtained by regressing TAI on NRI, GCI-TI and M-TAI indexes was used to impute the missing data[11]. The result was 123 countries ranked on an IR score as seen in table A-1 (see appendix).

[11] A number of imputation strategies were explored using explicit regression expressions and using in-built *Stata* imputation facilities which basically employ the same regression approach. The results were generally the same.

3.3.1 Stage Assignment

.

The IR score falls gradually, so using the trend to classify countries to stages when significant jumps are noted is not feasible. Another alternative is to use distance from mean such that countries that score one standard deviation above the mean are classified to stage 4, those between mean and one standard deviation go to stage 3, those below the mean by one standard deviation go to stage 2 and the rest to stage 1. The parameters of interest are the mean (μ) and the standard deviation (σ). The boundary points can now be calculated so that we now have:

$$\mu = -0.527; \quad \sigma = 1.016; \quad \mu + \sigma = 0.489; \quad \mu - \sigma = -1.543$$

Table 3-4 shows the boundary countries that result, the countries that lie at each side of the border of interest as shown in order of IR score. Therefore for stage 4 and stage 3 the boundary line is drawn between New Zealand and Estonia for stage 3 and stage 2 the line is drawn between Qatar and Thailand and for stage 2 and Stage 1 the line is drawn between Nicaragua and Malawi. But since countries at higher stages are over represented, this scheme will tend to move laggard countries to higher stages. So a number of Sub-Sahara Africa countries are now in stage 2 while they were in stage 1 in TAI (see table A-1 in the appendix for greater detail).

Table 3-4: IR Scale boundary countries (countries shown in IR scale order)

Stage	Boundary Values	Upper Boundary Countries	Lower Boundary Countries
4	> 0.489		New Zealand
3	–0.527—0.489	Estonia	Qatar
2	– 1.543— (-0.527)	Thailand	Nicaragua
1	< -1.543	Malawi	

An improvement to this scheme is to use the TAI boundaries to improve that scheme especially at lower stages. Desai, et al. (2002) classify countries to the various stages based on TAI score and the differentiating score is where there was a marked jump in some component of TAI, but the details of the components used to draw the line are not given. The countries that define the boundaries of the four stages are shown in table 3-5.

Table 3-5: TAI boundary countries

IR stage	TAI Score Cutoff	Upper Boundary	Lower Boundary
Leader (4th Stage)	> 0.5		Austria France Israel
Potential Leader (3rd Stage)	0.35—0.49	Spain Italy Czech republic	Romania Costa Rica Chile
Dynamic adopter (2nd Stage)	0.20—0.34	Uruguay South Africa Thailand	Honduras Sri Lanka India
Marginalized (1st Stage)	< 0.20	Nicaragua Pakistan Senegal	

The three countries on either side of borderline are shown in the order they are ranked

The strategy is to draw the demarcating line at the point that the IR scale scheme suggests and at the points that TAI suggests[12]. Table 3-6 shows what happens for stage 1 and stage 2. The IR scale suggests the line to be drawn below New Zealand. TAI suggests the line to be either below Israel or above Spain. If the line is above Spain as TAI would suggest, then Estonia, Hong Kong , Slovenia and Italy go to stage 4. Otherwise they stay in stage 3 if the line is below Israel. But drawing the line below New Zealand, which was in stage 4 in TAI classification, best preserves the spirit of TAI.

[12] There are two lines for TAI as the order of countries under IR scale is not the same as it was for TAI

Table 3-6: Demarcating strategy

Country		IR Score	IR-Stage
France	NAWE	0.810354	4
Austria	NAWE	0.787796	4
Israel	MENA	0.768412	4
New Zealand	EAP	0.757879	4
Estonia	EECIS	0.415182	3
Hong Kong, China	EAP	0.409046	3
Slovenia	NAWE	0.334212	3
Italy	NAWE	0.330551	3
Spain	NAWE	0.317841	3

This procedure was followed for demarcating between stage 3 and stage 2 and between stage 2 and stage 1. Therefore the choice was between the two lines defined by TAI boundary countries and the line suggested by the IR scale scheme. The final result was a list of 123 countries grouped into four stages of IR shown in table A-1 (see appendix). Tables 3-7 and 3-8 provide an analysis of the final list of 123 countries so classified.

Table 3-7: Regional representation

Region	**No.**	**Percent**	
NAWE	23	19%	North America and Western Europe
EECIS	19	15%	Eastern Europe and Former Soviet Republics
EAP	14	11%	East Asia and Pacific
LAC	22	18%	Latin America and Caribbean
SAS	5	4%	South Asia
MENA	13	11%	Middle East and North Africa
SSA	27	22%	Sub Sahara Africa

It is evident that North America and Western Europe (NAWE) countries are over-represented in the sample of countries used.

Table 3-8: Representation by stages

Region	Stage				Total
	1	2	3	4	
NAWE	0	0	7	16	23
EECIS	0	11	8	0	19
EAP	1	5	2	6	14
MENA	1	11	0	1	13
LAC	7	12	3	0	22
SAS	4	1	0	0	5
SSA	23	4	0	0	27
Total	36	44	20	23	123

Sub-Sahara Africa states - as expected - dominate in the marginalized stage (stage 1) with 63% of the countries in that stage. In stage 2, the dominant countries are the Latin American, Caribbean, and Arab states (Middle East and North Africa). Eastern Europe and the former Soviet republics dominate stage 3 while North America and Western Europe countries dominate stage 4. This grouping is consistent with anecdotal evidence but we have to worry about whether the countries used are representative of all the countries that belong to each stage. There is selection bias as countries used in the analysis were selected because data was available for them, so countries that have better data collection infrastructure are more likely to be included in the list.

3.3.2 Stages Transition: ICT Creation vs ICT Use Patterns

In assigning countries to stages there was no sharp demarcation point but the approach used pointed to a number of possible boundaries. A number of countries fall in the grey area between the preceding stage and the next stage. A further analysis to understand what happens at the boundaries is required to better articulate stage transitions. The approach used is to analyze the countries using an ICT creation index and ICT use index developed in the creation of M-TAI

index. These two dimensions define IR posture and it is reasonable to suppose that changes in one dimension may mark the transition from one stage to the next higher stage. Fig 3-2 shows the plot of countries on the ICT creation and ICT use indexes

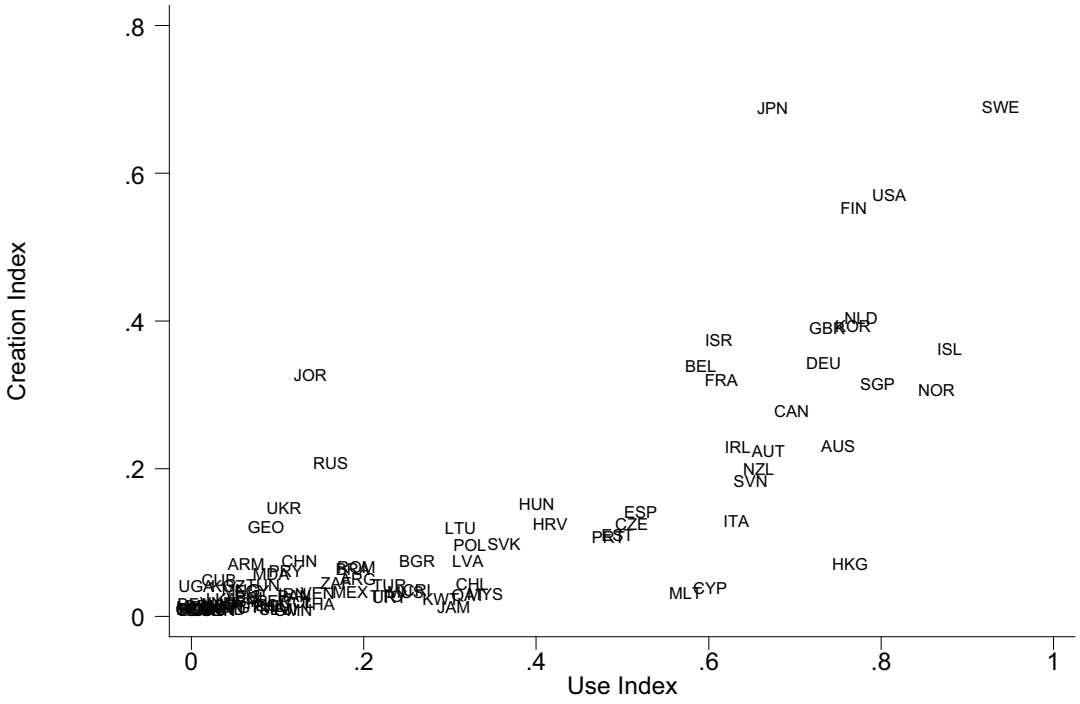

Fig 3-2: Plot of countries on ICT creation and ICT use indexes

Looking at the pattern created by plotting creation and use indexes one sees that the information revolution is much like a marathon race. At the beginning the crowd is tightly packed but as the race evolves winners start to separate out and the further the race moves on the greater the differentiation of the leaders on the two dimensions.

Superimposing the stages assigned to the countries, drawing lines to demarcate clusters of countries at various stages and taking into consideration the fact that stage boundaries are not clear cut, the pattern in Fig A-1[13] (appendix) is observed.

One can see that at stage 1 countries are tightly clustered together - scoring low in both creation and use indexes. It is hard to distinguish countries in this stage on either dimension. A great number of countries are also in the grey area between stage 1 and stage 2 and many can move to the next stage. Countries in stage 1 are doing very little. Doing anything in the right direction - i.e. either increasing use or increasing creation capacity - can move a country to the next stage. Thus, distinguishing a country in any small way easily moves a country from the laggard pack to the next stage. Note that countries in stage 2 are more differentiated in both dimensions (more so on the use dimension) than those in stage 1. Moving from stage 2 to stage 3 seems more influenced by increasing the use of ICTs. Best policies to move from stage 2 to stage 3 would seem to be policies focused on increasing access. In moving from stage 3 to stage 4, one observes that the overlap tends to be on the creation index. Thus moving from stage 3 to 4 is more influenced by increasing the ICT creative capacity of a nation. Countries in stage 4 are more differentiated than countries in stage 3 and this differentiation is more on the creation index as opposed to the use index.

Figure 3-3 best summarizes the patterns observed. As countries move to a higher stage, they become more distinguished from the rest - probably having found their niche and developing it or adapting ICTs in ways that are consistent with their development priorities,

[13] Note that Figs. A-1 and A-2 (both in the appendix) are the same. One uses country names and the other uses IR stage to code the data points.

cultural constraints etc. It demonstrates that as countries move further and further in IR, countries have more room to develop their IR postures in their own ways.

Fig. 3-3. Countries clustering pattern on Creation-Use indexes
(S1: Stage 1; S2: Stage 2; S3: Stage 3; S4:Stage 4)

4.0 INFORMATION REVOLUTION DRIVERS

The conceptual framework developed in section 1 identified potential drivers of IR and classified them according to demand, supply, and environmental factors. Further an IR scale has been constructed and countries scored on this scale and then assigned to stages of the information revolution. What now remains is to see which among the potential drivers is significant and how the drivers change across the stages of IR.

4.1 Analytical approach

The objective of the IR analysis is to investigate the drivers of IR and in particular what factors are key in moving from one stage of IR to the next. Then policy makers have information about the policy levers that will move their countries forward to the next level of IR. Short term, medium term, and long term strategies for moving forward can then be formulated. A regression strategy is employed for analysis. The regression model used is of the form:

$$IR_{i,} = \alpha + \boldsymbol{\beta_d}\, \mathbf{D}_i + \boldsymbol{\beta_s}\, \mathbf{S}_i + \boldsymbol{\beta_e}\, \mathbf{E}_i + \varepsilon_i$$

In this model,

IR_i : IR score for country *i*

D_i , S_i , E_i: Vector of explanatory variables for country i, the factors include; Supply factors (S), Demand factors (D) and Environmental factors (E)

ε_i : independently identically distributed (i.i.d.) error term

Some hypotheses of interest are:

H1: Environmental factors are more important for countries at early stages (stage1) of IR than countries in later stages. Countries in leadership roles have already developed high quality institutions (regulatory, political etc.) and markets so they are less important. Countries in stage 1 need to increase incomes so that ICTs can become affordable by creating an environment that attracts investments.

H2: Demand factors are more important for countries in the intermediate stages. In these stages the objective is to increase use of ICT and build a critical mass to sustain diffusion.

H3: Supply factors are more important in moving from stage 3 to stage 4, since at stage 3 the usage is high but level of creation of technology is low.

4.2 Data Sources and Data preparation

4.2.1 Socio-Economic Data

Data on economic and demographic indicators was derived from World Development Indicators (WDI). This is a dataset provided by the World Bank by subscription online. The dataset provides data on a variety of indicators of development for a large number of countries.

This data is the most comprehensive of all the data sources. The country codes in this dataset were used to form the unique identity that linked all the other data sources.

The main drawback of this data is that some indicators have data on very few countries. The indicators that were under consideration and the final indicators that were selected are given in table A-2 (see appendix). Therefore, the choice of indicators was based on the conceptual framework developed and also on availability of data on that indicator.

4.2.2 Governance Data

The governance dataset is provided by the World Bank (Kraay and Mastruzzi, 2003) is available online for downloading. This dataset provides estimates of six dimensions of governance covering 199 countries and territories for four time periods: 1996, 1998, 2000, and 2002. The indicators captured are:

- Voice and Accountability
- Political Stability and Absence of Violence
- Government Effectiveness
- Regulatory Quality
- Rule of Law
- Control of Corruption

The measures of governance are very highly correlated with each other as seen below. Thus the variables when used together in regression are likely to bring the problem of multi-colinearity.

	VA	PS	GE	RQ	RL	CC
VA	1.0000					
PS	0.6945	1.0000				
GE	0.7278	0.8147	1.0000			
RQ	0.7605	0.7188	0.8465	1.0000		
RL	0.7485	0.8199	0.9361	0.8334	1.0000	
CC	0.7173	0.7895	0.9290	0.7741	0.9363	1.0000

VA: Voice Accountability; PS: Political Stability; GE: Government Effectiveness; RQ: Regulatory Quality; RL: Rule of Law; CC: Corruption Control

Using factor analysis the governance dimensions were reduced to a single dimension called governance index, which was loaded very highly by all the factors. This new variable was thus used to explore whether governance matters. A more detailed analysis using the actual indicators was also done as needed to assess the impact of individual indicators.

4.2.3 Human Capital (Educational Attainment Data)

The Barro-Lee dataset (Barro and Lee 2000) is the main dataset used. This dataset provides data on educational attainment at various levels for the population age 25 and above and age 15 and above for about 129 countries. Educational attainment is given at four levels: no schooling, primary, secondary, and tertiary. They also provide a breakdown into incomplete and complete attainment at the three levels of schooling. Average number of years of schooling for the average person at each level and at all levels is also captured. Data are presented at 5 years intervals for the years 1960-2000.

The indicators selected are those that capture education attainment for the proportion of the population 25 years and over. In particular the following indicators are used.

i) Percent completed primary education

ii) Percent completed secondary education

iii) Percent completed tertiary education

Note the WDI dataset has data on school enrollment but WDI data focuses on the enrollment level as a percent of the age group that should be at that level of education. Thus the Barro-Lee dataset which provides data on attainment of those already in the workforce is more relevant than the WDI data. The key drawback of the Barro-Lee dataset is the 5 year spans used for data collection. The data set was supplemented by the education index developed by UNDP as part of the Human Development Reports series. The education index is a general measure of education achievement in a country.

4.2.4 Culture Data

The World Values Survey (WVS) is a worldwide investigation of socio-cultural and political change (Inglehart et. al 2004). WVS has carried out representative national surveys of the basic values and beliefs of publics in more than 80 societies covering about 70 countries. WVS claims to have covered almost 80 percent of the world's population from these 70 countries. WVS has been done through a number of waves carried out in 1990-1991, 1995-1996 and 1999-2001[14]. The survey items are numerous, covering a wide range of topics.

The items of interest in WVS were those that captured attitudes towards entrepreneurship (free market values), work, religiosity and trust as these are values that the conceptual framework

[14] Each wave has increased the country coverage and the 1999-2001 wave covered about 70 countries

deems as important in IR. A number of variables were explored and factor analysis was used to create compact measures where feasible.

i) Attitude towards jobs

The WVS asks a series of questions regarding the important aspects of jobs. The following aspects are captured: good pay; not too much pressure; respectable job; good hours; job that gives opportunity to use initiative; job that provides good holidays; job that is meaningful; a responsible job; an interesting job; a job that meets one's abilities.

The scores on these dimensions were analyzed using factor analysis to get a more compact set of measures of job attitude. Two dimensions were extracted. One factor was loaded heavily by: good Pay, security, respectable and good holidays job aspects. This factor was named Stable Jobs. The second factor was loaded heavily by: initiative, meaning, responsible, interesting and meets one's bbilities job aspects. This factor was named Challenging Job.

Scoring Coefficients

Variable	1	2
good_pay	-0.31227	0.53904
no_pressure	0.02538	0.16510
security	-0.02640	0.21903
prestige	0.01727	0.15664
good_hrs	0.00379	0.19005
initiative	0.33642	-0.23485
good_holidays	-0.09766	0.28767
meaning	0.28590	-0.16912
responsible	0.29360	-0.17867
interesting	0.19009	-0.09583
fits_ability	0.14199	0.01935

ii) Morals values

WVS asks a number of questions to gauge attitudes towards certain actions that capture moral values. These questions are on attitudes towards: abortion; avoiding fare on bus: accepting a bribe; cheating on taxes; cheating on government benefits; divorce; euthanasia; homosexuality; prostitution; and suicide.

The score on answers as to whether these actions are justifiable were analyzed using factor analysis and two dimensions were captured. One dimension loaded heavily on abortion, divorce, euthanasia, homosexuality, prostitution and suicide. This dimension was named Moral Conservative Index. The other dimensions loaded heavily on avoid fare, accept bribe, cheat on taxes and cheat on government benefits. This dimension was named Honesty Index.

	Scoring Coefficients	
Variable	1	2
abortion	0.16948	0.01124
avoid_fare	0.02820	0.27645
bribe	-0.05248	0.32696
cheat_taxes	0.00402	0.31294
divorce	0.18887	-0.01771
euthnasia	0.19654	-0.02404
gay	0.18736	-0.04184
govt_benefits	-0.07778	0.29332
prostitution	0.17922	-0.01075
suicide	0.19275	-0.01239

iii) Attitude towards work

WVS asks questions on work ethics that children can be encouraged to learn at home. The qualities captured are: independence; hard work; responsibility; imagination, tolerance; thrift; determination and perseverance; religious faith; unselfishness; and obedience. Factor analysis on

the scores identified three dimensions. One dimension loaded heavily on imagination, tolerance (respect) and unselfishness. This dimension was named Worker-X. The second dimension loaded heavily on obedience and religious faith. This dimension was labeled Worker-Y. The third dimension loaded heavily on hard work, thrift and perseverance and this dimension was labeled Worker-Z.

Variable	1	2	3
independence	0.13584	-0.15909	0.06325
hard work	-0.22478	0.12626	0.38930
responsible	0.06144	-0.26473	0.05812
imagination	0.33652	0.07809	0.05228
respect	0.31476	0.00171	-0.11145
thrift	-0.05421	-0.01138	0.48238
perseverance	0.11078	-0.04232	0.38168
religious_faith	0.05435	0.35126	-0.02909
unselfishness	0.29877	0.18609	0.00539
obedience	0.12890	0.38932	0.03213

iv) Attitude toward free market or entrepreneurship

WVS captured attitude toward free market ideas through views on the following statements; competition is good; private ownership of business should be encouraged; and efficiency should be paid more (merit pay). Factor analysis reduced the scores to a single factor that was named free market index.

Variable	1
private_ownership	0.52742
competition	0.54145
merit_pay	0.25172

v) Religiosity

This dimension was captured through questions on worship frequency, importance of god in one's life, whether one belongs to a religious group and whether one considers him or herself religious. Factor analysis collapsed the scores to one dimension that was named Religiosity.

Variable	1
worship_weekly	0.29148
relgion_belong	0.27005
god_important	0.31690
religious	0.30627

Other questions (values) captured without extra factor analysis were

i) Views on trust (whether other people can be trusted)

ii) Views on dependence (whether government should be more responsible in providing for oneself)

Note that where responses were scored in a number of ways, for a question like "Do you consider competition to be good?", responses will be on a scale of 1-10 where 1 is good and 10 is bad. Thus one needs to decide where the cutoff score is for the percent that say competition is good. Percent scoring 1-3 may be considered as the country score on attitude towards competition[15]. Other questions may be scored differently, e.g., "very important, important or not important". The strategy employed on each question (indicator) selected is given in the appendix (Table A-3).

[15] One can argue that a score of 1-4 is a better measure.

WVS captured data on about 70 countries (this number varied with each question) and also the countries that were captured were not necessarily the ones that were in the 123 countries that have an IR score. An imputation was used to increase the coverage of countries in the IR index.

The imputation strategy employed was based on grouping countries to sub-regions that can be said to have common cultures. The sub region and the countries assignments are given in table A-4 (see appendix). The countries that did not have a score were given the value of the average score on the countries in the same sub region that had a score.

4.2.5 Merging Data

Data from all the data sets were first coded so that all countries have the same country code as the country codes on the WDI data set. This was done by inserting a country code column for all the other datasets manually. The datasets were then merged based on the country code.

4.2.6 Data Availability

The initial period under consideration were the years 1993 to 2003, but using the data from all these years while increasing the sample size may not be a reasonable approach. In particular the following considerations make one hesitant to use this strategy.

i) The data used to create the IR score and IR stages is from years 1998 to 2003. While the IR construct is fairly stable across these years as seen from the high

correlation between the underlying indexes used to construct it, extending the IR stages to 1995 is stretching the construct. It is not reasonable to assume that countries have been in the IR stage for the last ten years.

ii) Data on culture (values) is collected over years 1999-2001. While culture and values are fairly stable it would be unreasonable to make the assumption that will stay the same for a long period, say, 10 years.

The actual period chosen for analysis was the 5-year period around year 2000, i.e., between 1998 and 2002. The year 2000 was chosen as the reference since it has data on all the indicators. Table 4-1 gives an enumeration of the data sources and years covered by each. The actual period chosen for consideration is the 5-year period around year 2000 - i.e., between 1998 and 2002, since 2003 WDI data is sparse on some indicators. The average value of the indicators over the five-year period was used.

Table 4-1: Data Availability

Data Sources	1998	1999	2000	2001	2002	2003
WDI	X	X	X	X	X	
KKM (Governance)	X		X		X	
Barro-Lee (Human Capital)			X			
WVS[1]		X	X	X		
IR indexes[2]	TAI	TAI	TAI[3]	GCI-TI	M-TAI	NRI

[1]WVS 1999-2001 wave was done over the three year period
[2]All the indexes were combined to form a single index
[3] Some data go as far back as 1995

4.3 IR Adoption Analysis

The driving forces of the Information Revolution (IR) have been theorized in the conceptual framework as demand, supply and environmental factors (governance and culture) which drive creation and use of ICT products and services. Though choice of indicators should be dictated by a theory on drivers of IR, some indicators are likely to have very high levels of correlations, thus making multi-colinearity a major problem. The choice of indicators is also dictated by the availability of data.

The summary statistics of the final indicators selected are as shown in table A-5 (appendix). The demand and supply indicators statistics are as expected. Stage 1 countries are worse in all measures and stage 2, 3 and 4 progressively better. Cultural variables show one unexpected result in that the stage 1 (laggard countries) countries have a higher free market index and have more favorable attitude towards technology than the countries in the other stages. Note that moral conservative index, religiosity and Worker-Y have a very similar pattern across the stages.

4.3.1 Cross-Section Regression Analysis

A preliminary analysis to identify deviations from normality and homoscedasticity was done on the data and no serious problems were identified. Figures A-3 to A-5 show the avplots, residual plots and residual vs. leverage plots. The plots show a fairly normal pattern which is further confirmed by formal test of heteroscedasticity. Leverage vs. residual plots shows a few

points (e.g., Norway and Congo Republic) have both high leverage and are also outliers. In general, classical linear regression assumptions hold.

The approach used to investigate the indicators is stepwise building, starting with demand indicators then adding the other indicators.

Demand Factors

The following indicators were selected to capture demand drivers of IR

- GDP per capita (purchasing power parity in 1995 dollars)
- Electricity consumption per capita
- Manufacturing value added as percent of GDP
- Services value added as percent of GDP
- Credit available to private sector as percent of GDP[16]
- Percent of urban population
- Percent of population between 15 years and 64 years
- Literacy levels as defined by proportion completed secondary education
- Televisions per capita

Televisions per capita is a proxy for mass media. Note that literacy level can be argued to be the proportion of the population with primary, or with secondary, education. Some ICT requires a fairly high level of education to use - e.g. computers - but others, like telephones, require only basic literacy. Both these measures of literacy were considered.

[16] Credit is also a supply factor.

The correlations between the demand factors and IR score are high, though variance inflation factors (VIF) are within acceptable limits. Regression of IR score on demand factors indicates that the key demand factors are the level of income (GDP per capita), electricity consumption, size of manufacturing sector, number of televisions per capita, credit available to private sector, urban population, and percent of people who have completed secondary education (see table A-6).

Supply Factors

Supply factors data is derived from two sources, WDI and the Barro-Lee dataset. The indicators used are: foreign direct investment (FDI) as percent of GDP; trade as percent of GDP; and proportion of population that has completed tertiary education. Note that FDI and trade are supply factors in the sense that spillovers of knowledge from trade and foreign direct investment cause local industry to acquire the expertise to use ICTs. But trade and FDI are also demand factors as local partners acquire ICTs to facilitate these global activities that arise which are underpinned by ICTs[17].

There are medium to high correlations between IR score and supply factors. Only tertiary education enters with significance when supply factors are added to the regression and credit ceases to be significant demand factor (see table A-6).

[17] But one can argue that the demand aspect is covered in the variables on size of manufacturing and service sectors, which are the main beneficiaries of trade and investment. The conceptual framework classifies trade and FDI as environmental factors which impact both supply and demand.

Governance

The governance index enters the regression with a significant level while television loses its significance as a demand factor. The result of the regression of IR on demand, supply and governance factors is shown in table A-6. Note that the model with governance shows high multi-colinearity with some variance inflation factors (VIF) above 10. To reduce the problem the model was re-run without television which lowered VIF to below 10. The results are essentially as before, indicating the impact of multi-colinearity is not severe.

When the individual governance indicators are used instead of the index, regulatory quality and political stability indicators fail to show significance (see table A-7). When government effectiveness, political stability or regulatory quality indicators are used, television regains its significance. When voice and accountability is the indicator, both credit and television regain their significance. In a regression where all the significant governance indicators are included in the specification, none of them is significant (possibly due to the high correlation between the indicators).

This is the specification that approximates those that one encounters in literature of ICT diffusion. There are key differences however

i) This specification uses two variables of education (human capital) - one to capture demand (secondary level) and the other to capture supply (tertiary) - as opposed to one measure of human capital. This specification may be contested on the basis that

tertiary level of education is also a demand factor. An alternative specification may be to have a variable that captures the proportion of population with at least secondary education i.e. (proportion with secondary education + proportion with tertiary education) as the literacy level indicator but this is likely to have a higher correlation with the tertiary level indicator. Using the UNDP (2003)[18] education index which is a general indicator of education achievement is another alternative. This variable does not enter the regression with any significance indicating that it is not literacy that matters but both secondary and tertiary education.

ii) No specification I have yet come across has used a mass media indicator as an indicator, though economic theory would indicate that mass media drives demand. Indeed, television does show significance in some specifications that use actual governance indicators.

iii) Most studies use actual governance indicators rather than a composite index.

Cultural Indicators

Examination of cultural constructs reveals that some constructs measure the same concept. So Religiosity and Worker-Y (obedience and religious faith) are closely related to Moral Conservatism and Honesty is closely related to Trust, so to reduce multi-colinearity, these constructs are not used together. The correlation between IR score and the culture (values)

[18] This is part of the Human Development Report (HDR) which is produced annually. The education index is one of the indexes that is reported. The education index used is the one reported in HDR 2003 , which uses 2001 data.

indicators ranges from low to high and some of the correlations, e.g., Free-Market index have signs that are opposite of what theory would postulate, as shown below. Note that correlations with Worker_Z and free market are weak and not significant.

	IR
Worker_X	0.3144
Worker_Z	-0.0647
Government responsible	-0.6458
Free market index	-0.0829
Challenging job	0.2045
Moral conservative	-0.7355
Trust	0.5535
Technology attitude	-0.4720

Table A-8 (appendix) shows regression results using various specifications that include electricity, or that leave out electricity, and also vary the variable used to measure literacy by using a primary education or a secondary education or general education achievement (education index). With electricity included in the specification, the governance index loses its significance. Note that when primary education or education index is used as a measure of literacy, then television is a significant indicator. In the specification where electricity is not included, free-market index enters with significance and with the expected sign across all specifications. If the primary education or education index is used as a measure of literacy rather than secondary education, the trust indicator also becomes significant. The significant indicators are summarized in table 4-2.

To get a more parsimonious model, three cultural values - namely, Free-Market index, Moral Cultural index and Trust index – were selected, though they are not very robust. With these three cultural indicators and secondary education as a literacy indicator, the actual indicators of

governance that are significant are control of corruption, voice and accountability, rule of law and government effectiveness. The results are shown in table A-9.

Table 4-2: General Indicators of IR

	Electricity			No Electricity		
	P	S	EDI	P	S	EDI
GDP	X	X	X	X	X	X
Electricity	X	X	X			
Manufacturing	X	X	X	X	X	X
Services						
Television	X		X			
Credit						
Urban population	X	X	X	X	X	X
Population 15-64						
EDI			X			X
Primary complete						
Secondary		X			X	
Trade						
FDI						
Tertiary Complete	X	X	X	X	X	X
Governance				X	X	X
Worker-X						
Worker-Z			X			X
Dependence						
Free-Market Index				X	X	X
Challenging Job			X			
Moral Conservative Index		X				
Trust index			X	X		X
Tech Attitude						

P: primary completed as measure of literacy; S: secondary completed as measure of literacy; EDI: Education index used as a measure of literacy

A review of the cross section regressions suggest that IR is associated with the indicators shown in table 4-3. Note that while 123 countries are classified to stages of IR, data on various indicators of interest are not available for all countries. Data on human capital (education attainment) are especially limited. Any analysis that covers all the indicators reduces the number of countries to at most 80.

Table 4-3: Significant IR indicators

Factor	**Indicators**
Demand	GDP Electricity* Mass media (television)* Size of manufacturing sector Level of urbanization Literacy level (percent completed secondary education)
Supply	Level of tertiary education
Governance	Government effectiveness Rule of law Political stability* Voice accountability Control of corruption Regulatory quality*
Cultural	Attitude towards free market Moral Conservatism* Trust

*The evidence is weak

4.4 Stage Drivers

While knowledge of the drivers of IR at an aggregate level may be important to policy makers at a macro (or global) level, it is not very insightful for a policy maker keen on moving to the next stage of IR. Analysis at a general level masks what is important at a given level and drivers that might be very critical but at only one stage will be swamped in an aggregate analysis. To tease out the drivers at the stage level, an analytical strategy that performs analysis at stage level is required.

The natural choice for such a strategy is using the IR stage as the categorical dependent variable. Depending on the assumptions made on the dynamics across stages, sequential or ordered logit methods can be applied. Unfortunately, due to the small sample sizes available these methods cannot be applied here, as the analysis fails to converge.

Another avenue available to explore the drivers of IR at stage level is to use the IR score and analysis drivers at each stage. However, due to data limitations only few countries are available at a given stage to analyze using a reasonable number of explanatory variables. The final alternative is to use a strategy where stages are grouped together by a window that moves from one end of IR scale to the other and then see how drivers change as one stage is dropped and another stage is added to the analysis.

Moving Window Strategy

A window that combines two stages at a time gives groups that are more amenable to analysis. The strategy is to have 3 groups as follows:

- Group I: combine countries in stages 1 and 2
- Group II: combine countries in stages 2 and 3
- Group III: combine countries in stages 3 and 4

Analysis can now be done at the level of these groups. Regression at group level with these groups yields interesting observations about how an indicator's importance changes as one moves from one stage of IR to the next. Regressions were done with and without electricity

[19]and using the three indicators of literacy - i.e., percent completed primary schooling, percent completed secondary schooling and the UNDP's education index.

4.4.1 Group I Analysis

Table 4-4 shows a summary of the significant indicators in Group I countries under the various specifications (see details in table A-10).

Table 4-4: Group I indicators

	Electricity			No Electricity		
	S	P	EDI	S	P	EDI
GDP						
Electricity	X	X				
Manufacturing						
Services						
Television						
Credit						
Urban population	X	X	X	X	X	
Population 15-64		X				
Literacy						
Trade						
FDI						
Tertiary Complete						
Governance			X	X	X	X
Free-Market Index						
Moral Conservative Index						
Trust index						

P: primary complete as measure of literacy
S: secondary completed as measure of literacy
EDI: Education index used as a measure of literacy

[19] Electricity is highly correlated to GDP and it is more of a measure for level of development when used with GDP. Therefore analysis with GDP alone captures impact of income while analysis with GDP and electricity is captures impact of level of development.

The significant indicator in all specifications is urban population. The governance and free market values show significance when electricity is not included in the specification. Therefore at the earliest stage of the information revolution, what seems to matter most is the level of urbanization or markets. This is reasonable, as IR requires a fairly heavy level of infrastructure investment and no entrepreneurs will invest if no market of sufficient concentration (as opposed to size) exists. Towns or urban areas are the markets that must first exist before any IR takes place. Governance index show significance (though not robust across the specifications), emphasizing the fact that markets are not enough; proper governance is a prerequisite for market entry. The individual governance indicators that are significant using secondary education as the indicator for literacy are shown in table 4-5. The rule of law indicator is robust across all specifications. Therefore we need markets and rule of law to protect those who enter that market.

Table 4-5: Group I Governance Indicators

Indicator	Electricity	No electricity
Voice and accountability		
Government effectiveness		X
Political stability		X
Regulatory quality		X
Control of corruption		
Rule of law	X	X

4.4.2 Group II Analysis

Table 4-6 shows the indicators that are significant in group II countries (details in table A-11). In these countries industrialization (as defined by electricity, manufacturing and services) is the key driver of IR. Indeed GDP is only significant when electricity is not included in the

specification, showing that it is level of development (or infrastructure) that matters not income. Demographics is also a key driver of demand, indicating that both the market size and market concentration are important. IR also requires sufficient levels of literacy, at least at the secondary level. Trade is the key driver of IR, though surprisingly foreign direct investment (FDI) seems to be an inhibitor of IR. The governance index is significant in all specifications, and indeed almost all the individual governance indicators show significance, as table 4-7 shows.

Table 4-6: Group II indicators

	Electricity			No Electricity		
	S	P	EDI	S	P	EDI
GDP				X	X	X
Electricity	X	X	X			
Manufacturing	X	X	X	X	X	X
Services	X	X	X			
Television						
Credit						
Urban population	X	X		X	X	
Population 15-64	X	X	X	X		
Literacy	X		X	X		X
Trade	X	X	X	X	X	X
FDI	X(-)	X(-)	X(-)	X(-)	X(-)	X(-)
Tertiary Complete						
Governance	X	X	X	X	X	X
Free-Market Index					X	
Moral Conservative Index						
Trust index						

P: primary complete as measure of literacy; S: secondary completed as measure of literacy; EDI: Education index

Table 4-7: Group II Governance Indicators

Indicator	Electricity	No electricity
Voice and accountability	X	X
Government effectiveness	X	X
Political stability		X
Regulatory quality	X	X
Control of corruption	X	X
Rule of law	X	X

4.4.3 Group III Analysis

Table 4-8 shows the indicators that become significant for group III countries (full details in table A-12). Moving to group III countries, the demand factors that matter in group II countries still matter, but the supply factors change. Trade and FDI are no longer the significant factors; the key supply factors are now tertiary education, credit and trust. These are also the supply factors that are the key in the creation of ICTs. Note that the governance index and the income indicator (GDP) show no significance under any specification. Even when the actual governance indicators are used, no indicators of governance show any significance. Note that services and credit are only significant when electricity is part of the specification - perhaps an indicator that these matter only when a certain level of development has been reached, as electricity is a proxy for infrastructure development.

Table 4-8: Group III indicators

	Electricity			No Electricity		
	S	P	EDI	S	P	EDI
GDP						
Electricity	X	X	X			
Manufacturing	X	X	X	X	X	X
Services	X	X	X			
Television						
Credit	X	X	X			
Urban population	X					
Population 15-64						
Literacy	X			X		
Trade						
FDI						
Tertiary Complete	X	X	X	X	X	X
Governance						
Free-Market Index						
Moral Conservative Index						
Trust index	X	X	X		X	X

P: primary complete as measure of literacy; S: secondary completed as measure of literacy; EDI: Education index

4.4.4 Assigning indicators to stages

By examining how factors change across the three groups, inference can be made about the factors that are important at various stages. Note that the default specification that guides in extracting the key indicators is the specification with electricity, and it uses secondary education as the measure of literacy. Table 4-9 provides the summary of the indicators.

Table 4-9: Summary of group indicators

Group I (Stage 1 & 2)	**Group II (Stage 2 & 3)**	**Group III (Stage 3 &4)**
		Credit Tertiary education Trust
	Secondary education Electricity Manufacturing Services	Secondary education Electricity Manufacturing Services
	Population 15-64 Trade FDI General literacy (ed_index) Control of corruption Voice and Accountability Govt. effectiveness Regulatory Quality	
Rule of Law Urban population	Rule of Law Urban population	
	Free market values*	

*The indicator is never significant using the default specification and only becomes significant when electricity is not part of the specification.

Assuming that the factors that overlap across the groups are factors that are important in the stage encompassed in the two groups we can infer the drivers at each stage of IR as shown in figure 4-1.

Thus the grouping of drivers and stages seems to be consistent with the hypotheses proposed in section 4. Note that the drivers are important in moving ahead in a given stage, i.e., they are short term drivers. This does not negate the aggregate drivers identified in table 4-2 which are the long run drivers.

STAGE			
1	**2**	**3**	**4**
Urban population Rule of law	Population 15-64 Trade General literacy Free market values Control of corruption Voice and accountability Govt. effectiveness Regulatory quality	Secondary education Electricity Manufacturing Services	Credit Tertiary education Trust
Market	Environment	Demand	Supply

Figure 4-1: IR stage drivers

4.5 Policy Choices

Stage 1

Markets creation is key at this stage. IR will only occur where there is a market concentration that makes it worthwhile to make the huge investments that underpin IR. Policies that encourage

urbanization through investments in urban infrastructure (i.e., water and sewerage, transportation systems, affordable housing etc.) are key. Rule of law through development of appropriate legal systems and institutions is the critical governance measure. Thus emphasis should be on market creation and protection of investors to attract and build the innovator class.

Stage 2

The focus at stage 2 is market development. This requires an environment that supports entrepreneurs and investors. This calls for favorable attitudes towards free markets as well as good governance. Markets need to be well regulated for proper functioning, which also requires an efficient and effective government free from corruption. Protection of civil liberties is also important, as ICTs are communication tools. Market development also requires a population that is literate enough to use ICT products and services. Policies that improve general literacy levels are required at stage 2. The demographic factor driving demand at this stage is the size of the population, i.e., the population between ages 15 and 64 rather than urban population (market concentration) as was in stage 1.

Trade is the key supply factor as trade promotes transfer of ICT knowledge directly by pushing partners to invest in ICTs, which underpin international trade, and also through unintentional knowledge spillovers as local and international partners interact. To move up in stage 2, policies that encourage international trade should be pursued.

Stage 3

In this stage the key IR drivers are demand factors. Growth in manufacturing and service sectors drive demand as well as better developed infrastructure (as measured by electricity consumption). The growth in IR is due to increasing sophistication of these sectors as they computerize and integrate ICT into all aspects of business. Human capital required is more than basic literacy, and attaining higher levels of education - especially secondary level - becomes important.

Policies needed are those that encourage firms to better integrate ICTs in their operation,

e.g., tax breaks for firms that restructure to integrate ICTs; policies aimed at improving levels of literacy - especially access to secondary education; and policies that encourage investments in power generation and infrastructure development.

Stage 4

At this stage the key drivers of IR are the supply factors necessary for the creation of ICTs, i.e., credit availability, high levels of human capital and trust. Entrepreneurs who create technology require credit or venture capital to create start-ups, which create and exploit new technologies. High levels of knowledge are key in development and exploitation of new technologies. Thus, tertiary education - especially science and engineering - becomes key. Trust is an important cultural resource as entrepreneurs and creditors (venture capitalists) need to have faith in each other. The general public (market) also needs to be "trusting" if they are to try to use new yet-unknown technologies.

The increasing sophistication of users in stage 4 means that market-savvy skills become important. The market for traditional ICTs is almost saturated and proliferation of personal communication devices creates new markets. The key to developing these new markets lies in developing marketing and business skills that can tap these markets further, emphasizing the need for developing tertiary education in business/entrepreneurship.

Thus, policy choices should be those that encourage the development of tertiary education - especially in science and engineering and in marketing (or business), policies that encourage capital growth or credit availability, and policies that promote the level of general trust in society.

4.6 IR Adoption Drivers – A Recap

The stages analysis provides insights that are normally missed when aggregate analysis of IR drivers is done. In particular the central role that income has played in explaining the digital divide needs to be re-examined. Though income shows up as significant at an aggregate level, its significance disappears when analysis is done at IR stage level. Aggregate analysis masks important dynamics underlying IR. While intuition tells us that the size of the service sector is a key driver of IR (as this sector is traditionally a heavy user of ICTs), many studies fail to find significance (as the aggregate level analysis failed to). Education tends not to be important in half of the studies of IR, yet it should be expected to be a key driver. Aggregate analysis thus fails to provide a complete picture of the IR drivers, making such an analysis of reduced use to policy makers who need to know what is important in their circumstances, as opposed to what is

important in general. Breaking down the analysis thus reveals the dynamics underlying the IR process and provides a better roadmap for moving forward in IR.

The analytic model used in the analysis is a cross-sectional one, thus it is hard to ascertain a cause and effect relation between IR and the drivers. But the analysis does give useful insights that are important in laying the groundwork for developing an IR strategy and for developing more powerful longitudinal models that can establish causality.

The next step is to build a longitudinal model powerful enough to ascertain causality. In building such a model, insight obtained from the cross-sectional analysis will be important. Note that it is not possible to investigate the determinants of IR, as the measure of IR that is available is unvarying over the period of analysis. What will be investigated is usage or diffusion of IR artifacts, in particular internet, PCs , telephone, and mobile phones.

5.0 MODELING ICT DIFFUSION

Policy makers want to know how the various factors that propel IR impact on the various ICT artifacts. Therefore, they can know how ICTs are impacted and in what way as IR gets underway. In particular, policy makers want to make choices that, while moving a country ahead in IR in the long run, also promote ICT artifacts diffusion in the short run, thus ensuring that long run goals are achieved. In analyzing the factors impacting the diffusion of ICTs some hypotheses of interest are:

1. H1: ICT diffusion is impacted positively by higher income
2. H2: ICT diffusion is impacted positively by a higher human capital existing in a country
3. H3: ICT diffusion is impacted positively by an institutional framework that encourages investment and trade openness.
4. H4: ICT diffusion is impacted positively by a political environment that encourages and protects freedom of speech and civil liberties.
5. H5: ICT diffusion is impacted positively by availability of credit
6. H6: ICT diffusion is impacted positively by an efficacious regulatory structure that encourages competition
7. H7: ICT diffusion is impacted positively by a culture that encourages risk taking and is receptive and willing to try new ideas.
8. H8: ICT diffusion is impacted positively by the presence of mass media
9. H9: ICT diffusion is impacted positively by the current level of use, i.e., epidemic or network effects

5.1 Approaches to modeling ICT diffusion

The literature points to two approaches for studying ICT diffusion. One approach is based on determining the factors that influence the adoption levels (adoption studies); the other approach aims to explain the S-shaped diffusion pattern observed over time (diffusion studies). These two approaches capture the two driving forces of diffusion:

i) Economic forces of supply and demand, which determine the market potential (long run adoption levels).

ii) Learning, which determines how much of the potential market is captured.

Thus, change in ICT use will be due to economic forces and due to learning. Under a given set of economic conditions, there will be diffusion over time as learning occurs when potential users get to know about the technology or as the price falls due to supplier learning (and thus the reservation price of more potential users is reached). If learning did not take place but the economy changed, there would be a change in the level of use as incomes rose and thus demand rose. In real life, a combination of the two will be taking place. Table 5-1 models the two effects.

Table 5-1: ICT Diffusion States

	Time: T1	Time: T2	Diffusion due to Learning
Economy State E1 $N^*_{1.}$	$N_{1,1}$	$N_{1,2}$	$\Delta S_{1.}$
Economy State E2 $N^*_{2.}$	$N_{2,1}$	$N_{2,2}$	$\Delta S_{2.}$
Diffusion due to Change in economy	$\Delta N_{.1}$	$\Delta N_{.2}$	

In state E1 the potential number of users is $N^*_{1.}$ but only $N_{1,1}$ users are using in time T1 due to, say, lack of information . In time T2 as information spreads we have $N_{1,2}$ users.Thus the increase in use if the economy stayed in state E1 can be seen as $\Delta S_{1.}$ in the table. If time was held constant and the economy changed to state E2 we would see an increase of $\Delta N_{.1}$ due to higher demand in economy E2 at given supply. For a given country we only observe $N_{1,1}$ in time T1 and state E1 and $N_{2,2}$ in time T2 and state E2. The change in usage levels observed thus incorporates both economic effects and learning effects. The model chosen should explain both effects.

5.1.1 Economic Framework Model of ICT diffusion

In this framework, the economy is the treatment of interest, but since time effects are present, a cross-section model that looks at ICT use across different economies will be biased. A longitudinal model that captures the changes due to time is required.

We can model the changes due to the economy by using a Difference-of-Difference (DoD) model.

A DoD model can thus be formulated as

$$\text{Log}(N_{it}) = \alpha + \beta_d \mathbf{D}_{it} + \beta_s \mathbf{S}_{it} + \beta_e \mathbf{E}_{it} + \boldsymbol{\tau}_t + \boldsymbol{\mu}_i + \varepsilon_{it}$$

Where:

N_{it} is the observed usage level in country *i* in time *t*

$\mathbf{D_{it}}$, $\mathbf{S_{it}}$ and $\mathbf{E_{it}}$ are the vectors of demand, supply and environmental variables country i in time t.

τ_t is a time dummy

μ_i is country dummy

ε_{it} is an independent identically distributed (i.i.d.) error term

Thus we have controlled for the effects of time and country effects. Country effects control for country specific effects that can capture factors like rate of mixing within the population, the history of the country, geography, etc., - factors that are important in determining level of adoption. If we can assume that countries in a given region exhibit similar patterns in information spreading, we can use a region dummy rather than a country dummy. This is economical on the degrees of freedom lost when full country effects are used. Thus the final model is really a compromise between a DoD fixed effects and a random effects model.

But the model cannot be used as it is, as it fails to account for the dynamics of adjustments of ICTs to the equilibrium that the model assumes. Diffusion of technologies and innovations has been observed empirically to follow an S-shape. The functional form used should be consistent with the theories of diffusion.

5.1.2 Diffusion Theories Approach To Modeling ICTs

The driving force of the S-shape (fig. 5-1) can be modeled as demand side learning, supply side learning, or as a result of competitive forces.

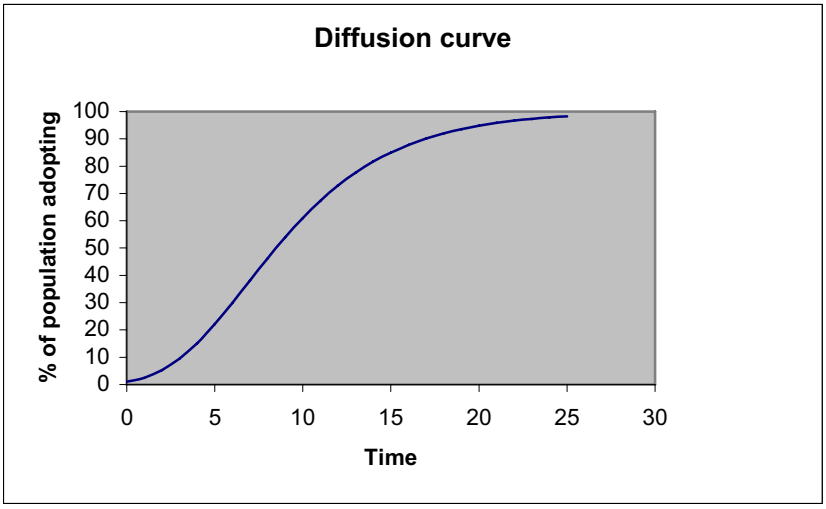

Fig 5-1: Diffusion curve profile

The diffusion data available does indeed show this pattern as can be seen in the appendix (figures A-6 to A-10). Note that for some technologies like mobile phones, which have diffused very quickly, all the various stages of the S-curve are evident. Also notice that for telephones the saturation level seems to have been reached especially for countries in stage 4 of IR. We now need a mathematical model that traces this shape.

5.2 Epidemic Diffusion Models

While a number of models are available to explain the S-shape (Geroski 2000, Stoneman 2002), the epidemic model is the pre-eminent model (due to its simplicity) used to model diffusion and a number of mathematical variations have been developed.

Logistic Specification

The logistic specification assumes a symmetrical S-curve and has been modeled as (Stoneman 2002, Gurbaxani 1990)

Differential Equation: $dy/dt = \beta y(t)\{N-y(t)\}$

Discrete Analog: $\Delta y_t = \beta y_{t-1}\{N- y_{t-1}\}$

Where $\Delta y_t = y_t - y_{t-1}$ is the number of new adopters in current period, y_{t-1} is market penetration at time t-1, N is the asymptotic level of use (market size), β is a measure of speed of diffusion.

The logistic curve traces a symmetrical S-curve which implies that rate of adoption is assumed constant throughout. But the model, as it is, does not capture some key aspects of reality that make a symmetrical distribution untenable.

i. The key driver of an epidemic model is contagion. That is, users making contact with non-users result in a flow of information to a non-user who then gets "infected" and

becomes a user and further infects other non-users. The implicit assumption is that contact leads to information and that non-users have not adopted because they do not know. But non-users need persuasion rather than just information to adopt, as adopters are risk averse. There is also the implied assumption that non-users are passive receivers of information, but it is more likely that non-users will actively seek information, especially where they stand to benefit. The assumption of internal influence (contagion) only is limiting, as external influence plays a big part in diffusion. Suppliers actively disseminate information through advertisements, exhibitions, etc; Government policy may actively promote diffusion; and mass media constantly disseminates information about new technologies.

ii. There is an assumption of a homogeneous population and constant mixing of population, which implies that the likelihood of any user meeting any non-user is the same. But populations are heterogeneous and subgroups exist. Mixing across groups is different from mixing within groups. At the extreme, subgroups may not mix, stopping diffusion altogether (Stoneman 2002). Heterogeneity also means that some individuals are more influential (infectious) than others.

iii. There is the assumption that the population of potential adopters is constant and users live forever, thus driving contagion forever. But as suppliers improve the performance (features) and quality of the technology the number of potential users increases[20]. Also

[20] Early PCs were marketed to technology hobbyists but as improvements were made people with less and less technological knowledge could use them.

users' enthusiasm reduces over time, so they become less effective in "infecting" over time. At the extreme, some users drop out and stop infecting altogether.

The key implication of the above failings is that it is unlikely that the diffusion curve will be symmetrical. Geroski (2000) argues strongly for asymmetry based on the fact that heterogeneity means that the adoption S-curve is really an aggregation of S-curves of various groups. Since various groups are of different abilities, this implies an asymmetrical S-curve with longer upper tail to reflect slowing rate of diffusion over time as laggards join the bandwagon. In response, a number of models to account for this asymmetry have been developed and some approaches will be discussed.

Gompertz Specification

A Gompertz curve is the solution commonly encountered in literature to fix the assumption of symmetry that underlies the logistic curve by allowing asymmetry in the S-curve. The Gompertz curve is written as:

Differential equation: $dy/dt = \beta\{\log N - \log y(t)\}$

This modification now traces an asymmetrical S-curve with a long upper tail that is more reflective of reality.

Bass Model

The marketing field has also seen a lot of work on diffusion - the focus being on forecasting a diffusion of new products. External influence plays a key role in marketing. That is, advertisement and modelers in this field have sought to capture this explicitly. The workhorse diffusion model is an epidemic model that incorporates external influence. This is the Bass (1969) model:

Bass Model: $dy/dt = (q + p y(t)/N)\{N-y(t)\}$

Where q and p are the external and internal influence coefficients respectively. Note that when q=0 we have the logistic curve. The Bass model has been extended to cater to a variety of situations, including forecasting new products, second generation products, etc. A survey of these variants is given in Mahajan, et al. (1990).

Karsehenas and Stoneman (KS) Model

Karsehenas and Stoneman (1992) have extended the Bass epidemic model by allowing *p* in the Bass model to vary as a function of economic variables and adding heterogeneity by splitting the stock of adopters into influential adopters, A, and non-influential adopters, B. The Karshenas and Stoneman (KS) model is:

KS Model: $dy/dt = p(q + A/N)\{N-y(t)\}$

$dB/dt = \alpha(N-B)$

Where:

$y = A+B$

and α determines the proportion of influential adopters A who become non-influential over time. That is, it reflects the decay of an adopter as a source of information. Note that if $\alpha=0$ and B=0 then KS reduces to the basic Bass model.

Stoneman (2002) has tested the KS model against the a modified Bass model (EMM) and a number of epidemic models, including the logistic and Gompertz, using data on diffusion of camcorders and CD players in the UK and cars in West Germany. Though the K-S model performs better than the basic epidemic models it does not perform better than the modified Bass model (EMM), putting to question whether the added complexity of the newer models is justified. In the same vein, models based on newer theories of diffusion like Probit models have not performed much better than epidemic models (Stoneman 2002). New models of technology diffusion is an area of active research and a number of models have been developed, but there is no clear answer as to which context the various models are applicable. Stoneman (2002) argues that the poor performance of newer models based on stock and order effects as compared to epidemic models when applied to diffusion of Computer Numerically Controlled (CNC) machine tools could be due to the nature of CNC technology. The implicit assumption here is that technology type and the context of adoption matters when choosing the appropriate model. Fichman (1992) proposes a framework to classify diffusion contexts that has two dimensions; (1) level of adoption as defined by individual or organizational context and (2) technology

complexity as defined by simple technologies (Type 1) that impose little knowledge burden to use (e.g., mobile phone) and complex technologies (Type II) that have high knowledge burden and interdependencies (e.g., Computer Aided Design (CAD) systems). Thus the Fichman (1992) framework produces four adoption contexts as shown in table 5-2.

Table 5-2: Fichman (1992) Technology Adoption Contexts

	Individual Level	Organizational Level
Simple Technologies (Type I)	e.g., Mobile Phones	e.g., Personal Computers
Complex Technologies (Type II)	e.g., Internet, e-mail, CASE tools etc.	e.g., Computer Aided Design/ Computer Aided Manufacturing

Fichman's (1992) focus is adoption of information technology at individual and organizational levels. Diffusion at the national level is the aggregation of adoption by both individuals and organizations and this context should be considered explicitly. Further, we expect differences when the context is national or when the context is global. Thus a framework that covers technology diffusion context could be modeled as shown in table 5-3.

Though there are common factors across the four contexts, there are some factors that may only apply to some contexts. Further, the relative importance of the various factors may vary across contexts. The question that needs to be asked is, "What classes of model best capture diffusion in each of the four contexts?" Many of the studies that compare performance of models have focused on contexts I and III. There is need for further research on the various models both from epidemic modeling tradition and models based on newer theories - like probit and stock and order - to determine which models are the most appropriate in various contexts - especially the global context.

Table 5-3: ICTs Diffusion contexts

	Country Level (National) Diffusion	Global (Cross Country) Diffusion
Simple Technologies e.g. Mobile phones	Context I	Context II
Complex Technologies e.g. Computer Aided Design (CAD)	Context III	Context IV

The focus of this study is context II and traditionally researchers in the economic field have modeled diffusion in this context using an epidemic model. The two competing models have been the logistic and the Gompertz models[21]. Empirical evidence on these models is mixed. Early empirical work on diffusion by Girliches (1957) pointed to a logistic fit, but Dixon (1980), using more data points, found that Girliches' data fitted a Gompertz model better. In an analysis of the growth pattern of BITNET, a computer network connecting universities across the United States, Gurbaxani (1990) found the diffusion to be S-shaped and consistent with a logistic curve. Ravichandran and Samaddar (1998) studying the early global diffusion of the Internet found that an exponential model performed better than the logistic and Gompertz models. Rouvinen (2004) argues that, though alternatives exist, the Gompertz model is attractive since it is parsimonious, linear in parameters, and allows for simple inclusion of variables.

5.2.1 ICT diffusion Model Specification

From the foregoing discussion, the Gompertz model is the model of choice to explain the observed diffusion patterns. The Gompertz model can be written as

[21] In the marketing field the Bass (1969) and variants play a similar role.

$$dNt/dt = \gamma(\log N^* - \log N_t)$$

The rate of change depends of the difference between saturation level (N*) and current level of use N_t, and the speed of diffusion γ. The common practice is to use the discrete analog of the differential equation

$$\Delta N_{it} = \gamma(\log N_{it}^* - \log N_{it})$$

To capture the fact that economic factors are changing, N* is modeled as a linear function of economic factors. We have shown that a DoD approach can be used to model N* as

$$\text{Log}\,(N^*_{it}) = \alpha + \boldsymbol{\beta_d D}_{it} + \boldsymbol{\beta_s S}_{it} + \boldsymbol{\beta_e E}_{it} + \boldsymbol{\tau}_t + \boldsymbol{\mu}_i + \varepsilon_{it}$$

Therefore

$$\Delta N_{i,t} = \gamma\alpha + \boldsymbol{\gamma\,\beta_d D}_{it} + \boldsymbol{\gamma\beta_s S}_{it} + \boldsymbol{\gamma\beta_e E}_{it} - \gamma \log N_{i,t} + \boldsymbol{\gamma\tau}_t + \boldsymbol{\gamma\mu}_i + \varepsilon_{it}$$

The growth can be expressed

$$\Delta N_{i,t} = \log N_{i,t} - \log N_{i,t-1}$$

Note that the change in use is now attributed to economic conditions, time effects (supplier learning) and past period use (epidemic effects) and country effects.

5.3 Analytical Results

To appreciate the kinds of changes taking place, table 5-4 shows a summary of growth of the ICT artifacts over the 5 year period that is being considered, contrasted with growth in GDP over the same period.

Table 5-4: ICT artifacts growth (1998-2002)

	Stage 1	**Stage 2**	**Stage 3**	**Stage 4**	**Overall**
PCs	105%	54%	87%	52%	57%
Internet Users	983%	494%	312%	138%	224%
Mobile Phones	789%	549%	343%	155%	257%
Telephones	29%	19%	9%	4%	9%
GDP	10%	14%	20%	20%	19%

The table shows that the growth experienced by countries at all stages is very high except for telephones, and is much larger than growth in GDP. Countries at lower stages of IR have above-average growth, while those at higher stages experience progressively lower growth. In contrast, countries at lower stages have experienced below average GDP growth, while countries at higher stages have had higher GDP growth.

The summary statistics (tables A-13 to A-17) show that while countries at lower stages may have experienced very high rates of growth in ICT artifacts, they are still very much behind in all measures of interest. They are starting from far behind.

Regression Results

Using the Gompertz growth model specification, a number of regressions were run to investigate the drivers of ICT artifacts' growth, namely PCs growth, Internet use growth, mobile phones growth and telephones growth.

The basic model used was the IR model used in section 4 with a number of variations to explore the robustness of results. A total of four models were run for each ICT artifact diffusion. Model 1 is closer to what would be typically found in literature, though many studies do not use the Gompertz formulation. Model 2 uses the demand, supply and environmental variables but without the cultural variables. Model 3 uses the full specification of demand, supply and environmental variables including three cultural values variables. Model 4 is a more parsimonious version of Model 3 that uses fewer demand, supply and environmental and cultural variables which tend to show some significance in the other models.

For each artifact the four models were run at an aggregate level and also at the group level, where group I consisted of countries in stages 1 and 2, group II of countries in stages 2 and 3 and group III of countries in stages 3 and 4. So we have a window moving from lower stages to higher stages to see how the drivers vary as we move to higher stages. All the models used regression with robust standard errors as all artifacts growth trends displayed heteroscedasticity.

Convergence

The speed of diffusion index for all the artifacts is substantial and significant, ranging from a high of 27% increase in users for 1% change in user base for internet users to a 3% change for telephone users for 1% change in user base at the aggregate level (see table 5-5). The index is higher when countries at lower stages of IR are considered. Therefore epidemic effects are much stronger at lower levels of IR, which ties well with the result noted in table 5-4. Internet use shows the most powerful epidemic effects. So, to an extent, the lower level countries are catching up. But the story is more complicated, as they are only catching up with themselves, i.e., moving to their equilibrium (market potential). We shall return to this.

Table 5-5: Speed of Diffusion (Convergence) estimates

	PC	Internet Users	Mobile Phone	Telephones
All	0.1234296	0.2709946	0.1760174	0.037775
	(3.68)***	(6.44)***	(4.81)***	(2.94)***
Group I (Stages 1& 2)	0.1746255	0.3681767	0.2054504	0.0159608
	(3.54)***	(6.72)***	(4.64)***	-0.73
Group II (Stages 2& 3)	0.0807726	0.2975341	0.2654508	0.0564014
	(2.11)**	(3.87)***	(6.74)***	(3.40)***
Group III (Stages 3& 4)	0.0200293	0.2768268	0.1587517	0.0656465
	-0.55	(4.13)***	(2.68)***	(2.56)**

t-values in parenthesis; *significant at 10%; ** significant at 5%; *** significant at 1%

Note that for telephones, table 5-5 shows very low levels of epidemic effects reflecting that it is a mature technology (well-known technology and thus low uncertainty). The telephones are losing out, especially to mobile phones - a fact that is evident in the graph of telephone diffusion, which shows it flattening out (see fig. A-6 and fig. A-10 in the appendix).

5.3.1 PC Growth Drivers

The aggregate drivers of PC growth are shown in table A-18 (Appendix). PC growth is driven by epidemic effects, size of manufacturing and service sectors, demographic factors (both the size of urban population and the size of population between 15 and 64), human capital as measured by the proportion of the population that has completed secondary school education, quality of governance, credit availability and a favorable attitude towards free market ideas. The positive role of human capital and governance has also been found by Chinn and Fairlie (2004) and Casseli and Coleman (2001).

At lower stages (stages 1 and 2) the growth of PCs is fuelled by epidemic effects, size of manufacturing sector, size of service sector, credit availability and a favorable attitude towards free markets (see table A-19). Urban population and television are drivers, though evidence is not very strong. Higher levels of trust tend to drive PC diffusion while social/religious conservative values tend to slow down PC diffusion, but evidence for both these drivers is weak. In contrast Balliamoune-Lutz (2003), using a sample of 47 developing countries, finds governance as the key driver of PC diffusion. In the intermediate stages of IR (stages 2 and 3) epidemic effects, governance and level of trust seem to be the key drivers. Urban population and size of the manufacturing sector are drivers, though not robust across specifications (see table A-20). At higher stages of IR (stages 3 and 4), it is instructive that in all specifications epidemic effects are not apparent - as table A-21 shows. The key drivers at these stages seem to be credit availability and human capital, as measured by the proportion of people who completed secondary education. Television and trade are associated with lower growth. Here we see the

dual role of television as a communications medium. At lower stages it acts as an information source, and thus a driver, but at later stages, television's other role as a competing communication and information technology kicks in. Table 5-6 gives a summary of PC growth drivers.

The negative coefficient on trade at higher levels of IR may be reflecting dominance of big closed economies like that of the US at these higher stages. Casselli and Coleman (2001) finds that imports from OECD matter rather than trade in general and also finds that when imports from non-OECD countries are considered, there is a negative impact of computer adoption (though weak).

Table 5-6: Summary of PCs growth drivers

	Aggregate	Group I (Stages 1 and 2)	Group II (Stages 2 and 3)	Group III (Stages 3 and 4)
Ln_PCs_1	X	X	X	
GDP				
Electricity	?			
Manufacturing	X	X	?	
Services	X	X		
Urban_pop	X	?	?	
Trade				X(-)
Tertiary_complete				
Governance_index	X		X	
Credit	X	X		X
Television		?		X(-)
Pop_15_64	X			
sec_complete	X			X
Free_mktx	X	X		
Conservative_new		?		
Trust_new		?	X	

? evidence is weak

The variation of drivers in Table 5-6 does not show a strong pattern of drivers as one moves to higher stages. But we note that, at the higher stages, epidemic effects are not important. Credit availability and human capital are the key drivers at the higher stages. At lower levels of IR, demand and epidemic factors are more important drivers and at intermediate levels governance seems to be key.

In general it seems that growth at lower stages will be positively affected by policies that focus on building PC ownership to exploit the strong epidemic effects at lower and intermediate stages of IR. Policies to expand manufacturing and service sectors will also help in the diffusion of PCs. At intermediate levels, focus on improving governance will have the greatest impact. Policies that increase credit availability and access to higher education are critical at higher stages.

5.3.2 Internet Use Growth

Internet users growth is mostly fueled by epidemic effects, which are very significant. Other key drivers are the size of the manufacturing sector, both measures of demographics (i.e., urban population and population between ages 14 and 65), and quality of governance (see table A-22 for details). The actual governance indicators that show significance are: rule of law, corruption control, and government effectiveness indicators. The Urban population finding is in contrast to Chinn and Fairlie (2004) who find urban population to act in the opposite direct in line with the "Global Village Theory" (which hypothesizes that the internet substitutes for benefits accruing to operating in an urban environment).

The key drivers of Internet use at the higher stages are epidemic effects and the level of urbanization, as table A-25 shows. Key drivers at intermediate stages (see table A-24) are epidemic effects, governance, and urban population, while an increase in television sets is associated with lower growth of Internet users, perhaps reflecting the fact that Internet and TV are competitors as media channels. At the lower stages (see table A-23) the key drivers of Internet growth are epidemic effects, the size of the service sector, and quality of governance, while trade seems to be associated with slower growth. The Internet use drivers are summarized in table 5-7.

Table 5-7: Internet Use Drivers

	Aggregate	Group I (Stages 1 and 2)	Group II (Stages 2 and 3)	Group III (Stages 3 and 4)
Ln_internet_users_1	X	X	X	X
GDP				
Electricity				
manufacturing	X			
Services		X		
urban_pop	X		X	X
Trade		X(-)		
Tertiary_complete				
governance_index	X	X	X	
Credit				
Television			X(-)	
pop_15_64	X			
sec_complete				
free_mktx				
Conservative_new				
trust_new				

In general, growth of Internet use will be fuelled by policies that improve governance on one hand and policies that improve infrastructure of urban areas to expand the markets on the other hand. These factors reflect that the Internet is a much newer technology and is very sensitive to market concentration and the protections provided. Policies that increase the stock of users to generate epidemic effects are also key.

5.3.3 Mobile Phones Growth

The aggregate drivers of mobile phones growth are shown in table A-26 (appendix). These are epidemic effects, size of the manufacturing sector, trade and favorable attitude towards free market ideas. Urban population also seems to be a driver, though evidence is weak. Income seems to operate in the opposite direction, which is somewhat puzzling. But this may be an indicator that poorer countries are experiencing higher growth than rich countries. Looking at the summary statistics over the years, we see that in countries at stage-4, mobile phone use grew by about 150% while GDP only grew by about 19%. But for countries at stage 1, mobile phones use grew by almost 800%, while GDP grew by only 10% (see table 5-4). Thus, analysis at an aggregate level may show mobile phones growth slowing relative to GDP.

The key drivers of mobile phone growth in lower stages are epidemic effects, the size of the manufacturing sector, and trade[22]. The drivers in the intermediate stages seem to be epidemic effects and favorable attitude towards free market. At higher stages of IR the drivers of mobile

[22] Note that while trade drives growth in mobile phones, it acts to reduce internet usage. It seems that trade pushes growth of mobile phones at the expense of Internet usage.

phones growth are the epidemic effects and urban population. See tables A-27 to A-29 for details.

The results are similar to the findings of Rouvinen (2004) who found significance in epidemic effects, trade and industrialization (defined by value added in mining construction, electricity, water, and gas per GDP). But his analysis differs in that demographic parameters were significant (though the measures used were odd in that he used the actual population for overall market size and the total number of residents in the largest city to proxy for market concentration). These measures are contentious in that they are mixing absolute measures (demographics) with per capita measures (mobile users).

Table 5-8: Mobile Phones Use Drivers

	Aggregate	Group I (Stages 1 and 2)	Group II (Stages 2 and 3)	Group III (Stages 3 and 4)
Ln_mobile_phones_1	X	X	X	X
GDP	X(-)			
Electricity				
manufacturing	X	X		
Services				
urban_pop	?	?		X
Trade	X	X		
Tertiary_complete				
Governance_index				
Credit				
Television				
pop_15_64				
sec_complete				
free_mktx		?	X	
Conservative_new		?		
trust_new				

5.3.4 Telephones

The key drivers of telephones diffusion, as table A-30 shows, are epidemic effects, the proportion of the population between ages 15 and 64, television, and level of trust. Surprisingly, urbanization and human capital seem to be hindrances to the growth of telephones. This may reflect the substitution effect as people move to other means of communications as they become more sophisticated, i.e., urbanized and more educated.

Key drivers at lower stages are television and level of trust. Note that epidemic effects are not drivers at this level. Electricity consumption, which is really a measure of level of infrastructure development, is now significant, but negative, and indicates that diffusion of the telephone is lower in the more developed regions. Size of the manufacturing sector, the proportion of the population between 15 and 64, and level of trust seem to be the main drivers of telephone diffusion in the intermediate stages. Higher levels of human capital seem to stem diffusion again, an indication that growth is higher in areas that have lower human capital. But this may reflect changing tastes for other forms of communication as people become more sophisticated. Epidemic effects (or network effects) and income seem to be the only drivers of telephone diffusion at higher stages, while growth in trade acts to slow down telephone diffusion. Again, this could be due to substitution of mobile phones which are more convenient for continuous communication. Tables A-31 to A-33 provides the details and table 5-9 shows the summary of telephones diffusion drivers.

Table 5-9: Drivers of telephone diffusion

	Aggregate	Group I (Stages 1 and 2)	Group II (Stages 2 and 3)	Group III (Stages 3 and 4)
Ln_telephones_1	X		X	X
GDP				X
Electricity		X(-)		
manufacturing			X	
Services			X	
urban_pop	?(-)			X(-)
Trade				
Tertiary_complete	X(-)		X(-)	
governance_index			?	
Credit			?	
Television	X	X		
pop_15_64	X		X	
sec_complete				
free_mktx				
Conservative_new				
trust_new	X	X	X	

?; Evidence is weak

Note that growth of telephones is more dependent on market size (population between 15 and 64) than market concentration (urban population) that seems to drive the other newer ICTs. Growth opportunities may then be in rural areas where Internet and mobiles phones have yet to arrive.

6.0 POLICY CHOICES

Two forces ICT policy makers need to balance are the forces that define the equilibrium level of ICTs - and thus the IR posture - and forces that determine how fast the equilibrium is attained. The drivers of IR provide the policy levers for determining equilibrium levels while the drivers of diffusion of the various ICT artifacts provide the policy levers to hasten diffusion. The policy problem is then to select, among the drivers available, those that will have the maximum impact at both levels of adoption and diffusion. Policy should be guided by the common drivers rather than a shortsighted view of policies that seeks to promote one technology at the expense of the others, or policies that promote diffusion at the expense of adoption and vice versa.

In section 3, drivers based on empirical analysis using IR as the measure were identified and pointers to short-term, medium-term and long-term policies proposed. We now revisit these proposals in light of the findings from the artifacts diffusion research to find common themes and refine the policies.

6.1 Leaping Forward

The leap forward involves many steps rather than a jump from stage to stage. A country must first move up in its stage before going to the next stage. Analysis at the stage level points to the steps needed before the leap to the next stage. Indeed moving forward requires navigation though the diffusion curve itself while at the same time navigating through the stages of IR.

Therefore policy must be cognizant of these two reference points that guide navigation. Table 6-1 summarizes the drivers of IR and the drivers of diffusion of ICT artifacts.

Table 6-1: Aggregate Drivers

	IR	PCs	Internet Use	Mobile Phone	Telephones
Epidemic Effects		X	X	X	X
GDP	X			X(-)	
Electricity	X				
manufacturing	X	X	X	X	
Services		X			
urban_pop	X	X	X	X	X(-)?
Trade				X	
Tertiary_complete	X				X(-)
governance_index	X	X	X		
Credit		X			
Television	X?				X
pop_15_64		X	X		X
sec_complete	X	X			
free_mktx	X	X			
Conservative_new	X				
trust_new	X				X

Looking at the table 6-1 we observe that urban-population and the size of the manufacturing sector seem to be the overriding drivers in both moving forward in IR and hastening the process through diffusion. Governance is the other point of reference at this aggregate general level. Note that the creation aspects of IR are not captured in diffusion of ICT artifacts so that common drivers will miss these important drivers of IR. Human capital, especially secondary and tertiary education, thus constitutes the other reference point. We see also that infrastructure as captured by electricity is important for IR, though not necessarily for

the diffusion of ICT artifacts. But we can reasonably assume that urbanization goes hand in hand with higher power consumption. Thus infrastructure may play a role in diffusion of artifacts but only through its impacts on facilitating urbanization. Income, while showing no impact on the short-term dynamics of the diffusion of artifacts, is important in navigating IR. Wealth is critical in the long run rather than the short run.

Long run policies should achieve the best results if the three points of reference are the overarching themes.

I. Urbanization and industrialization as reflected in growth of manufacturing sector
II. Improving quality of governance
III. Human capital development

But note that telephones will tend to be the loser in this framework, a sign that unless telephony re-invents itself, it will continue to decline under these conditions. But there is scope for growth in rural areas.

6.2 Short Term Policies

Navigating IR in the short term is about getting from the laggard stage to the higher stages and earlier analysis had suggested focus on developing markets (urban areas) as a first step. Fostering free market attitudes and improving governance to attract investors is the other focus. Looking at table 6-2 we see that these policies will also have the desired impact on PCs (in the case of urban population), mobile phones (in the case of free markets), and Internet use

(in the case of governance). Note again that the telephone loses out with respect to urban population.

Table 6-2: Stages 1 & 2 Drivers

	IR	PCs	Internet Use	Mobile Phone	Telephones
Epidemic Effects		X	X	X	X
GDP					
electricity					
manufacturing		X		X	
services		X	X		
urban_pop	X	X			X(-)
Trade			X(-)	X	
Tertiary_complete					X(-)
governance_index	X		X		
Credit		X			
television					X
pop_15_64					X
sec_complete					
free_mktx	X	X		X	
conservative_new					
trust_new					X

Over and above these policy initiatives, epidemic effects are key drivers of ICT artifacts, and increasing ownership to create the critical mass that will trigger epidemic effects is another policy avenue. One way to achieve this is to give tax breaks to individuals and firms buying ICTs; lower taxes and duties on ICT equipment; and giving ICTs equipment to promising entrepreneurs and brilliant students as they constitute the innovator class that sparks the epidemic. Technology demonstration centers and exhibitions are also other avenues of lowering information barriers.

6.3 Medium Term Policies

In the medium term the objective is to expand use of technology and at the same time adapt technology to serve local needs. In the medium term IR was seen to be best driven by improving the regulation of markets, protection of civil liberties to allow flourishing of communication industries, encouraging trade, investment in electric power and infrastructure, improving access to secondary level education and policies designed to encourage firms in services and manufacturing to integrate ICTs to their operations. We now need to see how these proposals fare when the diffusion of ICT artifacts is considered. Table 6-3 shows a summary of drivers of IR and ICTs artifacts at the intermediate stages.

Table 6-3: Stage 2 & 3 Drivers

	IR	PCs	Internet Use	Mobile Phone	Telephones
Epidemic Effects		X	X	X	X
GDP					
electricity	X	X			
manufacturing	X				X
Services	X				X
urban_pop	X	X	X		
Trade	X				
Tertiary_complete					X(-)
governance_index	X	X	X		?
Credit					?
television			X(-)		
pop_15_64	X				X
sec_complete	X				
free_mktx				X	
conservative_new					
trust_new		X			X

These policies are still valid though they have low impact on ICT artifacts diffusion, which are mostly driven by epidemic effects. To hasten diffusion of the ICT artifacts, policies that foster epidemic effects should be pursued, including technology centers and trade exhibitions.

6.4 Longer Term Policies

In the long term the objective is to move beyond consumption of ICTs to creation or to more sophisticated use at a minimum. Table 6-4 shows a summary of drivers of IR and ICTs artifacts at the intermediate stages.

Table 6-4: Stage 3 & 4 Drivers

	IR	PCs	Internet Use	Mobile Phone	Telephones
Epidemic Effects			X	X	X
GDP					X
electricity	X			X(-)	
manufacturing	X				
services	X			?(-)	
Urban_pop	X		X	X	
Trade		X(-)			X(-)
Tertiary_complete	X				
governance_index					
Credit	X	X			
television		X(-)			
pop_15_64					
sec_complete	X	X			
free_mktx					
conservative_new					
trust_new	X				

Analysis at the IR adoption level suggests a longer term policy regime that focuses on increasing access to tertiary education, increasing availability to credit by opening up capital markets, and policies that foster trust in society. At the higher levels of IR, these policies also hasten diffusion of PCs though having little impact on the other ICT artifacts which are mainly driven by epidemics. These policies are still valid and should be pursued. To hasten diffusion of the other artifacts, policies that foster epidemic effects should be pursued including technology centers and trade exhibitions.

6.5 Lessons Learned

In light of the findings at both diffusion and adoption levels, a few lessons become apparent.

I. The narrow pursuit of IR drivers may miss the big picture. IR is as much about diffusion of artifacts as it is about adoption of technology. Short term dynamics as ICTs move to their equilibrium level should be distinguished from long term drivers that change the overall IR posture of a nation. At the worst, long term policy choices that seem reasonable may slow down diffusion, ensuring that that objective will not be achieved in the planning horizon. Drivers of short term ICT diffusion dynamics and long term IR posture should, to the greatest extent possible, be harmonized.

II. Diffusion of artifacts is dominated by epidemic effects which may mask important drivers of the overall IR posture. Thus policy measures informed by diffusion analysis will be sub-optimal. At the same time decision makers must realize that epidemic effects are important and should be harnessed to facilitate diffusion of ICT artifacts.

III. There are stages of IR and at different stages both the dynamics of navigating through the stage and the dynamics of diffusion of the ICT artifacts at that stage change, and therefore policy levers need to be adjusted to stay on course.

IV. ICT artifacts exhibit both substitution and complementarity effects. Drivers sometimes move in the same direction, reflecting complementarities and sometimes in opposite directions, reflecting that ICT artifacts are themselves in competition. Focus should not be on promoting technologies per se but in moving ahead in IR. Policy that best improves IR posture will determine the optimal number of various ICT artifacts. In making choices, synergies and complementarities should be sought. Policy choices should aim to exploit complementarities for greater effectiveness.

V. In formulating policies, generalities across artifacts, across stages and at aggregate levels should be sought to make policies that have the biggest return on investment. It is also apparent that the telephone will be the loser in the wake of IR, though there will be new opportunities in the rural areas.

6.6 Does Education Matter?

There are mixed results in the literature, mostly showing that education does not matter (Higgatai 1999, Kiiski and Pohjola 2001). Note that the diffusion approach tends to find no role for education, while the adoption approach tends to find a role. Thus the weak evidence of human capital found in the literature is the result of looking at artifacts diffusion. IR posture is very much dependent on human capital, as both measures of education have shown very strong significant impact on IR score, but only the PC diffusion model found secondary education to be significant. Education does matter, but it may not be too important for short-term diffusion of technologies as they try to reach their equilibrium. It does matter, however, in establishing what that equilibrium will be. A technology like PCs, unlike other ICTs, requires a fair amount of sophistication to use it effectively. We need applications to be built and used in fairly sophisticated ways.

6.7 Can the Digital Divide be closed?

To answer this we need to distinguish between diffusion at the local level and overall level of adoption. Diffusion analysis only tells us how countries are moving towards their equilibrium level, which is defined by economic conditions. So greater speed of diffusion among the countries at lower stages of IR means that, yes, the gap is closing but it does not mean convergence in the long run. The equilibrium levels will determine whether the gap can be closed. In the long run, wealth does matter as it defines the equilibrium level. In the short run it

does not matter. This means that policy makers can do more to narrow the gap within the income constraints by, for example, focusing on measures that unleash the epidemic forces.

But note that the reverse causality also occurs and is the reason for adopting ICTs in the first place. We expect ICTs to promote economic growth and thus wealth (incomes). A vast literature on this exists, but it points out that this is not a simplistic process and requires that it be accompanied by innovations in management systems, organizational restructuring and other painful adjustments before feedback effects of ICT investments can be felt in the economy (Brynjolfson and Hitt 2000). This process takes time and it is problematic, as the path by which ICT affects development is not very clear; whether by increasing knowledge diffusion through better communication, or improving governance, or increasing worker productivity, etc. But if all works well, diffusion will be followed by economic growth, thus improving the equilibrium level and after a number of such cycles it will eventually lead to convergence. Therefore closing the digital divide is as much about hastening diffusion as it is about making necessary arrangements to effectively integrate technology into economic activities.

7.0 CONCLUSION

A two pronged approached to information revolution policy is suggested by the foregoing analysis. On the one hand there is a need to shift the equilibrium that is defined by the prevailing demand, supply, and environmental constraints (adoption policies), and on the other hand there is a need to ensure that the level of equilibrium is reached by hastening diffusion ICT technologies (diffusion policies).

7.1 Adoption Policies

One approach is to relax the structural constraints that determine the level of adoption possible. This has the impact of increasing the potential to absorb and use ICTs. These are macro-economic policies and the key drivers are the policy makers/politicians. This analysis points to a number of policies that would be most effective in moving ahead in the information revolution for laggard countries. These can be divided into policies applicable to moving from one stage to the next.

Short Term Strategies (Stage 1 to Stage 2)

I. Market development through investment in urban infrastructure and development of urban centers.
II. Improve governance with the aim of creating a business-friendly environment that will attract investors to invest in the infrastructure necessary for provision of ICT services

and products. These include lowering corruption, improving government effectiveness, protection of property rights and civil liberties and improving regulatory quality.

III. Promote free market values of competition, private ownership and merit pay.

Medium Term Strategies (Stage 2 to Stage 3)

I. Encourage investment in electricity generation to expand availability of power and improve general infrastructure.
II. Encourage firms (both in manufacturing and services sectors) to restructure so as to integrate ICTs in day-to-day operations.
III. Accelerate access to higher education, especially secondary education.

Long term Strategies (Stage 3 to Stage 4)

I. Improve and expand access to tertiary education in science and engineering, to improve the capacity to supply ICTs.
II. Improve and expand access to business and entrepreneurship education to create market-savvy people who can create sophisticated products and services for new types of ICT devices.
III. Develop capital markets and policies to increase credit to private enterprise.
IV. Adopt policies that promote trust in society.

Note that the policies reflect the relative emphasis that is required at various stages, as opposed to saying infrastructure is only important in moving from stage 1 to stage 2. Also note macroeconomic policies are made in the context of an overall economic framework and thus priorities based on some criteria determine which projects get what funding. This is therefore a zero sum game in that funds allocated for ICT infrastructure are not available for delivering clean water. In this sense it would be foolhardy to expect policy prescription to be adopted *in toto* and indeed the policy maker is highly constrained in the choices. Policy choices are likely to be adopted to the extent they help in achieving development priorities. Luckily, the policy recommendations here tend to also be policies that are important in overall development, so that some are likely to be adopted whether the desire is to improve IR or not.

7.2 Diffusion Policies

The second policy lever that the decision maker has is to hasten diffusion to ensure an efficient adoption level is attained. The analysis shows that the key drivers of diffusion are invariably the epidemic effects irrespective of stage of information revolution. Epidemic effects are triggered by learning that occurs through information spreading. Policies that unleash epidemic effects include:

i) Identify and nurture information evangelists in the public sector, the private sector, and in civil societies. Information plays a critical role in explaining new ICT products and their capacities to business leaders, NGO leaders, government officials and personal users (Wilson 2004 pp 195)

ii) Promote policies that increase ownership of ICTs by innovator classes to create the critical mass that will trigger epidemic effects. One way to achieve this is to give tax breaks to individuals and firms buying ICTs, and to lower taxes and duties on ICT equipment.

iii) Adopt policy initiatives to reduce information barriers on the use of ICTs through information centers, trade exhibitions and policies to ensure compatibility of equipment and software.

iv) Encourage creation of social networks and technical networks of ICT stakeholders to encourage sharing of knowledge, experiences, and best practices and to build trust.

v) Give ICT equipment to promising entrepreneurs and brilliant students, as these constitute the innovator classes that sparks the epidemic.

vi) Sponsor visits to international trade shows by entrepreneurs so that local entrepreneurs will share experience with international counterparts

vii) Encourage private-public partnerships to facilitate transfer of knowledge from the private to the public sector

viii) Encourage university-private sector collaboration to hasten transfer of knowledge and adaptation of ICTs to local needs.

ix) Link local universities to international universities to allow local universities to be at the cutting edge of technological developments.

x) Organize programming, robotic, etc; competitions for students to spark interest

xi) Give awards for best use of IT by entrepreneurs

The options available for promoting ICTs are numerous and those enumerated above are but a snapshot. Enthusiasm, creativity and proactively seeking for ways to promote the use of ICTs by all sectors of the society is the key input. ICT evangelism and ICT evangelists are the key. In contrast to adoption policies, diffusion policies require fewer resources but more organization and facilitation. They are also not in competition with other policies for resources.

7.3 Caveat

The policy prescriptions outlined above belie the complex nature of the adoption and diffusion of ICTs. They should be seen only as a starting point, bearing in mind there are missing pieces needed to complete the picture.

Experience has shown that developing regional clusters of tertiary institutions, research institutions, venture capitalist institutions, and a sophisticated populace are the best way to foster ICT creation capacity, as in the case of Silicon Valley in the U.S.A and Bangalore in India. But this analysis, while pointing to developing of the separate capabilities, does not point to clustering in a particular geographical location, as case studies would suggest. In this sense, the analysis fails to unearth the more complex interplay of IR drivers.

The foregoing analysis has only glossed over the surface, sacrificing depth over breadth. Issues of structure were given coverage, and policies outlined, in an attempt to provide the policy maker with an outline of the structural constraints to attack at various stages of the information revolution. Practical policymaking has to contend with depth issues and, unfortunately, the analytical approach and data available could not unearth the depth issues. Depth issues are best

analyzed by case studies, and the exemplar of capturing these issues is provided in Wilson's (2004) SRS model. The SRS model identifies 4 classes of drivers of ICT drivers, namely: (1) structures, (2) institutions, (3) elite politics and (4) policies. ICT diffusion is seen as the strategic interaction of a few elite stakeholders with opportunities and threats emerging from ICTs. These elites are driven by personal, institutional, professional and political motives and emanate from public, private and civil societies. Existing structures, institutions, and policies shape the political behavior of these elites and these institutions, and the structures are in turn shaped by the elites as the diffusion path is negotiated.

The analysis conducted here has at best focused or captured the structural aspect of the SRS model. Structure dictates what is feasible, but elite politics, institutions, and policies dictate what is achievable. The roadmap provided from the foregoing analysis, then, provides a starting point for practical policy analysis. Policy makers keen on moving the nations forward in IR will require further case studies to unearth the relationships between identified drivers and existing institutions, policies and politics to chart their individual paths.

Other Limitations

I. Research on a better measure of the IR concept is required as this is the construct of interest. In particular a criteria that best measures the creation aspect of IR is needed. Note that data on IR creation activities is very limited and greater effort should be made to capture data on these aspects.

II. This analysis uses data from 123 countries in the IR scale developed. In many analyses data was missing so that countries in the actual analysis tend to be between 70 and 90. Countries that have missing data tend to be those that are relatively backward so that countries at higher stages of IR are over-represented.

III. The limited number of countries meant that analysis using the IR stage as an independent variable could not be done. Sequential logit/probit analysis would have yielded more insights into how the various drivers impact on the propensity of moving from a given stage to the next.

IV. Though the drivers used were comprehensive, it is still possible that important drivers were left out of the analysis and omitted variable bias cannot be ruled out.

V. There is an inherent selection bias that occurs when analysis is done using subsamples rather than a full sample, as was done using the moving window strategy.

8.0 BIBLIOGRAPHY

An African Voice of Protest, *15 - Nzinga Mbemba (Afonso I),*
LETTERS TO THE KING OF PORTUGAL. Online at
http://www.wfu.edu/~watts/w04_Africa.html.

Arquila, James and David Ronfeldt (1996). *The Advent of Netwar.* RAND Santa Monica, MR-789-OSD, 1996

Avgerou, Chrisanthi (1998). "How Can IT Enable Economic Growth in Developing Countries?" *Information Technology for Development,* Vol. 8 (1).

BBC. "Central African Kingdoms: The Story of Africa," BBC World Service, online at http://www.bbc.co.uk/worldservice/africa/features/storyofafrica/index.shtml.

Baily, Martn N. and Robert Z. Lawrence (2001). Do We Have a New Economy?" *National Bureau of Economic Research*, NBER Working Paper Series, Working Paper 8243. Online at http://www.nber.org/papers/w8243.

Balianmoune-Lutz. (2003). "An Analysis of the Determinants and Effects of ICT Diffusion in Developing Countries." *Information Technology and Development,* Vol. 10.

Banji, Oyelaran-Oyenyika and Catherine Nyaki Adeya (2002). "Internet Access in Africa: An Empirical Investigation." *UNU-INTECH*, Discussion Paper, ISSN 1564-8370, United Nations International University (UNU)-Institute for New technologies.

Barro, Robert J. and Jong-Wha Lee (2000)., "International Data on Educational Attainment: Updates and Implications," manuscript, Harvard University, February 2000.

Baskerville, R. and Pries-Heje, J. (2001). " A Multiple-Theory Analysis of a Diffusion of Information Technology Case." *Information Systems Journal*, Vol. 11, No. 3, pp. 181-212.

Beilock, Richard and Daniela V. Dimitrova (2003). "An Exploratory Model of Inter-country Internet Diffusion." *Telecommunications Policy,* Vol. 27, pp. 237-252.

Benhabib, Jess and Mark M. Spiegel (2002). "Human Capital and Technology Diffusion." *Economic Research*, Federal Reserve Bank of San Francisco, San Francisco, CA.

Bresnaham, Timothy and Trajtenberg, M. (1995). "General Purpose Technologies: Engines of Growth?" *Journal of Econometrics*, Vol. 65, No. 1, pp. 83-108.

Brynjolfson, E. and L. Hitt (2000). "Beyond Computation: Information Technology, Organization Transformation and Business Performance." *Journal of Economic Perspectives*, Vol. 14, No. 4.

Casselli, Francesco (1999). "Technological Revolutions." *American Economic Review*, Vol. 89, No. 1.

Casselli, Francesco and Wilbur John Coleman II (2001). "Cross-Country Technology Diffusion: The Case of Computers," *American Economic Review*, Vol. 91, No. 2.

Chinn, M. D. and R. W. Fairlie (2004). "The Determinants of the Global Digital Divide: A Cross Country Analysis of Computer and Internet Penetration." Center for Global International & Regional Studies, University of California, Santa Cruz, CGIRS Working Paper Series, WP 2004-3.

Choucri Nazli, Vincent Maugis, Stuart Madnick, and Michael Siegel (2003). "Global E-Readiness for What?" *Center for E-Business, MIT* paper No. 177, May 2003.

Choi, Jay Pil (1997). Herd behavior, the "Penguin Effect" and the Suppression of Informational Diffussion: An Analysis of Informational Externalities and Payoff Interdependency". *The RAND Journal of Economics*, Vol 28, No. 3, Autumn 1997.

Comin, Diego and Bart Hobjin (2003). "Cross-Country Technology Adoption: Making the Theories face the Facts" Economics Research Reports, C.V. Starr Centre for Applied Economics, New York University, July 2003

Dator, Jim (2004). "Islam, Postmodernism and Other Futures: A Ziauddin Sardar Reader." *Future,* Vol. 36, pp. 115-129.

David, Paul A. (1990). "The Dynamo and the Computer: An Historical Perspective on the Modern Day Productivity Paradox." *The American Economic Review,* Vol. 80, No. 2, May 1990, pp. 355-361.

David, Paul A. and Gavin Wright (1999). "General Purpose Technologies and Surges in Productivity: Historical Reflections on the Future of ICT Revolution." *International Symposium on Economic Challenges of the 21st Century In Historical Perspective*, Oxford, England 2nd-4th July 1999.

David, P.A. and W. E. Steinmuller (1994). "Economics of Compatibility Standards and Competition in Telecommunication Networks." *Information Economics and Policy,* Vol. 6, No. 3.

Desai, Meghand, Sakk Fukuda-Parr, Claes Johansson and Francsisco Sagati (2002). Measuring the Technology Achievenent of Nations and the capacity to participate in the Network Age. *Journal of Human Development.* Vol. 3 (1).

Dewar, James A. (1998). *The Information Age and the Printing Press: Looking Backward To See Ahead.* RAND Santa Monica 1998 P-8014.

Deveneaux, Gustav K. (1976). "Public Opinion and Colonial Policy in Nineteenth-Century Sierra Leone." *The International Journal of African Historical Studies*, Vol. 9, No. 1.

DiNardo, John E. and Jorn-Steffen Pischke (1997). "The Returns to Computer Use Revisited: Have Pencils Changed the Wage Structure Too." *The Quarterly Journal of Economics*, Vol 112(1).

Doms, Mark, Timothy Dunne and Kenneth R. Troske (1997). "Workers, Wages and Technology", *Quarterly Journal of Economics*, Vol 112(1) February 1997 pp 253-290.

Dutta, Soumitra, Bruno Lavin and Fiona Paua eds. (2003). The Global Information Technology Report 2002-2003: Readiness For a Networked World. Oxford University Press, New York, 2003.

Dutta, Soumitra, Bruno Lavin and Fiona Paua eds. (2004). The Global Information Technology Report 2002-2004: Towards and Equitable Information Society. University Press, New York, 2004.

Eisenstein, Elizabeth (1993). *The Printing Revolution in Early Modern Europe*, Cambridge University Press, 1993.

Fichman, Robert G. (1992). "Information Technology Diffusion: A review of Empirical Researh" MIT Sloan School of Management. June 1992.

Fulford, Robert (1999). "Islam's Lost Empire." *The National Post,* December 28. 1999.

Gadsden, Fay (1980). "The African Press in Kenya, 1945-1952." *The Journal Of Africa History*, Volume 21(4) 1980.

Gibbs, Jennifer, Kenneth L. Kraemer and Jason Dedrick (2002). Environmental and Policy Factors Shaping E-commerce Diffusion: A Cross-Country Comparison" *Center for Research on Information Technology and Organization*, University of California, Irvine.

Geroski, P.A. (2000). "Models of Technology Diffusion." *Research Policy,* Vol. 29(2000) pp. 603-625.

Girliches, Zvi (1957). "Hybrid Corn: An Exploration in the Economics of Technological Change." *Econometrica*, Vol 25, pp501-522.

Gurbaxani, V. (1990). "Diffusion in Computing Networks; The Case of BITNET." *Communications of the ACM* Vol. 33(12) pp 65-75.

Hall, Bronwyn H. and Beethika Khan (2003). "Adoption of New Technology", Institute of Business and Economic Research." *Department of Economics*, University Of California Berkeley (UCB) Paper E03-330, 2003.
Http://repositories.cdlib.org/iber/econ/E03-330

Hargittai, Eszter (1999). "Weaving the Western Web: Explaining Differences in Internet Connectivity Among OECD Countries." *Telecommunications Policy* Vol 23(10/11)

Hundley, Richard O., Robert H. Anderson, Tora K. Bikson, James A Dewar, Jerrold Green, Martin Libicki and C. Richard Neu. (2000). *The Global Course Of Information Revolution: Political, Economic And Social Consequences – Proceedings Of An International Conference.*" Santa Monica, CA RAND, CF-154_NIC,2000

Hundley Richard O, Robert H. Anderson (1995). "Emerging Challenge: Security and Safety in Cyberspace*" IEEE technology and Society* pp. 19-28 Winter 1995/1996

Hundley Richard O, Robert H. Anderson, Tora K. Bikson, C. Richard Neu (2003). *The Global Course of the Information Revolution: Recurring Themes and Regional Variations.* National Defense Research Institute, RAND Santa Monica.

Hunwick John, The Arabic Literary Tradition of Nigeria, *Research in African Literatures* Volume 28, Number 3

International Telecommunication Union (ITU) (2003). "ITU Digital Access Index: World's First

Global ICT Ranking: Education And Affordability Key To Boosting New Technology Adoption." *International Telecommunication Union.* http://www.itu.int/newsarchive/press_releases/2003/30.html

Inglehart R, M. Basanez, J Diez-Medrano, L. Halman and R Luijkx (2004). *Human Beliefs and Values: A Cross-Cultural Sourcebook Based on the 1999-2002 Value Survey.* Siglo XXI Editores Mexico 2000.

Jovanovic, Boyan and Peter L. Rousseau (2003). "General Purpose Technologies." *Department of Economics*, New York University. Available http://www.econ.edu/user/jovanovi/GPT.pdf

Jovanovic, Boyan and Glenn M. Macdonald (1994). "Competitive Diffusion." *The Journal of Political Economy*, Vol 102(1) February 1994 pp.24-52

Kang , Steve W. (2000). "The Printing Press in Korea". *RAND Conference- New Paradigms and Parallels: The printing Press and the Internet*, October 5-6 2000. http://www.rand.org/multi/parrallels/SM/papernav.html

Katz, Bill (1995). *History of the Book.3rd Ed.* Metuchen, NJ Scarecrow 1995.

Katz, M. L. and C. Shapiro (1986). "Technology Adoption in the Presence of Network Externalities." *Journal of Political Economy*, Vol 94(4) pp.822-841

Kaufmann D., A. Kraay, and M. Mastruzzi (2003). "Governance Matters III: Governance Indicators For 1996–200", World Bank Policy Research Working Paper 3106, Washington DC.

Kedzie, C. R. (1997). *Communication and Democracy: Coincident Revolutions and the Emergent Dictator's Dilemma*. RAND RGSD127 Santa Monica CA

Keller, Wolfgang (2001). "The Geography And Channels Of Diffusion At The World's Technology Frontiers." *National Bureau of Economic Research,* Working paper 8150. http://nber.org/papers/w8150

Kenney, Charles (2003). "The Internet And Economic Growth In Less-Developed Countries: A Case Of Managing Expectations?" *Oxford Development Studies*, Vol. 31 (1) pp 99-103.

Kiiski, Sampsa & Matti Pohjola (2001). "Cross-Country Diffusion Of Internet. World Institute For Economics Research." *United Nations University (UNU/WIDER).* Discussion paper No. 2001/11

Krueger Alan B. (1993). "How Computers Have Changed the Wage Structure: Evidence from Microdata, 1984-1989." *The Quarterly Journal of Economics*. Vol 108(1)

Liao, Tim F. (1994). *Interpreting Probability Models: Logit Probit and Other Generalized Linear Models* Sage Thousand Oaks CA.

Loch, Christoph H. and Bernardo A Huberman. (1999). "A Punctuated-Equilibrium Model of Technology Diffusion." *Management Science*. Vol. 45(2). February 1999 pp 160-1777.

Mansfield, Edwin (1961). "Technical Change and the Rate of Imitation." *Econometrica* Vol 29(4) pp 741-766.

Mukoyama, Toshihiko (2002). "A Theory of Technology Diffusion". *Department of Economics*, University Of Rochester, January 2002.

Nelson R and Phelps E. (1966). Investment in Humans, Technological Diffusion and Economic Growth." *American Economic Review*, Vol. 56(1/2) 69-75

Oliner, S and Sichel, D. (2000). "The Resurgence Of Growth In The Late 1990s: Is Information Technology The Story?" *Journal of Economic Perspectives*, Vol. 14(4).

Pedersen, Per E. and Rich Ling (2002). "Modifying Adoption Research for Mobile Internet Service Adoption: Cross-disciplinary Interactions", *Proceeding of the 36th Hawaii International Conference on System Sciences*". Computer Society IEEE 2002.

Pohjola, Matti (2001). "The new economy: Facts, impacts and policies", *World Institute for Economics Research*, United Nations University (UNU/WIDER).

Reed , Christopher (2000). "Printing and Publishing in Late Imperial China." *RAND Conference- New Paradigms and Parallels: The printing Press and the Internet*, October 5-6 2000. http://www.rand.org/multi/parrallels/SM/reed.html

Rogers, E. M (2000). "Diffusion of Printing and Internet." *RAND Conference- New Paradigms and Parallels: The printing Press and the Internet,* October 5-6 2000. http://www.rand.org/multi/parrallels/SM/rogers.html

Rogers, E. M. (1995). *Diffusion of Innovations (4th Ed.)*. New York. The Free Press

Rodriguez, Francisco and Ernest J. Wilson (2000). "Are Poor countries Losing the Information Revolution?" *InfoDev Working Paper*, University Of Maryland at College Park

Ronfeldt David F., John Arquila, Graham E. Fuller and Melissa Fuller (1998). *The Zapatista "Social Netwar" in Mexico*. RAND MR-994-A Santa Monica 1998.

Rosenberg, Nathan (1972). "Factors Affecting the Diffusion of Technology", *Explorations in Economics History*, Vol. 10(1) pp. 3-33.

Rosenberg, Nathan and Manuel Trajtenberg (2001). "A General Purpose Technology at Work: The Corliss Steam Engine in the Late 19th Century US." *National Bureau of Economic Research*, NBER Working Paper Series, Working Paper 8485 http://www.nber.org/papers/w8485

Rouvinen, Petri (2004). “Diffusion of Digit Mobile Telephony: Are Developing Counties Different.” *World Institute for Development Economics Research (WIDER*), United Nations University, Research Paper No. 2004/13

Rubinstein Goeffrey, Printing: History and Development, *Jones International and Jones Digital Century 1994-1999*. www.digitalcentury.com

Saloner, Garth and Andrea Shedpard (1995). “Adoption of technologies with Network Effects: An Empirical Examination of the Adoption of Automated Teller Machines” The RAND Journal of Economics, Vol 26. No. 3 Autumn 1995.

Schwab, K., M. Porter, J Sachs, P. Cornelius and J. McArthur, eds. (2002). Global Competitiveness Report 2001-2002. Oxford University Press, New York 2002.

Scotton James F, “The First African Press in East Africa; Protestant and Nationalist in Uganda in the 1920’s’ *International Journal Of African Historical Studies* Volume 6 Issues 2 1973

Stoneman, Paul (2002). The Economics of Technology Diffusion. Blackwell Publishers, Oxford 2002.

Tallon Peter and Kenneth L. Kraemer, (1999). "Information Technology and Economic Development: Ireland's Coming of Age with Lessons for Developing Countries." *Center for Research on Information Technology and Organizations*. I.T. in Business, Paper 136. http://repositories.cdlib.org/crito/business/136

United Nations Development Programme (UNDP) (2001). *Human Development Report 2001: Making New Technologies Work for Human Development.* Oxford University Press: New York

United Nations Development Programme (2004). *Cultural Liberty in Today’s Diverse World.* UNDP, New York

Volken, Thomas, (2002). “Elements of trust: The cultural dimension of Internet diffusion revisited.” *Electronic Journal of Sociology* Vol. 6 (4)

Wenjert, B. (2002) “Integrating Models of Diffusion of Innovations: A conceptual Framework.” *Annual Review of Sociology*, vol 28, N1. pp 297-326

Wilson, Ernest J and Kelvin Wong (2003).”Africa Information Revolution: A Balance Sheet.” *Telecommunication Policy* Vol 27(2003).

Wilson, Ernest J III (2004). *Information Technology and Developing Countries.* MIT press, Cambridge MA 2004..

Wolcott, P., L. Press, W. McHenry, S Goodman and W. Forster (2001). “A Framework for Assessing the Global Diffusion of the Internet” *Journal of the Association for Information Systems*, Vol 2(6) 2001.

9.0 APPENDIX

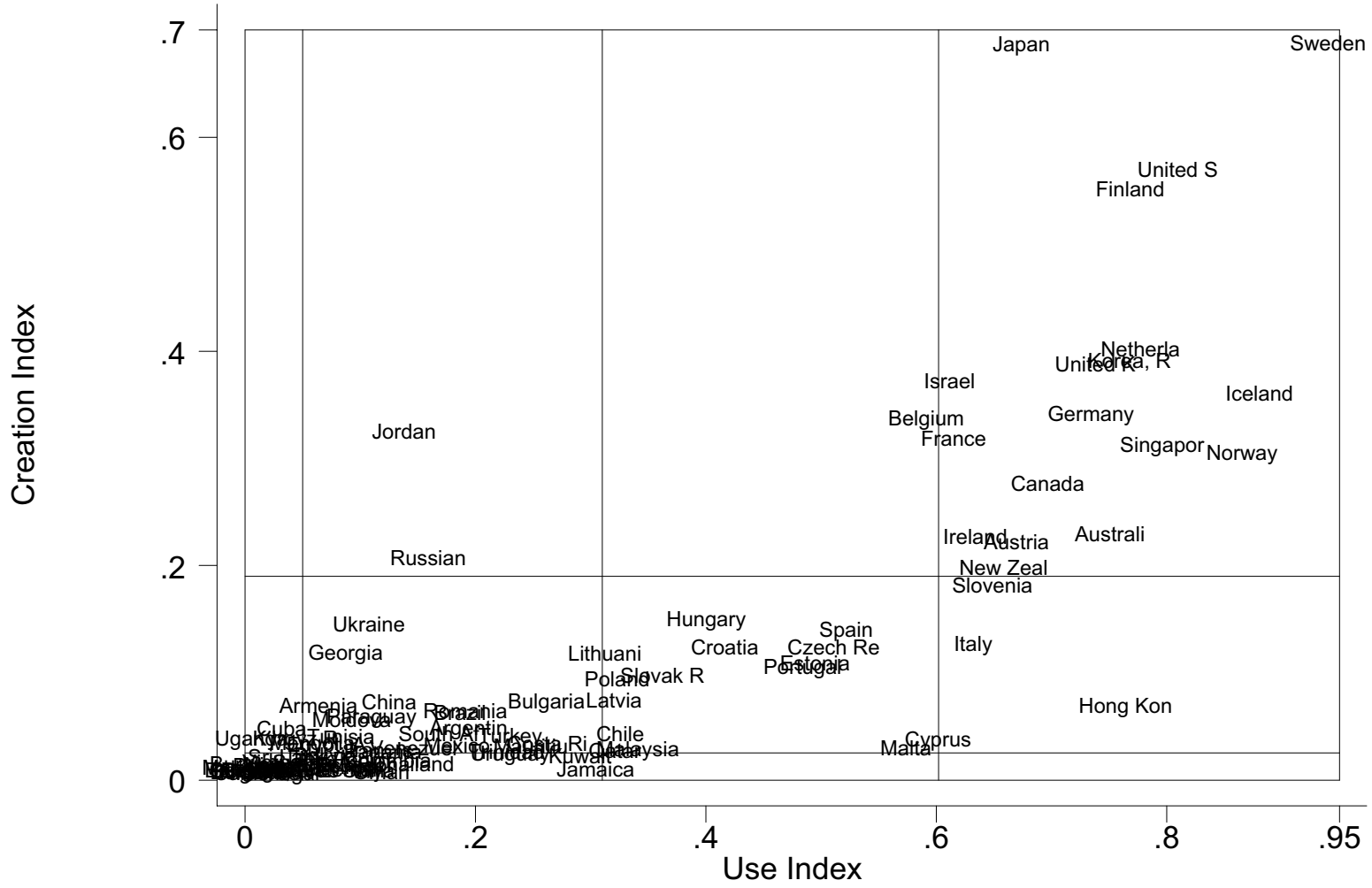

fig A-1: Countries plotted on Creation and Use indexes showing the lines demarcating them according to stages of information revolution (IR)

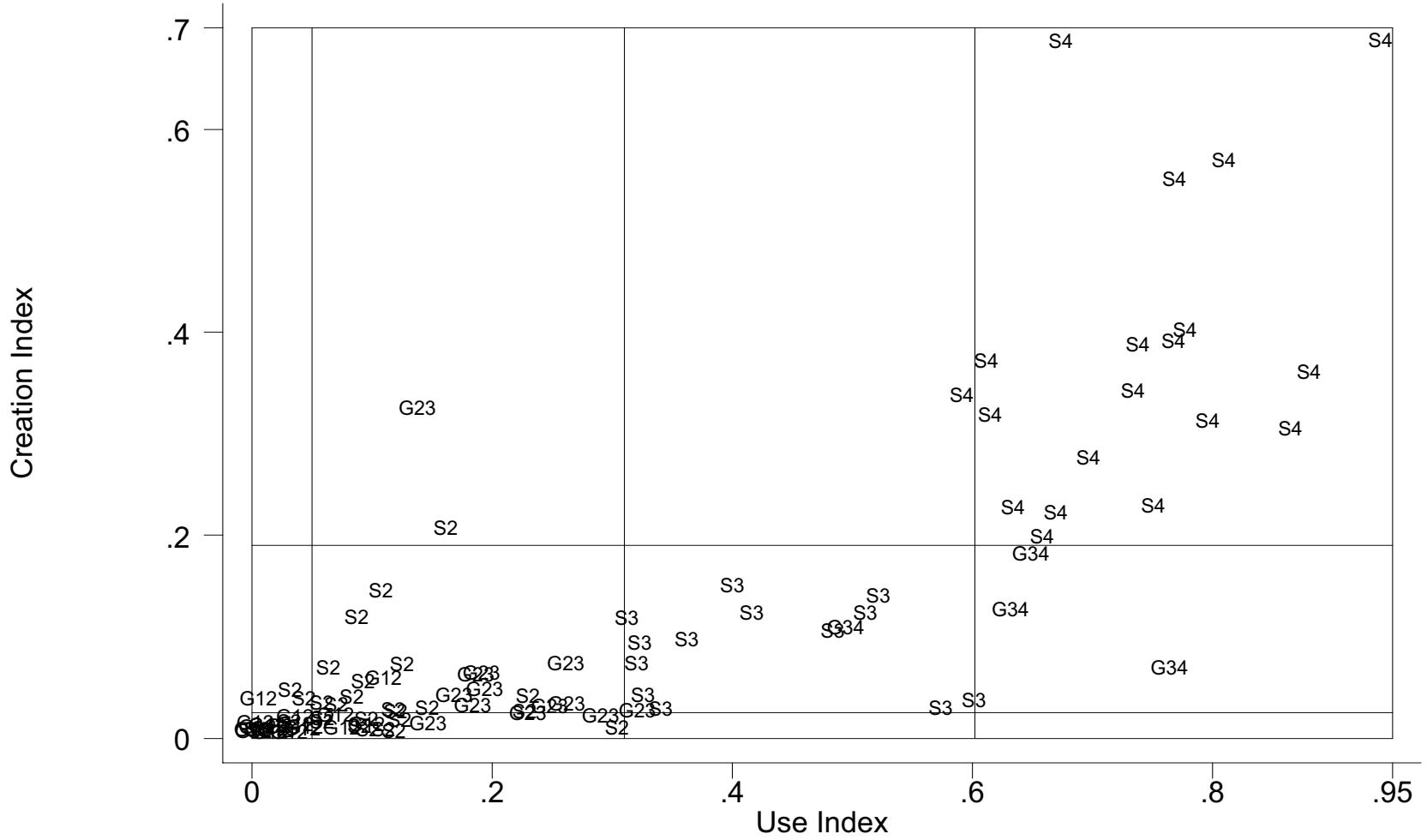

Fig A-2: Fig A-1 is re-plotted but showing stage assignments rather than countries themselves to show the clustering according to stages S1=Stage 2; G12= Grey area between Stage 1 and Stage 2; S2=Stage 2; G23= grey area between Stage 2 and Stage 3; S3=Stage 3; G34= Grey area between stage 3 and 4; S4= Stage 4

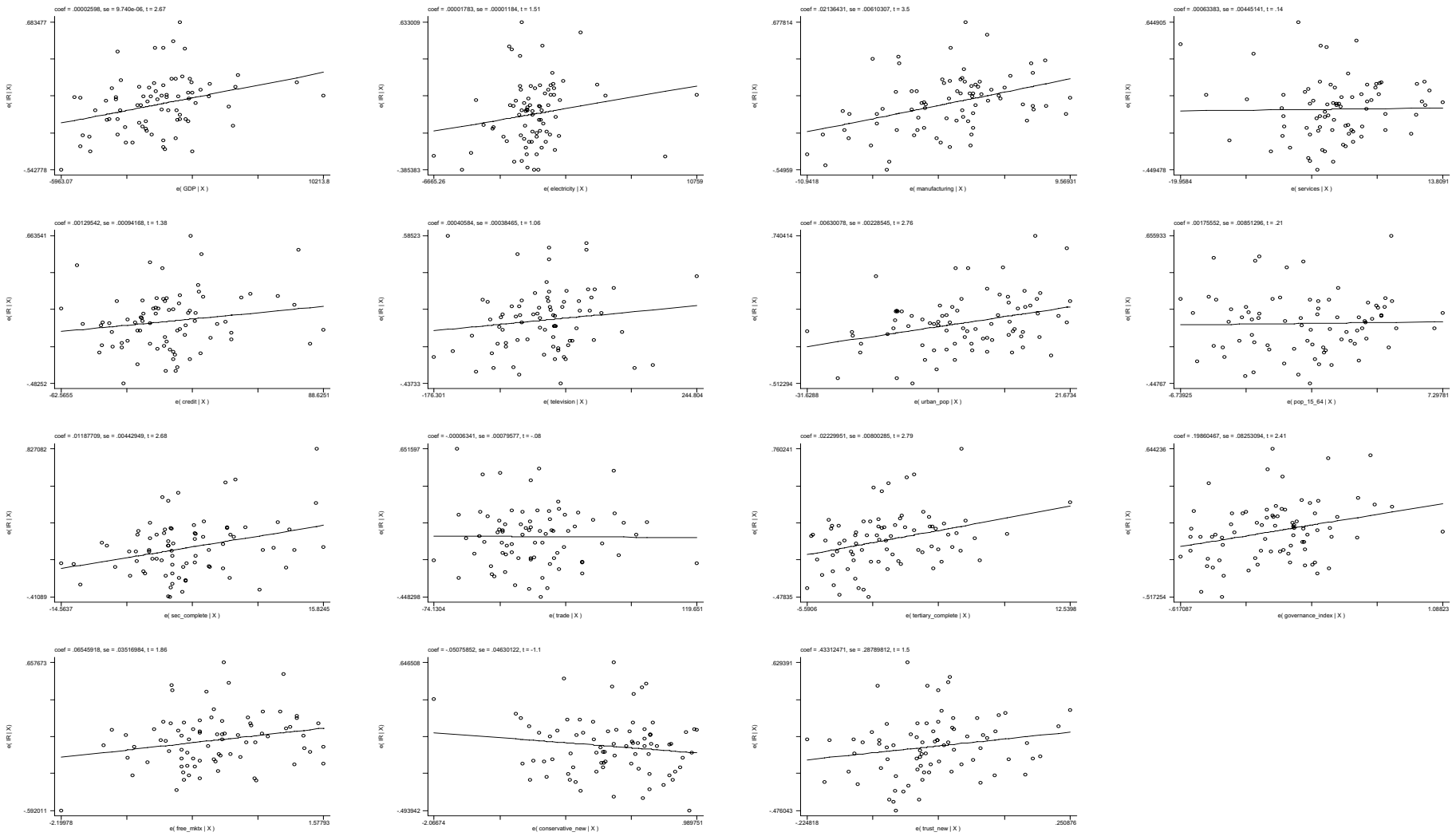

Figure A-3: Avplots for IR index

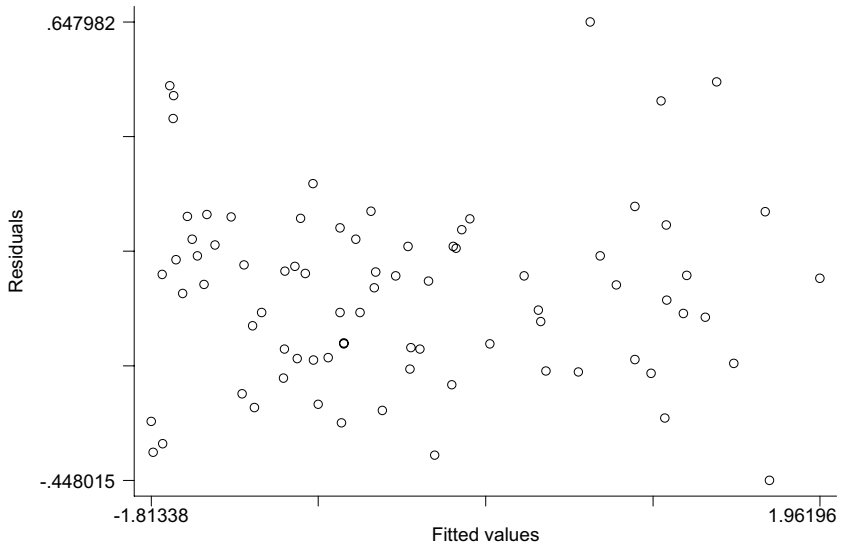

Figure A-4: residual plots for IR

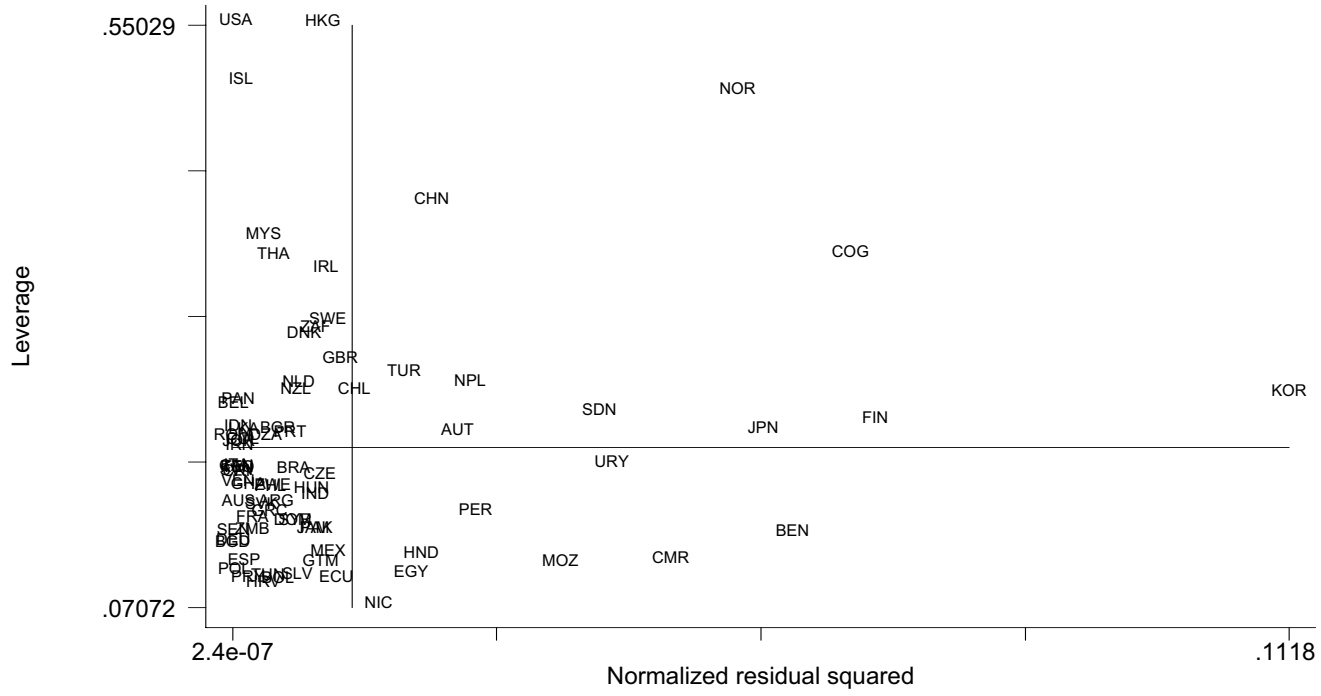

Figure A-5: Leverage plots for IR

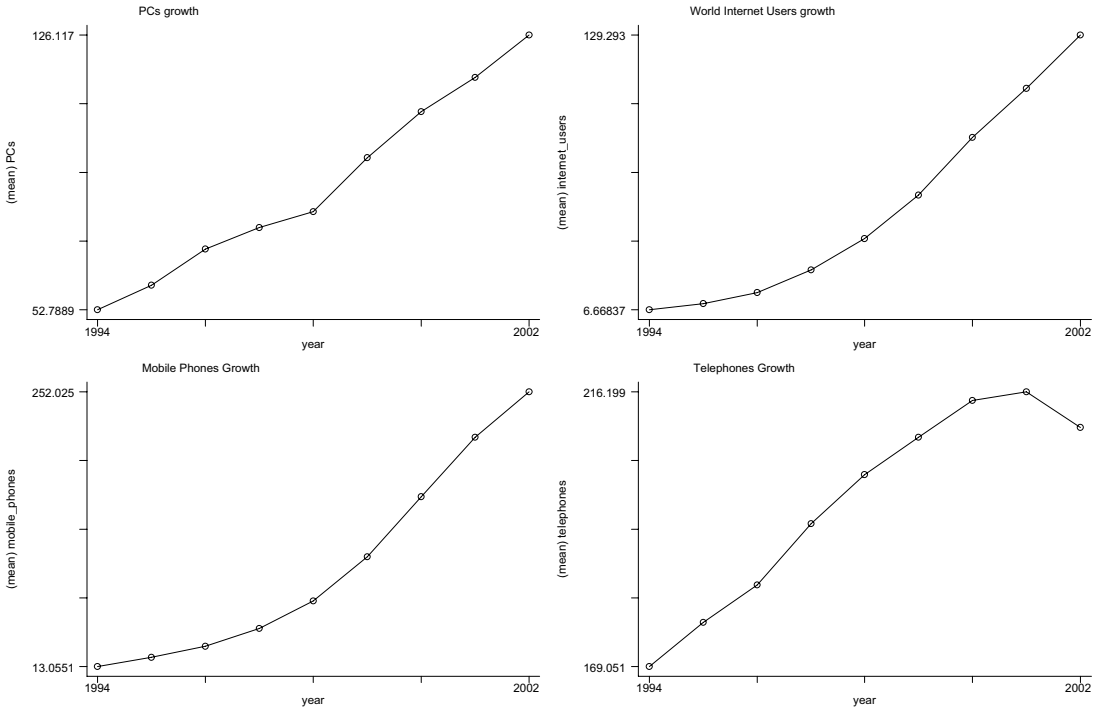

figure A-6: Aggregate Growth of PCs Internet Users, Mobile Phones Telephones (1993-2002)

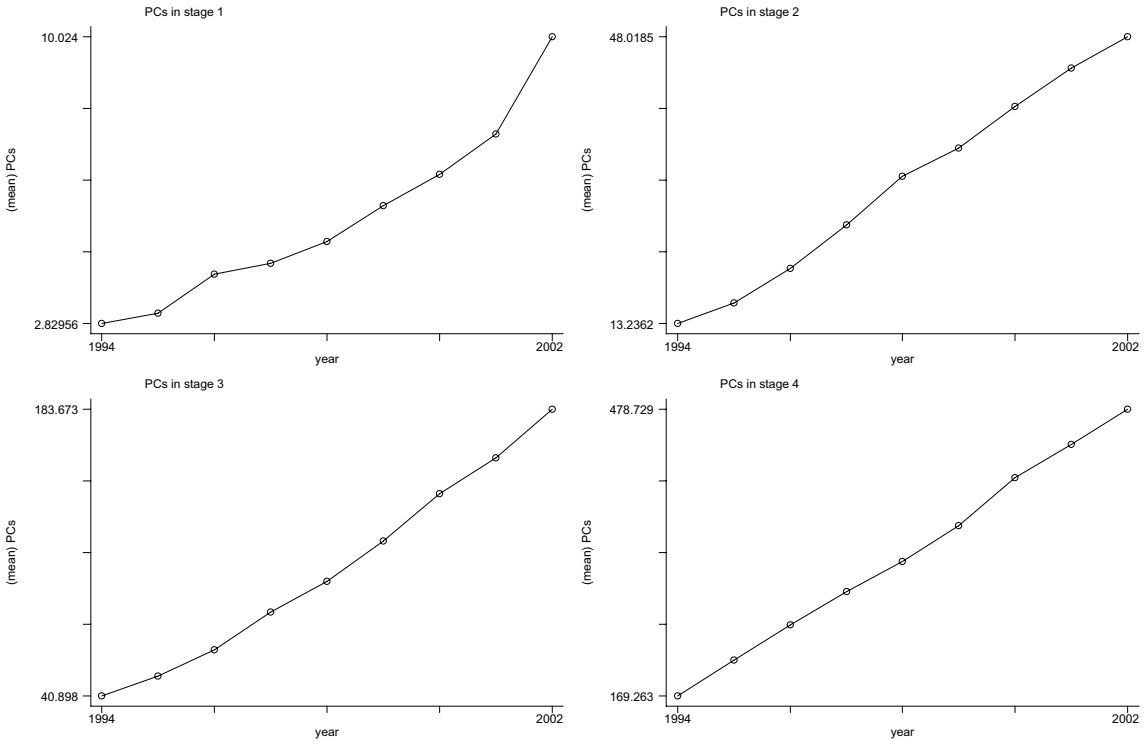

Figure A-7: PCs growth across regions

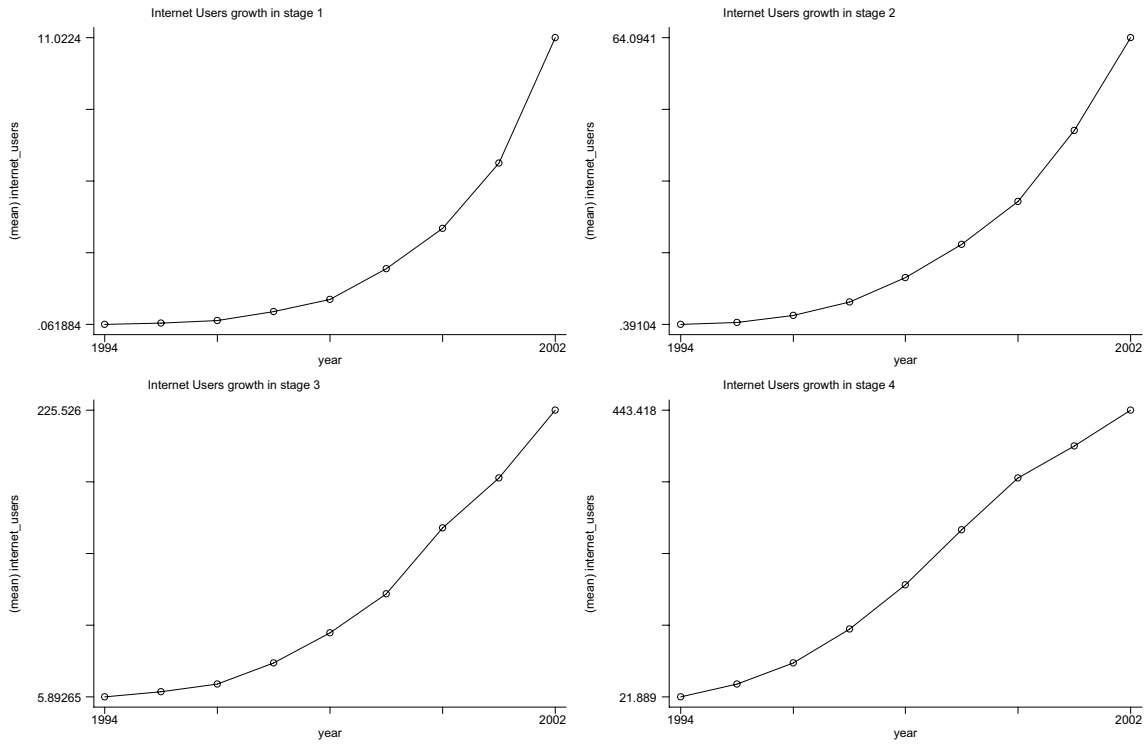

Figure A-8: Internet users growth across IR stages

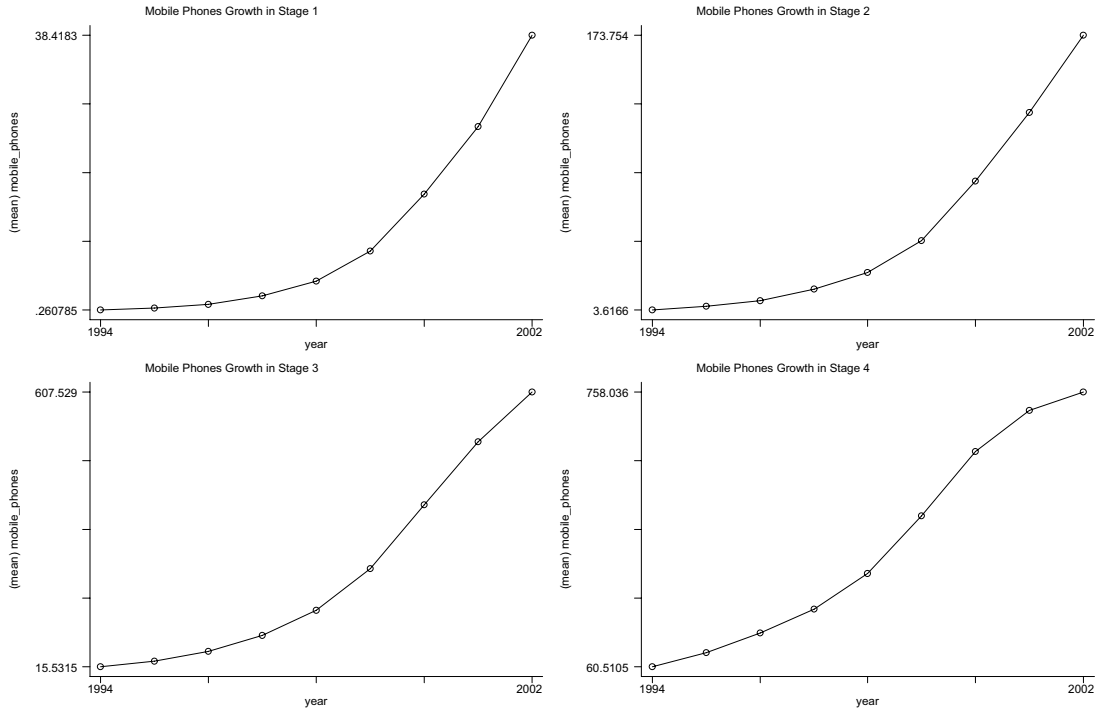

Figure A-9: Mobile phones growth across IR stages

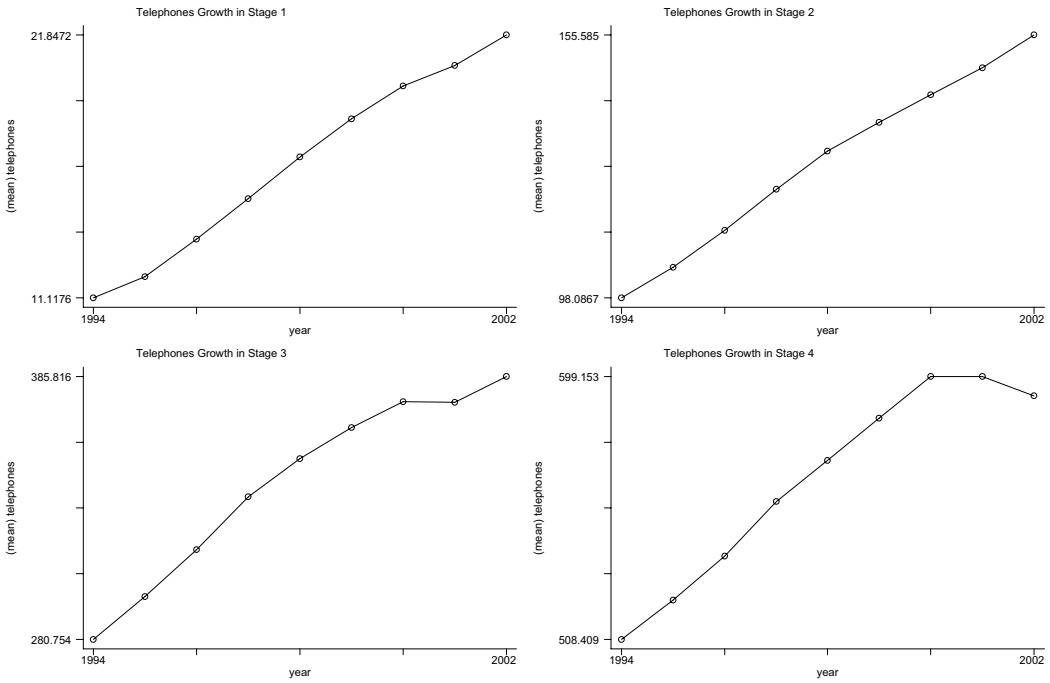

Figure A-10: Telephones growth across regions (stages)

Table A-1: All Indexes Scores Rankings and Stages

Country	Region	Indexes Rankings				Poll Stage	No. of Imputes	IR Score	IR Rank	IR Stage
		NRI	TAI	TI	M_TAI					
United States	NAWE	1	2	1	2	4	0	1.99668	1	4
Finland	NAWE	4	1	3	4	4	0	1.884202	2	4
Sweden	NAWE	3	3	6	1	4	0	1.848786	3	4
Japan	EAP	9	4	23	3	4	0	1.522888	4	4
Korea, Rep.	EAP	20	5	9	8	4	0	1.311806	5	4
Denmark	NAWE	5		12		4	2	1.307742	6	4
Singapore	EAP	2	10	18	10	4	0	1.264464	7	4
Netherlands	NAWE	13	6	14	6	4	0	1.257764	8	4
Iceland	NAWE	12		19	5	4	1	1.255221	9	4
Canada	NAWE	7	8	2	14	4	0	1.251311	10	4
Norway	NAWE	8	12	7	7	4	0	1.227703	11	4
Switzerland	NAWE	6		24		4	2	1.166586	12	4
Taiwan	EAP	16		4		4	2	1.143844	13	4
Australia	EAP	10	9	5	13	4	0	1.141166	14Z	4
United Kingdom	NAWE	17	7	10	9	4	0	1.124439	15	4
Germany	NAWE	11	11	15	11	4	0	1.079629	16	4
Luxembourg	NAWE	14				4	3	1.067777	17	4
Belgium	NAWE	22	14	13	16	4	0	0.832088	18	4
Ireland	NAWE	19	13	28	18	4	0	0.816016	19	4
France	NAWE	18	17	17	15	4	0	0.810354	20	4
Austria	NAWE	21	16	16	17	4	0	0.787796	21	4
Israel	MENA	15	18	26	12	4	0	0.768412	22	4
New Zealand	EAP	24	15	11	19	4	0	0.757879	23	4
Estonia	EECIS	27		8	27	4	1	0.415182	24	3
Hong Kong, China	EAP	23	24	33	20	3	0	0.409046	25	3
Slovenia	NAWE	30	23	30	21	3	0	0.334212	26	3
Italy	NAWE	26	20	31	22	3	0	0.330551	27	3
Spain	NAWE	29	19	27	23	3	0	0.317841	28	3
Czech Republic	EECIS	33	21	20	25	3	0	0.230224	29	3
Hungary	EECIS	35	22	21	29	3	0	0.164285	30	3
Malta	NAWE	28			26	4	2	0.126938	31	3
Portugal	NAWE	31	27	25	28	3	0	0.09108	32	3
Slovak Republic	EECIS	39	25	29	32	3	0	0.016323	33	3
Malaysia	EAP	25	30	22	36	4	0	0.002822	34	3
Greece	NAWE	34	26	38		3	1	-0.02219	35	3
Cyprus	NAWE		33		24	3	2	-0.09874	36	3
Latvia	EECIS	37		34	35	3	1	-0.20546	37	3

Poland	EECIS	46	29	35	34	3	0	-0.22014	38	3
Croatia	EECIS	45	31		30	3	1	-0.25302	39	3
Lithuania	EECIS	41		41	33	3	1	-0.30875	40	3
Chile	LAC	32	37	42	37	3	0	-0.3365	41	3
Mexico	LAC	44	32	36	52	3	0	-0.37728	42	3
Costa Rica	LAC	48	36	32	43	3	0	-0.3919	43	3
Mauritius	SSA	43		37	44	3	1	-0.42026	44	2
Bulgaria	EECIS	66	28	50	40	2	0	-0.43066	45	2
Argentina	LAC	49	34	48	51	2	0	-0.47837	46	2
Jordan	MENA	50		54	31	2	1	-0.49561	47	2
Qatar	MENA				39	3	3	-0.49679	48	2
Thailand	SAS	36	40	39	58	3	0	-0.53072	49	2
South Africa	SSA	40	39	46	53	2	0	-0.53503	50	2
Romania	EECIS	58	35	47	46	2	0	-0.54173	51	2
Kuwait	MENA				42	3	3	-0.57715	52	2
Brazil	LAC	38	43	49	50	2	0	-0.59198	53	2
Uruguay	LAC	55	38	45	47	2	0	-0.60089	54	2
Turkey	MENA	53		51	45	2	1	-0.63835	55	2
Trinidad and Tobago	LAC	52	41	52	48	2	0	-0.68	56	2
Russian Federation	EECIS	61		60	38	2	1	-0.72266	57	2
Botswana	SSA	59				2	3	-0.77398	58	2
China	EAP	51	45	53	55	2	0	-0.79009	59	2
Jamaica	LAC	57	49	43	41	2	0	-0.79016	60	2
Panama	LAC	54	42	57	61	2	0	-0.7941	61	2
Namibia	SSA	62				2	3	-0.81033	62	2
Georgia	EECIS				54	2	3	-0.81376	63	2
Tunisia	MENA	42	51		65	2	1	-0.84551	64	2
Philippines	SAS	74	44	40	71	2	0	-0.84855	65	2
Morocco	MENA	64				2	3	-0.89515	66	2
Venezuela, RB	LAC	67		55	56	2	1	-0.89618	67	2
Colombia	LAC	60	47	56	62	2	0	-0.93665	68	2
Moldova	EECIS				59	2	3	-0.94323	69	2
Ukraine	EECIS	75		63	49	2	1	-0.95343	70	2
Dominican Republic	LAC	56	55	44		2	1	-0.96935	71	2
Armenia	EECIS				63	2	3	-0.97894	72	2
Oman	MENA				64	2	3	-0.9968	73	2
Iran, Islamic Rep.	MENA		50		60	2	2	-1.00661	74	2
Fiji	EAP				66	2	3	-1.01019	75	2
Peru	LAC	71	48	62	67	2	0	-1.04801	76	2
Macedonia, FYR	EECIS	73				1	3	-1.05267	77	2
El Salvador	LAC	69	54	58	69	2	0	-1.05753	78	2
Mongolia	EECIS				73	2	3	-1.06823	79	2
Kyrgyz Republic	EECIS				75	2	3	-1.09055	80	2
Cuba	LAC				76	2	3	-1.09502	81	2
Libya	MENA				77	2	3	-1.09948	82	2
Serbia and Montenegro	EECIS	77				1	3	-1.12537	83	2

Egypt, Arab Rep.	MENA	65	57	64	70	2	0	-1.13534	84	2
Syria	MENA		56		78	2	2	-1.14603	85	2
Vietnam	SAS	63		65	83	2	1	-1.17621	86	2
India	SAS	47	63	66	86	2	0	-1.17909	87	2
Bolivia	LAC	90	46	67	72	1	0	-1.19556	88	1
Uganda	SSA	80			84	1	2	-1.2101	89	1
Congo, Rep.	SSA				87	1	3	-1.21109	90	1
Benin	SSA				88	1	3	-1.21556	91	1
Sri Lanka	SAS	68	62	59	79	2	0	-1.2209	92	1
Burkina Faso	SSA				91	1	3	-1.23341	93	1
Indonesia	SAS	72	60	61	80	2	0	-1.23509	94	1
Burundi	SSA				96	1	3	-1.25573	95	1
Central African Republic	SSA				95	1	3	-1.25573	96	1
Ecuador	LAC	88	53	69	68	1	0	-1.26946	97	1
Cameroon	SSA	82			90	1	2	-1.27046	98	1
Guatemala	LAC	84		68	74	1	1	-1.31053	99	1
Paraguay	LAC	93	52	73	57	1	0	-1.31805	100	1
Algeria	MENA	85	58			2	2	-1.33875	101	1
Madagascar	SSA	92			92	1	2	-1.40346	102	1
Pakistan	SAS	76	65		89	1	1	-1.4249	103	1
Zimbabwe	SSA	91	59	72		1	1	-1.45282	104	1
Zambia	SSA	86				1	3	-1.46464	105	1
Gambia, The	SSA	87				1	3	-1.47676	106	1
Senegal	SSA	81	66		85	1	1	-1.49405	107	1
Honduras	LAC	98	61	70	81	1	0	-1.50413	108	1
Nicaragua	LAC	95	64	71	82	1	0	-1.54186	109	1
Malawi	SSA	89				1	3	-1.57369	110	1
Ghana	SSA	78	67			1	2	-1.59353	111	1
Bangladesh	SAS	94		74	94	1	1	-1.63498	112	1
Nigeria	SSA	79		75	93	1	1	-1.6679	113	1
Kenya	SSA	83	68			1	2	-1.70546	114	1
Mali	SSA	97				1	3	-1.74333	115	1
Tanzania	SSA	70	70			1	2	-1.7961	116	1
Angola	SSA	99				1	3	-1.97355	117	1
Haiti	LAC	100				1	3	-1.98566	118	1
Ethiopia	SSA	101				1	3	-2.10683	119	1
Mozambique	SSA	96	72			1	2	-2.10891	120	1
Nepal	SAS		69			1	3	-2.12056	121	1
Chad	SSA	102				1	3	-2.14318	122	1
Sudan	SSA		71			1	3	-2.18263	123	1

Note: the shaded part shows the countries upper and lower boundary countries under TAI

Table A-2: WDI Indicators

VARIABLE	SELECTED	COMMENT
Personal Computers/1000	YES	
Telephones/1000	YES	
Cellular/1000	YES	
Internet Users/1000	YES	
GDP per capita	YES	
GINI coefficient	NO	Very little data
Urban population (%of total)	YES	
Telephone Wait List	NO	Very little data
Population 15-64 (% of total)	YES	
School enrollment, Primary	YES	Data is limited and thus sample sizes are reduced.
School enrollment, Secondary	YES	
School enrollment, Tertiary	YES	
Newspapers/1000	NO	.Data on newspapers and radios is limited not available for recent years. Data on television is available
Radios/1000	NO	
TVs per 1000	YES	
R&D expenditure as % GDP	NO	Data is limited to a few countries
R&D personnel per 1,000,000	NO	Data is limited to a few countries
Domestic credit to private sector (% of GDP)	YES	
Lending Interest rates	NO	Data is not available for many countries of interest thus reducing sample size
Foreign Direct Investment (FDI) as % of GDP	YES	
Electricity consumption	YES	
Share of Services (%GDP)	YES	
Share of Manufacturing (%GDP)	YES	
Trade as % of GDP	YES	

Table A-3: WVS Questions and response categories used

Question	Comment
– Important quality for child: Respect – Important quality for child: Thrift – Important quality for child: Perseverance – Important quality for child: Religious faith – Important quality for child: Unselfishness – Important quality for child: Obedience	Scored on percent who indicated the quality as "Important".
– Responsibility for providing for oneself	Scored on scale 1 –10 where 1: Individual should be responsible 10: Government should be responsible Aggregate on score 8-10 used to indicate level of dependency
– Important in a job: Good pay – Important in a job: Not too much pressure – Important in a job: A respectable job – Important in a job: Good hours – Important in a job: Opportunity to use initiative – Important in a job: Generous holidays – Important in a job: Meaningful job – Important in a job: A responsible job – Important in a job: An interesting job – Important in a job: Meets one's ability	Scored on percent that indicate the quality as "important"
– Trust: people can be trusted	Percent indicating people can be trusted
– Can Never be Justified: Accept bribe – Can Never be Justified: Cheat on government benefits – Can Never be Justified: Cheat on taxes – Can Never be Justified: Avoid bus fare – Can Never be Justified: Suicide – Can Never be Justified: Euthanasia – Can Never be Justified: Divorce – Can Never be Justified: Prostitution – Can Never be Justified: Homosexuality – Can Never be Justified: Abortion	Scored on scale 1-10 1: Never Justifiable 10: Always Justifibale Aggregate of score 1-3 use to score the country on moral index
– Efficiency is paid more	Percent that indicated this is "fair"
– Private Ownership of business should be increased – Competition is good	Score ranges from 1-10 with score 1: Total agreement 10: Total disagreement. Score 1-3 aggregated to create a score for each country
Religious person	Percent who describe themselves as religious
How important God is in your life?	Score ranges from 1-10 where 1: "not important" 10: "very important" Aggregate of score 8-10 used to capture religiosity
How often does one attend church services?	Response "once a week "or ">1 a week" captured and aggregate score used to capture religiosity
Belong to a religious denomination	Yes or No response. Yes response captured

Table A-4: WVS imputation Groupings

Country	Region	Sub-Region	Trust	Commnent
China	EAP	EAP-C	0.525	This are East Asia and Pacific Communist countries
Vietnam	EAP	EAP-C	0.389	
Japan	EAP	EAP-D	0.396	This East Asia Developed Countries
Philippines	EAP	EAP-E	0.083	These are East Asia and Pacific Emerging countries
Thailand	EAP	EAP-E		
Indonesia	EAP	EAP-M	0.457	These are the East Asia and Pacific Muslim countries
Malaysia	EAP	EAP-M		
Fiji	EAP	EAP-O		This the East Asia and Pacific Indian Ocean countries (Islands)
Hong Kong, China	EAP	EAP-T		These are the East Asia and Pacific Tigers (Newly industrialized Countries)
Korea, Rep.	EAP	EAP-T	0.273	
Singapore	EAP	EAP-T	0.167	
Taiwan	EAP	EAP-T	0.369	
Australia	EAP	EAP-W	0.395	These are east Asia and Pacific Western Countries
New Zealand	EAP	EAP-W	0.484	
Armenia	EECIS	EECIS-R	0.235	These are former Soviet Republics
Bulgaria	EECIS	EECIS-R	0.249	
Georgia	EECIS	EECIS-R	0.177	
Kyrgyz Republic	EECIS	EECIS-R		
Lithuania	EECIS	EECIS-R	0.234	
Moldova	EECIS	EECIS-R	0.141	
Mongolia	EECIS	EECIS-R		
Russian Federation	EECIS	EECIS-R	0.229	
Ukraine	EECIS	EECIS-R	0.261	
Czech Republic	EECIS	EECIS-W	0.234	These are former Eastern Europe Countries
Estonia	EECIS	EECIS-W	0.217	
Hungary	EECIS	EECIS-W	0.214	
Latvia	EECIS	EECIS-W	0.167	
Poland	EECIS	EECIS-W	0.183	
Romania	EECIS	EECIS-W	0.099	
Slovak Republic	EECIS	EECIS-W	0.152	
Croatia	EECIS	EECIS-Y	0.179	These are former Yugoslavia Republics
Macedonia, FYR	EECIS	EECIS-Y	0.131	
Serbia and Montenegro	EECIS	EECIS-Y	0.183	
Colombia	LAC	LAC-C	0.107	These are Central American countries (Colombia is misplaced here!)
Costa Rica	LAC	LAC-C		
Guatemala	LAC	LAC-C		
Honduras	LAC	LAC-C		
Mexico	LAC	LAC-C	0.208	
Nicaragua	LAC	LAC-C		
Panama	LAC	LAC-C		
El Salvador	LAC	LAC-C	0.141	
Cuba	LAC	LAC-I		These are Caribbean countries or Islands
Dominican Republic	LAC	LAC-I	0.252	
Haiti	LAC	LAC-I		

Jamaica	LAC	LAC-I		
Trinidad and Tobago	LAC	LAC-I		
Argentina	LAC	LAC-SA	0.15	These are South American countries
Bolivia	LAC	LAC-SA		
Brazil	LAC	LAC-SA	0.028	
Chile	LAC	LAC-SA	0.222	
Ecuador	LAC	LAC-SA		
Peru	LAC	LAC-SA	0.106	
Paraguay	LAC	LAC-SA		
Uruguay	LAC	LAC-SA	0.216	
Venezuela, RB	LAC	LAC-SA	0.158	
Algeria	MENA	MENA	0.108	These are Arab countries
Egypt, Arab Rep.	MENA	MENA	0.375	
Jordan	MENA	MENA	0.271	
Kuwait	MENA	MENA		
Libya	MENA	MENA		
Morocco	MENA	MENA	0.229	
Oman	MENA	MENA		
Qatar	MENA	MENA		
Syrian Arab Republic	MENA	MENA		
Tunisia	MENA	MENA		
Iran, Islamic Rep.	MENA	MENA-P	0.496	This are Persian countries
Turkey	MENA	MENA-T	0.156	These are Turkish
Israel	MENA	MENA-W	0.23	This is Middle east but western
Austria	NAWE	NAWE	0.313	These are North America and Western Europe countries
Belgium	NAWE	NAWE	0.294	
Canada	NAWE	NAWE	0.384	
Switzerland	NAWE	NAWE	0.379	
Cyprus	NAWE	NAWE		
Germany	NAWE	NAWE	0.331	
Denmark	NAWE	NAWE	0.641	
Spain	NAWE	NAWE	0.345	
Finland	NAWE	NAWE	0.567	
France	NAWE	NAWE	0.214	
United Kingdom	NAWE	NAWE	0.286	
Greece	NAWE	NAWE	0.205	
Ireland	NAWE	NAWE	0.346	
Iceland	NAWE	NAWE	0.393	
Italy	NAWE	NAWE	0.318	
Luxembourg	NAWE	NAWE	0.249	
Malta	NAWE	NAWE	0.204	
Netherlands	NAWE	NAWE	0.594	
Norway	NAWE	NAWE	0.648	
Portugal	NAWE	NAWE	0.098	
Slovenia	NAWE	NAWE	0.212	
Sweden	NAWE	NAWE	0.637	
United States	NAWE	NAWE	0.355	

India	SAS	SAS-H	0.389	These are Hindu South Asian countries
Sri Lanka	SAS	SAS-H		
Nepal	SAS	SAS-H		
Bangladesh	SAS	SAS-M	0.233	These are Muslim South Asia countries
Pakistan	SAS	SAS-M	0.282	
Angola	SSA	SSA-G		These are Central and East African countries or Great Lakes Region.
Burundi	SSA	SSA-G		
Central African Republic	SSA	SSA-G		
Congo, Rep.	SSA	SSA-G		
Ethiopia	SSA	SSA-G		
Kenya	SSA	SSA-G		
Malawi	SSA	SSA-G		
Sudan	SSA	SSA-G		
Chad	SSA	SSA-G		
Tanzania	SSA	SSA-G	0.077	
Uganda	SSA	SSA-G	0.076	
Madagascar	SSA	SSA-O		These are African Indian Ocean Island countries
Mauritius	SSA	SSA-O		
Botswana	SSA	SSA-S		These are Southern Africa countries
Mozambique	SSA	SSA-S		
Namibia	SSA	SSA-S		
South Africa	SSA	SSA-S	0.115	
Zambia	SSA	SSA-S		
Zimbabwe	SSA	SSA-S	0.117	
Benin	SSA	SSA-W		These are West Africa countries
Burkina Faso	SSA	SSA-W		
Cameroon	SSA	SSA-W		
Ghana	SSA	SSA-W		
Gambia, The	SSA	SSA-W		
Mali	SSA	SSA-W		
Nigeria	SSA	SSA-W	0.253	
Senegal	SSA	SSA-W		

Note the construct Trust is used here to demonstrate which countries need imputation. The countries lacking data were imputed using the average of the score of the countries in their groupings.

Table A-5: Summary statistics by IR stage

	IR Stage			
	1	2	3	4
IR	-1.546	-0.842	0.011	1.201
Internet_users	4.630	28.768	135.121	323.241
Telephones	19.514	141.889	369.835	589.141
mobile_phones	18.664	91.379	367.144	563.754
PCs	6.889	39.200	140.175	398.451
GDP	1817.623	5748.849	13628.660	27220.060
Electricity	277.676	2177.548	3420.603	9877.845
manufacturing	11.473	17.770	20.016	19.545
Services	45.762	54.585	63.622	67.180
Credit	17.857	39.263	66.415	111.255
Television	66.271	262.748	427.672	599.479
Trade	61.690	77.499	112.999	87.594
FDI	3.571	3.125	5.308	34.752
Pop_15_64	54.188	63.615	67.167	66.898
urban_pop	36.361	60.994	68.592	82.009
Primary_complete	9.004	15.367	19.524	14.859
Sec_complete	5.179	12.770	16.965	22.741
Tertiary_complete	2.832	8.380	9.347	13.127
years_schooling	3.511	6.534	7.835	9.895
voice_accountability	-0.561	-0.174	0.841	1.286
political_stability	-0.758	-0.012	0.827	1.162
govt_effectiveness	-0.677	-0.103	0.801	1.765
regulatory_quality	-0.402	-0.045	0.907	1.392
Rule_of_law	-0.725	-0.095	0.738	1.768
corruption_control	-0.759	-0.195	0.685	1.884
governance index	-0.712	-0.131	0.821	1.693
trust_new	0.177	0.215	0.232	0.389
Worker_X	-0.086	-0.459	-0.051	0.699
Worker_Y	1.657	0.452	-0.149	-0.781
Worker_Z	-0.105	-0.215	0.285	-0.351
Dependence	0.472	0.380	0.309	0.190
Free market index	0.288	-0.280	-0.312	0.067
Challenging_job_new	-0.045	-0.009	-0.112	0.466
Religiosity	1.382	0.310	-0.073	-0.612
technology attitude	0.746	0.739	0.663	0.580
Moral conservative index	1.241	0.529	-0.112	-1.103

Table A-6: IR regression adding demand, supply and governance drivers

	1	2	3	4
GDP	0.0000398	0.0000393	0.0000298	0.0000365
	(4.23)***	(3.99)***	(2.99)***	(4.04)***
Electricity	0.000035	0.0000318	0.0000248	0.0000237
	(2.96)***	(2.71)***	(2.16)**	(2.05)**
manufacturing	0.0277846	0.023375	0.0193001	0.0193901
	(4.52)***	(3.76)***	(3.16)***	(3.15)***
Services	0.0040229	0.0023954	-0.0014163	-0.0016127
	-0.95	-0.56	-0.33	-0.37
Television	0.0005969	0.0007816	0.0005698	
	(1.79)*	(2.01)**	-1.5	
Credit	0.0018413	0.0012554	0.0009881	0.0010254
	(1.94)*	-1.31	-1.07	-1.1
urban_pop	0.0082937	0.005992	0.0059221	0.006755
	(3.69)***	(2.44)**	(2.53)**	(2.95)***
pop_15_64	0.0064018	0.0026311	0.0021051	0.0067957
	-0.73	-0.29	-0.25	-0.84
sec_complete	0.0129277	0.0121174	0.0126316	0.0135292
	(2.89)***	(2.64)**	(2.89)***	(3.09)***
FDI		-0.0047121	-0.0046392	-0.0042488
		-0.66	-0.68	-0.62
Trade		0.0006554	0.0002664	-0.0002917
		-0.68	-0.29	-0.34
tertiary_complete		0.0191771	0.0217858	0.0227502
		(2.29)**	(2.71)***	(2.81)***
Governance_index			0.220654	0.2448633
			(2.77)***	(3.11)***
Constant	-3.043812	-2.6873483	-2.2183066	-2.4305675
	(6.38)***	(5.50)***	(4.48)***	(5.07)***
Observations	80	79	79	79
R-squared	0.94	0.95	0.95	0.95

Absolute value of t statistics in parentheses

*Significant at 10%; ** Significant at 5%; *** significant at 1%

Table A-7: Regression of IR with actual governance indicators

	1	2	3	4	5	6
GDP	0.0000296	0.0000281	0.0000292	0.0000373	0.0000379	0.000034
	(2.91)***	(2.78)***	(2.85)***	(3.78)***	(3.88)***	(3.46)***
Electricity	0.000027	0.0000252	0.0000248	0.0000306	0.0000276	2.84E-05
	(2.36)**	(2.22)**	(2.13)**	(2.62)**	(2.32)**	(2.47)**
manufacturing	0.0189439	0.0208558	0.0214556	0.022109	0.0192889	0.02149
	(3.05)***	(3.50)***	(3.57)***	(3.55)***	(2.90)***	(3.53)***
Services	0.000218	0.0001693	0.0005612	-0.0000932	-0.0000034	-0.00126
	-0.05	-0.04	-0.14	-0.02	0	-0.29
Television	0.0006555	0.0005662	0.0005797	0.0006632	0.0006787	0.000731
	(1.74)*	-1.5	-1.51	(1.67)*	(1.74)*	(1.93)*
Credit	0.0006149	0.0007199	0.000903	0.0011594	0.0012305	0.001669
	-0.64	-0.77	-0.97	-1.21	-1.29	(1.76)*
urban_pop	0.0052328	0.0063755	0.0056707	0.0060397	0.005889	0.006638
	(2.20)**	(2.73)***	(2.40)**	(2.48)**	(2.43)**	(2.77)***
pop_15_64	0.0022347	0.0005824	0.0032327	0.0020383	0.0034184	0.000641
	-0.26	-0.07	-0.37	-0.23	-0.38	-0.07
sec_complete	0.0123411	0.0119962	0.0123215	0.0125026	0.0126497	0.012638
	(2.80)***	(2.76)***	(2.80)***	(2.74)***	(2.78)***	(2.84)***
FDI	-0.004806	-0.0039564	-0.0043225	-0.0046603	-0.0045384	-0.00578
	-0.7	-0.58	-0.63	-0.65	-0.64	-0.83
Trade	0.0004404	0.0002012	0.00042	0.0003292	0.0003225	0.000714
	-0.47	-0.22	-0.45	-0.33	-0.33	-0.76
tertiary_complete	0.0249783	0.0211815	0.0227473	0.0195553	0.0201884	0.01702
	(2.99)***	(2.65)***	(2.78)***	(2.35)**	(2.43)**	(2.08)**
govt_effectiveness	0.1963784					
	(2.55)**					
rule_of_law		0.2316988				
		(2.88)***				
corruption_control			0.1830363			
			(2.54)**			
voice_accountability						0.133108
						(2.27)**
regulatory_quality				0.1099013		
				-1.39		
political_stability					0.0936974	
					-1.58	
Constant	-2.3163422	-2.2235036	-2.4161979	-2.4496648	-2.4651878	-2.32472
	(4.71)***	(4.53)***	(5.02)***	(4.76)***	(4.90)***	(4.65)***
Observations	79	79	79	79	79	79
R-squared	0.95	0.95	0.95	0.95	0.95	0.95

Absolute value of t statistics in parentheses
** significant at 5%; *** significant at 1%

Table A-8: IR regression with varying literacy specification and infrastructure (electricity)

	-1	-2	-3	-4	-5	-6
GDP	0.0000254	0.0000271	0.0000266	3.36E-05	3.68E-05	3.58E-05
	(2.60)**	(2.62)**	(2.65)**	(3.41)***	(3.58)***	(3.59)***
Electricity	0.000022	0.0000261	0.0000232			
	(1.88)*	(2.13)**	(1.93)*			
Manufacturing	0.0271044	0.0277504	0.0234776	0.020334	0.020481	0.016752
	(4.33)***	(4.14)***	(3.44)***	(3.14)***	(3.00)***	(2.43)**
Services	0.0040716	0.0048273	0.0039313	-0.00204	-0.00154	-0.00329
	-0.87	-0.97	-0.81	-0.44	-0.32	-0.69
Television	0.0005765	0.0007275	0.0007505	0.000397	0.000551	0.00057
	-1.52	(1.83)*	(1.95)*	-0.97	-1.3	-1.38
Credit	0.0012333	0.000933	0.0010834	0.000841	0.000577	0.000741
	-1.27	-0.91	-1.09	-0.81	-0.53	-0.7
urban_pop	0.0076175	0.007764	0.005645	0.00671	0.006955	0.005277
	(3.11)***	(2.99)***	(2.04)**	(2.59)**	(2.56)**	(1.90)*
Pop_15_64	-0.0036812	-0.0021179	-0.0107746	-0.01116	-0.01066	-0.01651
	-0.36	-0.19	-0.93	-1.01	-0.92	-1.41
Sec_complete	0.0113609			0.012222		
	(2.56)**			(2.53)**		
Trade	0.0001412	0.0008409	0.0004582	-0.00016	0.000466	0.000167
	-0.15	-0.87	-0.48	-0.16	-0.44	-0.16
FDI	-0.0018945	-0.0051828	-0.0022962	-0.00323	-0.00639	-0.00408
	-0.28	-0.72	-0.33	-0.44	-0.84	-0.54
tertiary_complete	0.0211706	0.0232551	0.0195138	0.023757	0.026713	0.022281
	(2.69)***	(2.80)***	(2.35)**	(2.77)***	(2.99)***	(2.50)**
governance_index	0.1393932	0.1225382	0.1300452	0.286097	0.267329	0.260664
	-1.59	-1.32	-1.44	(3.48)***	(3.09)***	(3.11)***
worker_X	-0.0138675	-0.022787	-0.0387509	-0.02734	-0.03519	-0.04746
	-0.33	-0.51	-0.87	-0.6	-0.73	-1.01
worker_Z	0.0570331	0.0643907	0.0734798	0.064414	0.069397	0.078888
	-1.44	-1.53	(1.79)*	-1.49	-1.51	(1.78)*
govt_resp_new	0.0281301	0.0783599	0.0613962	0.150651	0.21896	0.176762
	-0.09	-0.24	-0.19	-0.45	-0.62	-0.52
Free_mktx	0.0535558	0.0541312	0.0462107	0.093556	0.104551	0.084803
	-1.51	-1.38	-1.25	(2.56)**	(2.62)**	(2.24)**
challenging_job_new	0.0489282	0.0530771	0.0727525	0.028624	0.031497	0.056544
	-1.21	-1.24	(1.70)*	-0.65	-0.69	-1.22
conservative_new	-0.0843912	-0.0805578	-0.0717443	-0.08176	-0.07036	-0.07238
	(1.76)*	-1.51	-1.45	-1.56	-1.24	-1.35
trust_new	0.3005776	0.5064164	0.578557	0.294787	0.595585	0.581837
	-0.91	-1.47	(1.75)*	-0.85	(1.68)*	(1.72)*
Tech_attitude_new	-0.0146118	-0.0808894	0.0519245	0.024251	-0.08393	0.088983
	-0.05	-0.24	-0.16	-0.07	-0.23	-0.26
primary_complete	-0.0005446				0.002812	
		-0.11			-0.53	
ed_index			0.8641065			0.877263
			(1.84)*			(1.96)*
Constant	-2.3900846	-2.5276419	-2.5042931	-1.40193	-1.50167	-1.60145

	(3.80)***	(3.78)***	(3.89)***	(2.20)**	(2.24)**	(2.46)**
Observations	75	75	75	79	79	79
R-squared	0.96	0.96	0.96	0.96	0.95	0.95
Absolute value of t statistics in parentheses						
** Significant at 5%; *** significant at 1%						

Table A-9: IR regression with final cultural variables and Actual governance indicators

	-1	-2	-3	-4	-5	-6
GDP	0.0000379	0.0000389	0.0000308	0.0000297	3.67E-05	0.0000312
	(4.26)***	(4.42)***	(3.27)***	(3.16)***	(4.20)***	(3.27)***
Electricity	0.0000189	0.0000175	0.0000171	0.0000164	0.000017	0.000016
	-1.56	-1.43	-1.44	-1.39	-1.41	-1.33
Manufacturing	0.0242846	0.0218273	0.0216349	0.0233323	0.023802	0.0239075
	(3.93)***	(3.26)***	(3.49)***	(3.90)***	(3.91)***	(3.95)***
Services	0.0017457	0.0018412	0.0014807	0.0015946	0.001256	0.0021366
	-0.38	-0.4	-0.34	-0.37	-0.28	-0.49
Credit	0.001366	0.0015086	0.0010388	0.0010842	0.001821	0.0012437
	-1.39	-1.54	-1.06	-1.12	(1.87)*	-1.28
urban_pop	0.0074948	0.0073443	0.0066465	0.0076146	0.008205	0.0069875
	(3.23)***	(3.15)***	(2.89)***	(3.39)***	(3.57)***	(3.05)***
pop_15_64	0.0040533	0.0051092	0.0035757	0.0020766	0.004104	0.0047827
	-0.48	-0.6	-0.43	-0.25	-0.49	-0.58
sec_complete	0.0112251	0.0115058	0.0120576	0.0116049	0.011272	0.0117584
	(2.43)**	(2.47)**	(2.66)***	(2.59)**	(2.48)**	(2.58)**
Trade	-0.0000851	0.0000443	0.0000561	-0.0001346	0.000233	0.0000812
	-0.09	-0.05	-0.06	-0.15	-0.26	-0.09
FDI	-0.0045641	-0.0049719	-0.0047728	-0.0038494	-0.00548	-0.004269
	-0.65	-0.7	-0.69	-0.56	-0.79	-0.62
tertiary_complete	0.021947	0.0222661	0.0260636	0.0222519	0.019767	0.0238488
	(2.65)**	(2.68)***	(3.15)***	(2.78)***	(2.42)**	(2.92)***
free_mktx	0.076074	0.0647954	0.0767041	0.0699076	0.072958	0.0684032
	(2.11)**	(1.79)*	(2.18)**	(2.01)**	(2.06)**	(1.94)*
conservative_new	-0.0717831	-0.0853517	-0.0838846	-0.0699262	-0.06128	-0.07007
	-1.51	(1.85)*	(1.87)*	-1.55	-1.3	-1.52
trust_new	0.6168764	0.5672193	0.4085153	0.3927162	0.641733	0.4270895
	(2.13)**	(1.93)*	-1.38	-1.33	(2.25)**	-1.43
regulatory_quality	0.1255774					
	-1.57					
political_stability		0.0857995				
		-1.47				
govt_effectiveness			0.1949458			
			(2.42)**			
rule_of_law				0.2203772		
				(2.63)**		
voice_accountability					0.131163	
					(2.16)**	
corruption_control						0.1680076
						(2.23)**
Constant	-2.6850281	-2.683083	-2.4515381	-2.395438	-2.69833	-2.609738
	(5.14)***	(5.09)***	(4.67)***	(4.58)***	(5.38)***	(5.13)***
Observations	79	79	79	79	79	79
R-squared	0.95	0.95	0.96	0.96	0.96	0.96

Absolute value of t statistics in parentheses
** significant at 5%; *** significant at 1%

Table A-10: IR stages 1& 2 Drivers

	-1	-2	-3	-4	-5	-6
GDP	-0.0000033	-0.0000118	-0.000008	0.0000349	0.0000225	0.0000279
	-0.12	-0.45	-0.24	-1.64	-1.01	-1.35
Electricity	0.0000909	0.0001001	0.0001039			
	(1.73)*	(1.97)*	-1.51			
manufacturing	0.0146947	0.0097604	0.0122807	0.0100747	0.0054211	0.0065389
	-1.58	-1.07	-1.4	-1.15	-0.64	-0.73
Services	-0.0008173	-0.0025202	-0.0017704	-0.0025137	-0.0029694	-0.0035557
	-0.16	-0.52	-0.35	-0.67	-0.8	-0.88
Credit	0.0006251	0.0013476	0.0006515	0.0006181	0.0015914	0.0008382
	-0.45	-0.93	-0.38	-0.51	-1.24	-0.72
Television	-0.0001334	-0.0001067	-0.0000967	-0.0000809	0.0000141	-0.0000113
	-0.23	-0.18	-0.18	-0.12	-0.02	-0.02
urban_pop	0.0102683	0.0108386	0.0094058	0.006898	0.0077713	0.0064015
	(2.65)**	(2.81)***	(2.54)**	(1.74)*	(2.01)*	-1.59
pop_15_64	0.0188133	0.0196293	0.0181321	0.0114714	0.013289	0.0123491
	-1.67	(1.71)*	-1.36	-0.97	-1.16	-1.02
sec_complete	0.0073376			0.0075875		
	-1.15			-1.37		
Trade	0.0021989	0.001782	0.0019994	0.0016252	0.0011214	0.0013544
	-1.52	-1.07	-1.38	-1.16	-0.75	-1
FDI	-0.024564	-0.0260125	-0.026762	-0.021055	-0.0197146	-0.0215337
	-1.23	-1.35	-1.43	-1.11	-1.06	-1.18
tertiary_complete	0.0028225	0.0053941	0.0035407	0.0098231	0.0118655	0.0097918
	-0.28	-0.57	-0.31	-0.91	-1.2	-0.99
Governance_index	0.1845764	0.227284	0.2132426	0.2625043	0.271003	0.2815944
	-1.43	-1.67	(1.81)*	(2.65)**	(2.62)**	(2.65)**
free_mktx	0.0182777	0.0160225	0.0094668	0.0954622	0.0906925	0.0794888
	-0.38	-0.3	-0.16	-1.69	-1.59	-1.45
conservative_new	-0.0230149	0.0152343	-0.0067624	-0.0457022	-0.0031315	-0.023631
	-0.39	-0.22	-0.11	-0.64	-0.04	-0.31
trust_new	-0.0758742	-0.0607103	-0.0274374	0.0222606	0.0893415	0.0914318
	-0.23	-0.21	-0.07	-0.06	-0.26	-0.25
primary_complete		0.0077437			0.0089829	
		-1.05			-1.5	
ed_index			0.336409			0.3920332
			-0.76			-1.02
Constant	-3.0935042	-3.0427257	-3.101112	-2.3465072	-2.4813876	-2.4848724
	(4.03)***	(3.95)***	(4.07)***	(3.27)***	(3.52)***	(3.57)***
Observations	46	46	46	52	52	52
R-squared	0.84	0.85	0.84	0.8	0.8	0.8

Robust t statistics in parentheses

** significant at 5%; *** significant at 1%

Table A-11: IR stage 2 & 3 Drivers (Group II)

	-1	-2	-3	-4	-5	-6
GDP	0.0000134	0.0000113	0.0000147	0.0000318	0.0000302	0.0000306
	-1.36	-1.1	-1.51	(3.60)***	(3.26)***	(3.67)***
Electricity	0.0000936	0.0001069	0.0000895			
	(2.58)**	(2.83)***	(2.49)**			
manufacturing	0.0264296	0.0242491	0.0208553	0.0187743	0.0177565	0.0146691
	(4.73)***	(4.23)***	(3.72)***	(3.54)***	(3.23)***	(2.98)***
Services	0.0101111	0.0091539	0.009241	0.0039843	0.0041361	0.0052055
	(2.27)**	(1.95)*	(2.11)**	-0.95	-0.94	-1.3
Credit	-0.001456	-0.000967	-0.0011776	-0.0010836	-0.0004232	-0.0008045
	-1.71	-1.13	-1.46	-1.14	-0.45	-0.94
Television	-0.000163	-0.0000629	-0.0000987	-0.0000894	0.0000283	-0.0000523
	-0.46	-0.17	-0.29	-0.22	-0.07	-0.14
urban_pop	0.0054233	0.0055278	0.00318	0.0047771	0.005254	0.0022599
	(2.50)**	(2.42)**	-1.33	(1.98)*	(2.06)**	-0.91
pop_15_64	0.034785	0.0301372	0.0259415	0.0241165	0.0222518	0.0176041
	(2.76)**	(2.23)**	(2.01)*	(1.85)*	-1.63	-1.41
sec_complete	0.0079048			0.0086844		
	(1.89)*			(1.85)*		
Trade	0.0020582	0.0022056	0.0025251	0.0024732	0.0025902	0.0028723
	(2.89)***	(2.93)***	(3.75)***	(3.12)***	(3.07)***	(4.01)***
FDI	-0.0298196	-0.0291192	-0.0286608	-0.0316466	-0.0308532	-0.0287338
	(2.23)**	(2.00)*	(2.16)**	(2.07)**	(1.87)*	(1.98)*
tertiary_complete	-0.005464	-0.0019904	-0.0068814	-0.0051822	-0.0000781	-0.0069867
	-0.77	-0.28	-0.96	-0.65	-0.01	-0.93
Governance_index	0.1693128	0.170459	0.1425527	0.2404258	0.2300618	0.1838997
	(2.72)**	(2.58)**	(2.31)**	(3.73)***	(3.44)***	(2.94)***
free_mktx	-0.0304417	-0.0051701	-0.0118985	0.0357982	0.0677633	0.045777
	-0.75	-0.12	-0.31	-0.92	(1.73)*	-1.3
conservative_new	-0.0055599	0.0003397	-0.0098169	-0.0455771	-0.0440113	-0.0463914
	-0.15	-0.01	-0.26	-1.14	-1.04	-1.23
trust_new	0.1393534	0.2093562	0.4083993	0.0259594	0.1763554	0.448415
	-0.57	-0.82	-1.57	-0.1	-0.65	-1.65
primary_complete		0.0034159			0.0037394	
		-1.06			-1.09	
ed_index			0.8993886			1.1840603
			(2.07)*			(2.59)**
Constant	-4.5855293	-4.2672299	-4.4830238	-3.3321392	-3.3133497	-3.7552228
	(4.82)***	(4.23)***	(4.80)***	(3.90)***	(3.71)***	(4.53)***
Observations	39	39	39	40	40	40
R-squared	0.96	0.96	0.96	0.94	0.94	0.95

Absolute value of t statistics in parentheses
** significant at 5%; *** significant at 1%

Table A-12: IR drivers in Stages 3 & 4 (Group III)

	-1	-2	-3	-4	-5	-6
GDP	-0.0000025	-0.0000004	-0.0000016	0.0000217	0.0000257	0.0000241
	-0.23	-0.03	-0.12	-1.53	-1.65	-1.56
Electricity	0.0000503	0.0000532	0.0000524			
	(4.63)***	(4.24)***	(4.21)***			
Manufacturing	0.066633	0.0668812	0.0644415	0.0476223	0.0460503	0.0440253
	(6.50)***	(5.55)***	(5.42)***	(3.41)***	(2.96)***	(2.88)**
Services	0.0327938	0.0322351	0.0334953	0.0153637	0.0138395	0.0153341
	(3.69)***	(3.11)***	(3.27)***	-1.29	-1.04	-1.17
Credit	0.0027616	0.0022585	0.002354	0.0013682	0.0006948	0.0008145
	(2.48)**	(1.77)*	(1.86)*	-0.86	-0.4	-0.48
Television	0.0003548	0.0006652	0.00062	0.0001939	0.0005313	0.0005011
	-0.82	-1.35	-1.28	-0.3	-0.76	-0.73
urban_pop	0.0077536	0.0077215	0.0075577	0.0097167	0.0094372	0.0095979
	(1.98)*	-1.65	-1.66	-1.68	-1.43	-1.5
Pop_15_64	0.0253523	0.03213	0.0263505	0.0102342	0.0180582	0.0104724
	-1.52	-1.68	-1.27	-0.42	-0.68	-0.36
Sec_complete	0.0111086			0.0131088		
	(2.47)**			(1.98)*		
Trade	-0.0012928	-0.0005271	0.0000062	-0.001125	-0.0003122	0.0004476
	-1.04	-0.36	0	-0.61	-0.15	-0.19
FDI	-0.0025025	-0.0061002	-0.007946	-0.0056664	-0.0095997	-0.0123754
	-0.31	-0.65	-0.81	-0.48	-0.72	-0.9
tertiary_complete	0.0283981	0.030647	0.0282606	0.0342314	0.0361775	0.0343596
	(2.89)**	(2.57)**	(2.50)**	(2.37)**	(2.16)**	(2.18)**
governance_index	0.1487052	0.0450086	0.0004315	0.1718644	0.0560404	-0.0047399
	-1.31	-0.36	0	-1.02	-0.31	-0.02
Free_mktx	-0.0149021	-0.0156626	-0.0169334	0.0463173	0.0485889	0.0470074
	-0.34	-0.31	-0.34	-0.76	-0.71	-0.7
conservative_new	-0.0016725	-0.0011019	0.0185269	-0.0320977	-0.0303531	-0.0092747
	-0.02	-0.01	-0.23	-0.32	-0.27	-0.08
trust_new	0.7452779	1.2460463	1.1838294	0.9841791	1.591502	1.5164528
	(1.86)*	(3.08)***	(2.92)**	-1.67	(2.84)**	(2.71)**
primary_complete		0.0042619			0.0029799	
		-0.65			-0.32	
ed_index			1.5552321			1.8889025
			-0.83			-0.72
Constant	-6.6871699	-7.2442448	-8.1419147	-4.4673482	-4.9469792	-6.1098458
	(5.31)***	(5.00)***	(4.39)***	(2.58)**	(2.60)**	(2.42)**
Observations	33	33	33	33	33	33
R-squared	0.97	0.96	0.96	0.93	0.91	0.91

Absolute value of t statistics in parentheses
** significant at 5%; *** significant at 1%

Table A-13: Summary statistics by Year (Full Sample)

	Year				
	1998	1999	2000	2001	2002
PCs	89.66	100.95	115.27	126.86	141.15
Internet Users	47.06	69.39	95.38	123.34	152.49
Mobile Phones	87.01	136.60	204.22	263.43	310.29
Telephones	212.60	220.02	226.85	229.19	232.66
GDP	9018.35	9400.34	10005.88	10345.75	10688.91
Electricity	3362.62	3451.16	3563.44	3595.51	3658.93
Manufacturing	16.77	16.66	16.57	16.19	16.07
Services	55.00	55.12	55.08	55.70	55.93
Credit	46.65	49.99	50.50	51.83	51.72
Television	273.89	282.20	295.79	303.83	321.97
Urban population	58.06	58.40	58.74	59.12	59.50
Population group 15-64	61.40	61.71	61.96	62.25	62.54
Secondary Education	13.58	13.58	13.58	13.58	13.58
Trade (Imports + Exports)	77.67	77.74	83.59	82.27	81.06
Tertiary Education	8.02	8.02	8.02	8.02	8.02
Governance index	0.220	0.219	0.219	0.158	0.158
Free market index	-0.054	-0.054	-0.054	-0.054	-0.054
Moral conservative Index	0.317	0.317	0.317	0.317	0.317
Trust index	0.240	0.240	0.240	0.240	0.240

Table A-14: Summary Statistics by Year (Stage 1 Countries)

	Year				
	1998	1999	2000	2001	2002
PCs	4.90	5.79	6.58	7.59	10.02
Internet Users	1.02	2.20	3.75	6.23	11.02
Mobile Phones	4.32	8.44	16.36	25.78	38.42
Telephones	16.89	18.44	19.77	20.62	21.85
GDP	1721.95	1762.24	1820.64	1869.31	1893.22
Electricity	260.90	268.85	275.88	286.35	296.40
Manufacturing	11.70	11.58	11.42	11.60	11.48
Services	45.98	45.36	45.08	45.75	46.63
Credit	18.37	18.06	18.16	16.67	17.34
Television	56.55	61.62	67.27	67.79	84.18
Urban population	35.18	35.77	36.35	36.95	37.55
Population group 15-64	53.76	54.08	54.06	54.36	54.67
Secondary Education	5.18	5.18	5.18	5.18	5.18
Trade (Imports + Exports)	61.39	60.99	63.11	61.78	61.18
Tertiary Education	2.83	2.83	2.83	2.83	2.83
Governance index	-0.642	-0.683	-0.683	-0.775	-0.775
Free market index	0.288	0.288	0.288	0.288	0.288
Moral conservative Index	1.241	1.241	1.241	1.241	1.241
Trust index	0.177	0.177	0.177	0.177	0.177

Table A-15: Summary Statistics by Year (Stage 2 Countries)

	Year				
	1998	1999	2000	2001	2002
PCs	31.13	34.55	39.56	44.26	48.02
Internet Users	10.78	18.18	27.80	43.57	64.09
Mobile Phones	26.77	46.85	83.45	126.08	173.75
Telephones	130.21	136.48	142.53	148.39	155.58
GDP	5379.10	5508.45	5753.30	5954.02	6149.37
Electricity	2091.67	2128.37	2218.64	2195.87	2253.19
Manufacturing	18.18	17.86	17.59	16.99	17.10
Services	53.82	54.40	54.55	55.42	55.36
Credit	39.12	39.87	38.93	38.97	39.42
Television	250.18	253.94	269.72	249.30	277.31
Urban population	60.33	60.65	60.98	61.33	61.68
Population group 15-64	62.48	62.94	63.66	64.08	64.50
Secondary Education	12.77	12.77	12.77	12.77	12.77
Trade (Imports + Exports)	74.35	74.78	80.18	79.56	79.68
Tertiary Education	8.38	8.38	8.38	8.38	8.38
Governance index	-0.124	-0.085	-0.085	-0.181	-0.181
Free market index	-0.280	-0.280	-0.280	-0.280	-0.280
Moral conservative Index	0.529	0.529	0.529	0.529	0.529
Trust index	0.215	0.215	0.215	0.215	0.215

Table A-16: Summary Statistics by Year (Stage 3 Countries)

	Year				
	1998	1999	2000	2001	2002
PCs	98.06	118.06	141.73	159.35	183.67
Internet Users	54.73	84.90	135.48	173.76	225.53
Mobile Phones	137.04	226.98	364.24	499.93	607.53
Telephones	352.88	365.32	375.64	375.45	385.82
GDP	12301.77	12837.82	13800.57	14373.21	14738.69
Electricity	3225.63	3299.18	3428.29	3519.97	3629.94
Manufacturing	19.97	20.36	20.29	19.73	19.31
Services	62.55	62.85	63.49	64.28	64.94
Credit	63.11	66.22	67.53	68.72	67.55
Television	399.63	415.17	435.77	464.62	500.45
Urban population	68.19	68.36	68.53	68.80	69.07
Population group 15-64	66.82	67.05	67.09	67.32	67.55
Secondary Education	16.96	16.96	16.96	16.96	16.96
Trade (Imports + Exports)	109.24	107.88	120.30	116.92	114.15
Tertiary Education	9.35	9.35	9.35	9.35	9.35
Governance index	0.780	0.805	0.805	0.858	0.858
Free market index	-0.312	-0.312	-0.312	-0.312	-0.312
Moral conservative Index	-0.112	-0.112	-0.112	-0.112	-0.112
Trust index	0.232	0.232	0.232	0.232	0.232

Table A-17: Summary Statistics by Year (Stage 4 Countries)

	Year				
	1998	1999	2000	2001	2002
PCs	314.12	353.19	405.19	441.02	478.73
Internet Users	186.35	267.62	344.03	390.89	443.42
Mobile Phones	297.34	443.66	607.73	712.01	758.04
Telephones	570.11	584.87	599.08	599.15	592.48
GDP	24589.81	25850.23	27682.18	28539.90	29438.21
Electricity	9431.32	9719.57	9982.72	10079.37	10176.23
Manufacturing	20.01	19.68	19.78	19.17	20.32
Services	66.73	67.16	66.58	67.63	68.07
Credit	105.80	107.53	110.80	116.97	115.50
Television	562.63	577.48	593.43	646.75	617.39
Urban population	81.73	81.86	81.99	82.15	82.32
Population group 15-64	66.87	66.92	66.83	66.90	66.97
Secondary Education	22.74	22.74	22.74	22.74	22.74
Trade (Imports + Exports)	82.31	83.82	92.48	91.47	87.89
Tertiary Education	13.13	13.13	13.13	13.13	13.13
Governance index	1.741	1.704	1.704	1.658	1.658
Free market index	0.067	0.067	0.067	0.067	0.067
Moral conservative Index	-1.103	-1.103	-1.103	-1.103	-1.103
Trust index	0.389	0.389	0.389	0.389	0.389

Table A-18: Aggregate PCs diffusion regression results

	-1	-2	-3	-4
	PCs Growth	PCs Growth	PCs Growth	PCs Growth
ln_PCs_1	-0.0949589	-0.1222671	-0.1234296	-0.0893486
	(3.13)***	(3.53)***	(3.68)***	(3.08)***
GDP	0.0000051	0.0000037	0.000003	-0.0000002
	(1.95)*	-1.26	-1.07	-0.06
Electricity	0.0000027	0.0000037	0.0000008	-0.0000025
	(1.68)*	(1.98)**	-0.42	-1.35
manufacturing	0.0058157	0.0061558	0.0067601	
	(3.25)***	(3.11)***	(3.37)***	
Services	0.0025133	0.0024972	0.0027251	0.001069
	(2.45)**	(2.19)**	(2.40)**	-1.04
urban_pop	0.0010444	0.0015487	0.0018022	0.0005667
	-1.56	(2.10)**	(2.49)**	-0.95
Trade	-0.0000517	-0.0000087	-0.0000077	-0.0000841
	-0.42	-0.05	-0.04	-0.48
tertiary_complete	-0.0008735	-0.0005415	-0.0005846	
	-0.57	-0.3	-0.32	
governance_index	0.0295175	0.0304222	0.033959	0.0470284
	(1.80)*	(1.72)*	(1.86)*	(2.29)**
Credit		0.0002683	0.0003497	0.0003943
		-1.42	(1.81)*	(2.21)**
Television		0.0000119	-0.0000262	0.0000716
		-0.13	-0.28	-0.71
pop_15_64		0.0066876	0.005796	
		(2.94)***	(2.65)***	
sec_complete		0.0020991	0.0019838	0.0025875
		(2.56)**	(2.24)**	(2.81)***
free_mktx			0.03207	0.0280625
			(3.68)***	(3.01)***
Conservative_new			-0.0106421	
			-1.01	
trust_new			0.0763818	
			-1.28	
Constant	0.1138414	-0.2477618	-0.2166224	0.4056809
	(1.79)*	-1.52	-1.37	(5.21)***
Observations	369	313	313	318
R-squared	0.26	0.32	0.35	0.29

Robust t statistics in parentheses

** significant at 5%; *** significant at 1%

Table A-19: PCs Diffusion in Stage 1 & 2

	-1	-2	-3	-4	-6	-5
ln_PCs_1	-0.1594993	-0.1758407	-0.1746255	-0.1492332	-0.1659272	-0.1606092
	(3.76)***	(3.62)***	(3.54)***	(3.26)***	(3.53)***	(3.46)***
GDP	-0.0000001	-0.0000073	0.0000019	0.0000026	0.0000015	-0.0000003
	-0.01	-0.94	-0.21	-0.3	-0.17	-0.04
Electricity	0.0000411	0.0000416	0.000023	0.0000149	0.0000262	0.0000277
	(1.83)*	-1.59	-0.83	-0.58	-1.03	-1.07
manufacturing	0.0053411	0.0059801	0.00626			
	(2.29)**	(1.99)**	(2.00)**			
Services	0.004786	0.0055963	0.0060024	0.0042209	0.004741	0.0042864
	(2.66)***	(2.78)***	(2.94)***	(2.29)**	(2.40)**	(2.30)**
pop_15_64	0.0093403	0.0080286	0.0046666			
	(2.95)***	(2.27)**	-1.41			
Trade	-0.0001968	-0.0001387	-0.0000736	-0.0003526	-0.0002834	-0.0003331
	-0.54	-0.33	-0.17	-0.91	-0.7	-0.86
tertiary_complete	-0.0003609	-0.0043419	-0.0016401			
	-0.13	-1.29	-0.45			
governance_index	-0.0052682	-0.013524	-0.0152635	0.0148148	0.0048215	0.0106811
	-0.18	-0.44	-0.49	-0.49	-0.15	-0.34
Credit		0.0006479	0.0007174	0.0009112	0.0007858	0.000801
		-1.44	(1.68)*	(2.11)**	(1.72)*	(1.73)*
Television		0.0001024	0.0000299	0.0003418	0.0003911	0.0004031
		-0.56	-0.16	(2.17)**	(2.37)**	(2.39)**
urban_pop		0.0029165	0.0028996	0.0012903	0.0012106	0.0011426
		(2.86)***	(2.79)***	-1.34	-1.21	-1.14
sec_complete		0.0003189	-0.0000999	0.0005851	0.0010062	0.0010649
		-0.14	-0.04	-0.25	-0.41	-0.43
free_mktx			0.0424419	0.0313028		
			(2.34)**	(1.98)**		
trust_new			0.1980401		0.0805967	
			(1.80)*		-0.83	
Conservative_new			-0.032175			0.0049379
			(2.08)**			-0.35
Constant	-0.3775346	-0.3675022	-0.2330826	0.2912388	0.251694	0.2847286
	(2.35)**	-1.54	-1.07	(2.51)**	(2.05)**	(2.39)**
Observations	215	184	184	188	188	188
R-squared	0.37	0.44	0.45	0.41	0.4	0.4

Robust t statistics in parentheses

** significant at 5%; *** significant at 1%

Table A-20: PCs Diffusion in Stage 2 & 3

	-1	-2	-3	-4
ln_PCs_1	-0.0476062	-0.0734634	-0.0807726	-0.0690512
	(2.15)**	(2.42)**	(2.11)**	(2.24)**
GDP	-0.0000021	-0.0000042	-0.0000032	0.0000022
	-0.5	-0.79	-0.59	-0.57
Electricity	0.0000159	0.0000199	0.0000011	0.0000067
	-0.93	-0.86	-0.04	-0.36
manufacturing	0.0027527	0.005825	0.0048234	0.0016056
	(1.99)**	(2.66)***	(1.93)*	-0.91
Services	0.0015528	0.0019112	0.0029825	
	-0.95	-0.93	-1.3	
pop_15_64	-0.0021331	0.0050181	0.0051097	0.0042992
	-0.61	-1.01	-0.85	-1.18
Trade	-0.000151	-0.0001412	0.0000265	-0.0000059
	-0.57	-0.33	-0.06	-0.02
tertiary_complete	-0.0060041	-0.0075014	-0.0053222	
	(1.84)*	-1.66	-1.14	
governance_index	0.049417	0.0602159	0.0781158	0.0623331
	(2.69)***	(1.85)*	(2.16)**	(2.29)**
Credit		-0.0000803	-0.0002875	-0.000202
		-0.22	-0.63	-0.48
Television		-0.0002637	-0.0003713	-0.0001709
		-1.26	-1.56	-0.92
urban_pop		0.0020009	0.0022787	
		-1.58	(1.83)*	
sec_complete		0.0027914	-0.0002308	0.0008905
		-1.52	-0.09	-0.42
free_mktx			0.0146812	
			-0.71	
trust_new			0.3293518	0.2205085
			(2.26)**	(2.01)**
Constant	0.2634246	-0.2415882	-0.1992987	0.0485416
	-1.17	-0.68	-0.44	-0.19
Conservative_new			-0.019715	
			-1.09	
Observations	183	154	154	154
R-squared	0.26	0.3	0.33	0.27

Robust t statistics in parentheses

** significant at 5%; *** significant at 1%

Table A-21: PCs Diffusion in Stage 3 & 4

	-1	-2	-3	-4
	PCs Growth	PCs Growth	PCs Growth	PCs Growth
ln_PCs_1	0.0187599	0.0038708	0.0200293	-0.0000977
	-1.14	-0.16	-0.55	0
GDP	-0.0000016	-0.0000013	-0.0000017	-0.0000013
	-1.1	-0.82	-0.98	-0.85
Electricity	-0.0000018	-0.0000021	-0.0000024	-0.0000018
	-1.65	-1.34	-1.42	-1.51
manufacturing	-0.0011913	-0.0005623	-0.0006876	
	-0.87	-0.33	-0.38	
Services	-0.0023616	-0.00159	-0.0012987	-0.0010089
	(2.19)**	-1.38	-1.05	-1.31
pop_15_64	0.001616	0.0012252	0.0009302	0.0014167
	-0.46	-0.33	-0.27	-0.39
Trade	-0.0001538	-0.0003015	-0.0003982	-0.0003
	(1.78)*	(2.16)**	(2.02)**	(2.20)**
tertiary_complete	-0.000556	0.0006326	0.0003427	
	-0.48	-0.45	-0.24	
governance_index	-0.0382403	-0.0196562	-0.0168485	-0.0157218
	(2.19)**	-0.94	-0.74	-0.78
Credit		0.000299	0.0002332	0.0003184
		(2.54)**	(1.71)*	(3.05)***
Television		-0.0001374	-0.0001351	-0.0001269
		(1.97)*	(1.86)*	(1.88)*
urban_pop		0.0002742	0.0004624	
		-0.35	-0.59	
sec_complete		0.0018762	0.00182	0.0018653
		(2.56)**	(2.03)**	(2.79)***
free_mktx			0.0003726	0.0028287
			-0.04	-0.43
Constant	0.2559536	0.220709	0.1532172	0.1842524
	-1.1	-0.88	-0.64	-0.74
Conservative_new			0.017149	
			-1.14	
trust_new			-0.0105024	
			-0.16	
Observations	154	129	129	130
R-squared	0.43	0.47	0.48	0.47

Robust t statistics in parentheses

** significant at 5%; *** significant at 1%

Table A-22: Aggregate Internet Use Drivers

	-1	-2	-3	-4
ln_internet_users_1	-0.2428512	-0.2717807	-0.2709946	-0.2484301
	(6.91)***	(6.54)***	(6.44)***	(6.46)***
GDP	-0.0000028	-0.0000012	-0.0000014	0.0000016
	-0.54	-0.2	-0.22	-0.26
Electricity	-0.0000005	0.0000045	0.0000036	-0.0000011
	-0.09	-0.76	-0.59	-0.19
manufacturing	0.0091645	0.0098605	0.0099444	
	(2.50)**	(2.43)**	(2.45)**	
Services	0.0054327	0.0052152	0.005313	0.0042312
	(1.91)*	(1.66)*	-1.61	-1.51
urban_pop	0.0034929	0.005395	0.0054389	
	(1.80)*	(2.55)**	(2.52)**	
Trade	-0.0005068	-0.0009191	-0.0009247	-0.0008005
	-1.19	-1.64	-1.6	-1.42
sec_complete	0.0024754	0.0024062	0.0022781	
	-1.2	-1.12	-0.86	
governance_index	0.1686295	0.167273	0.1670266	0.1986228
	(2.85)***	(2.53)**	(2.40)**	(2.98)***
Credit		0.0003352	0.0003452	0.0000672
		-0.68	-0.69	-0.13
Television		-0.0004012	-0.0004108	-0.0002834
		(1.93)*	(1.94)*	-1.33
pop_15_64		0.0208774	0.020732	0.0215622
		(2.91)***	(2.83)***	(3.01)***
tertiary_complete		-0.0004686	-0.0003633	0.0019475
		-0.1	-0.08	-0.4
free_mktx			0.00818	
			-0.37	
trust_new			0.0363942	0.0359856
			-0.17	-0.2
Conservative_new			-0.0010585	
			-0.04	
Constant	0.1319472	-1.1851815	-1.1844125	-0.4402439
	-0.69	(2.35)**	(2.20)**	-0.87
Observations	365	310	310	318
R-squared	0.44	0.49	0.49	0.46

Robust t statistics in parentheses

** significant at 5%; *** significant at 1%

Table A-23: Internet use drivers Stage 1 & 2

	-1	-2	-3	-4
ln_internet_users_1	-0.3421642	-0.3432867	-0.3681767	-0.3245605
	(7.31)***	(6.76)***	(6.72)***	(6.96)***
GDP	0.0000233	0.0000248	0.0000285	0.0000468
	-1.17	-1.15	-1.19	(2.49)**
Electricity	0.0000762	0.0000484	0.0000478	0.0000121
	-1.29	-0.91	-0.8	-0.25
manufacturing	-0.0018735	-0.0013621	-0.0005185	
	-0.26	-0.17	-0.06	
Services	0.0104909	0.0110957	0.012861	0.0100261
	(2.69)***	(2.54)**	(2.95)***	(2.48)**
urban_pop	0.0004952	0.002632	0.0030702	0.002073
	-0.16	-0.68	-0.77	-0.58
Trade	-0.002346	-0.0026246	-0.0026245	-0.0021359
	(2.05)**	(2.03)**	(1.98)**	(1.82)*
sec_complete	0.0029172	0.0013651	0.0006386	
	-0.53	-0.2	-0.09	
governance_index	0.252204	0.2507598	0.247603	0.2740535
	(2.67)***	(2.36)**	(2.26)**	(2.68)***
Credit		-0.0000987	0.0000094	-0.0000551
		-0.08	-0.01	-0.05
Television		-0.0004099	-0.0005567	-0.0001176
		-0.94	-1.19	-0.29
pop_15_64		0.0158597	0.0129421	
		-1.27	-1	
tertiary_complete		-0.0014557	0.002686	-0.0032959
		-0.14	-0.24	-0.3
free_mktx			0.0293928	
			-0.55	
trust_new			0.4104793	0.1613732
			-1.22	-0.51
Conservative_new			-0.0752014	
			-1.61	
Constant	0.5094463	-0.3548694	-0.3306856	0.3807779
	-1.48	-0.4	-0.37	-1.35
Observations	215	183	183	190
R-squared	0.44	0.47	0.48	0.46

Robust t statistics in parentheses

** significant at 5%; *** significant at 1%

Table A-24: Internet use in Stages 2 & 3

	-1	-2	-3	-4
ln_internet_users_1	-0.2990542	-0.291517	-0.2975341	-0.2788466
	(4.76)***	(4.04)***	(3.87)***	(3.67)***
GDP	-0.0000043	-0.0000041	-0.0000074	0.0000086
	-0.31	-0.26	-0.41	-0.61
Electricity	0.0000516	0.0000369	0.0000473	0.0000204
	-1.1	-0.71	-0.62	-0.45
manufacturing	0.0060545	0.011822	0.0123148	
	-1.19	(1.79)*	-1.65	
Services	0.001747	0.0011696	0.0026281	-0.0028952
	-0.41	-0.24	-0.49	-0.61
urban_pop	0.0040071	0.009926	0.0100381	0.0057079
	-1.38	(2.32)**	(2.31)**	(1.72)*
Trade	-0.0003329	-0.000923	-0.0010618	-0.0007708
	-0.36	-0.71	-0.8	-0.66
sec_complete	0.0025277	0.0044206	0.0038071	
	-0.45	-0.67	-0.42	
governance_index	0.2175238	0.2426182	0.2721257	0.2587673
	(2.25)**	(1.94)*	(1.99)**	(2.23)**
Credit		0.0004346	0.0004952	0.0002565
		-0.38	-0.46	-0.23
Television		-0.0011221	-0.0014199	-0.0005874
		(2.24)**	(2.46)**	-1.26
pop_15_64		0.0292127	0.027092	
		-1.61	-1.45	
tertiary_complete		-0.0066874	-0.0079695	-0.0092933
		-0.75	-0.8	-1.06
free_mktx			-0.0117094	
			-0.19	
trust_new			0.2090404	-0.0285476
			-0.45	-0.08
Conservative_new			-0.0425958	
			-0.7	
Constant	0.8048616	-1.3419055	-1.2614002	0.9219113
	(1.92)*	-1.13	-0.91	(2.84)***
Observations	179	150	150	155
R-squared	0.42	0.49	0.5	0.45

Robust t statistics in parentheses

** significant at 5%; *** significant at 1%

Table A-25: Internet use in Stage 3 &4

	-1	-2	-3	-4
ln_internet_users_1	-0.2108722	-0.2498362	-0.2768268	-0.2369482
	(4.73)***	(3.82)***	(4.13)***	(3.82)***
GDP	-0.0000061	-0.0000065	-0.0000082	-0.0000042
	-1.51	-1.01	-1.28	-0.7
Electricity	-0.0000013	0.0000033	0.0000034	-0.000003
	-0.29	-0.52	-0.54	-0.47
manufacturing	0.0076245	0.0100083	0.0104318	
	-1.4	-1.56	-1.6	
Services	-0.0001473	-0.0012467	-0.0001258	-0.0044347
	-0.03	-0.22	-0.02	-1.17
urban_pop	0.004021	0.0058048	0.0065704	0.0043476
	(2.03)**	(2.72)***	(2.89)***	(2.13)**
Trade	-0.0003735	-0.0003284	-0.000482	-0.0002428
	-1.29	-0.76	-0.97	-0.6
sec_complete	0.00067	0.0008647	0.000278	
	-0.36	-0.4	-0.1	
governance_index	0.0635884	0.0748542	0.1015298	0.074174
	-1.07	-0.98	-1.25	-0.98
Credit		0.0003162	0.0002732	-0.0000436
		-0.52	-0.43	-0.08
Television		-0.0000926	-0.0000476	-0.0001088
		-0.42	-0.22	-0.51
pop_15_64		0.0119003	0.0153815	
		-0.95	-1.13	
tertiary_complete		0.0016243	0.0009714	0.0047868
		-0.31	-0.18	-0.92
free_mktx			0.028728	
			-1.3	
trust_new			0.1243622	-0.0138757
			-0.47	-0.09
Constant	0.9125605	0.0274425	-0.2588486	1.2221507
	(2.13)**	-0.04	-0.3	(5.40)***
Conservative_new			0.0412789	
			-1.08	
Observations	150	127	127	128
R-squared	0.47	0.52	0.53	0.5
Robust t statistics in parentheses				
** significant at 5%; *** significant at 1%				

Table A-26: Aggregate mobile phones drivers

	-1	-2	-3	-4
ln_mobile_phones_1	-0.1522056	-0.1770114	-0.1760174	-0.137742
	(5.47)***	(5.06)***	(4.81)***	(4.35)***
GDP	-0.0000125	-0.0000153	-0.0000169	-0.0000143
	(2.64)***	(2.69)***	(2.88)***	(2.43)**
Electricity	0.0000012	0.0000057	0.0000022	-0.0000033
	-0.25	-0.96	-0.35	-0.7
manufacturing	0.0068538	0.0112936	0.0123586	0.0084833
	-1.56	(2.06)**	(2.31)**	(1.90)*
Services	0.0057281	0.0075327	0.0071198	
	-1.39	-1.37	-1.24	
urban_pop	0.0024815	0.0039599	0.0042797	0.0040298
	-1.2	-1.61	(1.72)*	(1.71)*
Trade	0.0008338	0.0009652	0.0010068	0.0009885
	(2.36)**	(1.67)*	(1.72)*	(1.76)*
sec_complete	0.0006477	0.0007109	0.0012147	
	-0.33	-0.32	-0.47	
governance_index	0.0281704	0.0120275	0.0192143	0.0536206
	-0.56	-0.19	-0.31	-0.84
Credit		-0.0001716	0.0000449	0.0000519
		-0.41	-0.1	-0.12
Television		0.0000932	0.0000362	0.0001514
		-0.43	-0.16	-0.68
pop_15_64		0.0101306	0.0070046	
		-1.35	-0.87	
tertiary_complete		-0.0013083	-0.0022067	0.0011332
		-0.27	-0.47	-0.26
free_mktx			0.0459164	0.0436298
			(1.77)*	(1.88)*
Constant	0.0728378	-0.6962841	-0.4202637	0.3116274
	-0.3	-1.31	-0.67	(2.05)**
Conservative_new			-0.0350968	
			-1.4	
trust_new			-0.0144723	
			-0.07	
Observations	377	315	315	315
R-squared	0.4	0.4	0.41	0.39

Robust t statistics in parentheses

** significant at 5%; *** significant at 1%

Table A-27: Mobile phones drivers in stage 1 &2

	-1	-2	-3	-4	-5
ln_mobile_phones_1	-0.1824203	-0.1944149	-0.2054504	-0.1658936	-0.1836316
	(5.37)***	(4.91)***	(4.64)***	(3.86)***	(4.29)***
GDP	-0.0000161	-0.0000279	-0.0000056	-0.0000125	-0.0000247
	-0.85	-1.31	-0.22	-0.55	-1.14
Electricity	0.0000706	0.0000584	0.0000186	0.0000379	0.0000732
	(1.82)*	-1.17	-0.34	-0.7	-1.48
manufacturing	0.0212225	0.0310367	0.0315045	0.0299102	0.030393
	(2.56)**	(3.22)***	(3.32)***	(3.03)***	(3.08)***
Services	0.0050372	0.0068689	0.0080202		
	-0.99	-0.96	-1.12		
urban_pop	0.002837	0.004617	0.004793	0.0037351	0.0044206
	-0.86	-0.94	-0.96	-0.78	-0.89
Trade	0.0032899	0.0038188	0.0037965	0.0038661	0.0038705
	(2.41)**	(2.23)**	(2.27)**	(2.33)**	(2.31)**
sec_complete	-0.0012102	0.0029227	0.0026717		
	-0.22	-0.43	-0.39		
governance_index	-0.0420356	-0.0445041	-0.0400963	0.0107502	-0.010322
	-0.44	-0.36	-0.34	-0.09	-0.08
Credit		-0.0013507	-0.0009297	-0.0009622	-0.0007809
		-0.97	-0.64	-0.75	-0.58
Television		0.0002123	0.0000197	0.0002888	0.0002936
		-0.47	-0.04	-0.69	-0.69
pop_15_64		0.0091295	-0.0022615		
		-0.77	-0.16		
tertiary_complete		-0.0014332	0.0048908	0.0051356	0.0036295
		-0.15	-0.48	-0.57	-0.4
free_mktx			0.1242107	0.0577424	
			(1.87)*	-1.23	
Conservative_new			-0.1051606		-0.0211092
			(2.03)**		-0.55
trust_new			0.427418		
			-1.3		
Constant	-0.3317285	-0.8152363	-0.3015977	-0.2075331	-0.2619092
	-1.07	-1.03	-0.35	-0.68	-0.85
Observations	223	186	186	186	186
R-squared	0.35	0.36	0.37	0.35	0.35

Robust t statistics in parentheses

** significant at 5%; *** significant at 1%

Table A-28: Mobile phone drivers in Stages 2 and 3

	-1	-2	-3	-4
	Mobile Phones Growth	Mobile Phones Growth	Mobile Phones Growth	Mobile Phones Growth
ln_mobile_phones_1	-0.234819	-0.2530838	-0.2654508	-0.2147873
	(5.71)***	(6.06)***	(6.74)***	(5.20)***
GDP	-0.00002	-0.0000255	-0.0000133	-0.0000067
	(2.10)**	(1.92)*	-0.94	-0.58
Electricity	0.000075	0.0000287	-0.0000113	-0.0000444
	(2.11)**	-0.56	-0.19	-0.91
manufacturing	0.0057634	0.011734	0.0074644	
	-1.03	(1.67)*	-1.01	
Services	0.0063012	0.0083614	0.0037381	0.0018922
	-1.55	(1.78)*	-0.73	-0.53
urban_pop	0.0011042	0.00406	0.0042491	0.002242
	-0.45	-1.22	-1.27	-0.86
Trade	0.0006017	0.0014455	0.0012469	0.0015566
	-1.01	-1.42	-1.23	(1.71)*
sec_complete	0.0019362	0.0066069	0.0051304	
	-0.46	-1.24	-0.86	
governance_index	0.041047	0.0092486	0.0477538	0.1023067
	-0.77	-0.11	-0.51	-1.44
Credit		-0.0009702	0.0003838	-0.001047
		-1.05	-0.37	-1.13
Television		0.0005044	0.0005049	0.0003962
		-1.15	-1.03	-1.15
pop_15_64		0.0087375	-0.0088311	
		-0.55	-0.51	
tertiary_complete		-0.0081432	-0.0055059	-0.0062239
		-0.97	-0.65	-0.76
free_mktx			0.0942143	0.0766751
			(1.95)*	(2.33)**
Conservative_new			-0.0745167	
			(1.68)*	
trust_new			-0.1829606	
			-0.67	
Constant	0.551883	-0.8241367	1.2183981	1.3968951
	-1.47	-0.73	-0.86	(4.69)***
Observations	190	156	156	161
R-squared	0.49	0.5	0.52	0.48

Robust t statistics in parentheses

** significant at 5%; *** significant at 1%

Table A-29: Mobile phone drivers in Stage 3 &4

	-1	-2	-3	-4
ln_mobile_phones_1	-0.1359985	-0.1625114	-0.1587517	-0.1266948
	(3.23)***	(2.62)***	(2.68)***	(2.53)**
GDP	-0.0000058	-0.0000038	-0.0000038	-0.0000026
	(1.99)**	-0.95	-0.92	-0.68
Electricity	-0.0000085	-0.0000052	-0.0000055	-0.0000085
	(2.58)**	-1.02	-1.14	(2.80)***
manufacturing	-0.0043572	-0.0028651	-0.0036029	
	-1.37	-0.79	-0.94	
Services	-0.0038271	-0.0051158	-0.0069096	-0.0019966
	-1.25	(1.82)*	(2.33)**	-0.81
urban_pop	0.0036043	0.0043106	0.0040544	0.0046253
	(2.67)***	(2.63)***	(2.25)**	(2.85)***
Trade	0.0000633	-0.0001618	0.0000388	-0.0002633
	-0.32	-0.45	-0.09	-0.79
sec_complete	0.0005657	0.0001835	0.0011768	
	-0.46	-0.12	-0.58	
governance_index	-0.0453774	-0.0564762	-0.0593007	-0.0572491
	-1.33	-1.3	-1.19	-1.25
Credit		-0.0003517	-0.0001995	-0.0006021
		-1.06	-0.57	-1.47
Television		-0.0000356	-0.0000463	-0.0001262
		-0.19	-0.25	-0.79
pop_15_64		0.0221182	0.0174203	
		(1.85)*	-1.41	
tertiary_complete		-0.0044925	-0.0046836	-0.0028117
		-1.44	-1.4	-0.8
free_mktx			0.0030285	0.0083523
			-0.16	-0.5
Conservative_new			-0.0407737	
			-1.16	
trust_new			-0.1636659	
			-0.84	
Constant	1.2017897	-0.1326019	0.410791	0.8602534
	(4.61)***	-0.21	-0.58	(3.22)***
Observations	154	129	129	130
R-squared	0.63	0.64	0.64	0.62

Robust t statistics in parentheses

** significant at 5%; *** significant at 1%

Table A-30: Aggregate telephones drivers

	-1	-2	-3	-4
ln_telephones_1	-0.0126785	-0.0404855	-0.037775	-0.0361774
	-1.44	(3.22)***	(2.94)***	(3.47)***
GDP	0.0000013	-0.0000005	-0.0000003	-0.0000017
	-1.2	-0.42	-0.23	-1.48
Electricity	-0.0000016	0.0000003	-0.0000007	-0.0000014
	(1.94)*	-0.26	-0.52	-1.24
manufacturing	0.0002436	0.0008729	0.0006158	
	-0.31	-0.93	-0.69	
Services	-0.0009155	-0.000363	0.0001061	-0.0007113
	-1.55	-0.54	-0.17	-1.24
urban_pop	-0.0007739	-0.0006705	-0.000715	
	(2.31)**	-1.59	(1.74)*	
Trade	-0.0002669	-0.0000928	-0.0001069	-0.0001143
	(3.18)***	-0.9	-1.05	-1.14
sec_complete	-0.0004262	-0.0001621	-0.0007963	
	-1.04	-0.34	-1.62	
governance_index	0.0100801	-0.0010654	-0.0061761	0.0000999
	-0.98	-0.09	-0.53	-0.01
R7	-0.0426907	-0.0186323	0.0031223	0.014171
	-1.62	-0.61	-0.1	-0.41
Credit		-0.0000173	-0.0000773	0.0000192
		-0.15	-0.66	-0.17
Television		0.0001712	0.000162	0.0001346
		(2.68)***	(2.44)**	(2.22)**
pop_15_64		0.0059676	0.0068439	0.0063974
		(3.10)***	(3.57)***	(3.36)***
tertiary_complete		-0.0027196	-0.0019327	-0.0021529
		(2.76)***	(1.96)*	(2.18)**
free_mktx			-0.0004481	
			-0.1	
trust_new			0.1202189	0.0918821
			(3.24)***	(2.70)***
Conservative_new			0.008948	
			-1.44	
Constant	0.2107184	-0.1176129	-0.2397821	-0.1925059
	(4.97)***	-0.99	(1.96)*	-1.63
Observations	381	320	320	329
R-squared	0.27	0.33	0.36	0.32

Robust t statistics in parentheses ** significant at 5%; *** significant at 1%

Table A-31: Telephones stages 1 & 2

	-1	-2	-3	-4
ln_telephones_1	0.0130823	-0.0213361	-0.0159608	-0.0279466
	-0.92	-1.16	-0.73	(2.08)**
GDP	0.0000017	-0.0000049	0.0000012	-0.0000035
	-0.43	-1.2	-0.26	-0.9
Electricity	-0.0000213	-0.0000313	-0.0000416	-0.0000336
	(2.04)**	(2.68)***	(3.27)***	(3.41)***
manufacturing	-0.0012702	-0.0007806	-0.0012222	
	-0.85	-0.42	-0.66	
Services	-0.0017641	-0.0009996	-0.000563	-0.0005434
	(2.21)**	-0.98	-0.58	-0.63
urban_pop	-0.0011884	-0.0010226	-0.0013005	
	(2.31)**	-1.51	(1.96)*	
Trade	-0.0007245	-0.0004521	-0.000362	-0.0002894
	(3.21)***	(1.81)*	-1.33	-1.12
sec_complete	-0.000465	0.0014145	0.0008187	
	-0.35	-0.8	-0.5	
governance_index	0.034471	0.0202028	0.0171051	0.0067353
	(2.04)**	-0.92	-0.76	-0.36
Credit		0.0001181	-0.000009	0.0001988
		-0.35	-0.03	-0.79
Television		0.0003944	0.0004085	0.0003856
		(2.89)***	(3.01)***	(3.26)***
pop_15_64		0.0053996	0.0049506	0.0059847
		(1.76)*	-1.53	(1.97)*
tertiary_complete		-0.0015548	0.000233	-0.0001095
		-0.77	-0.11	-0.06
free_mktx			0.005226	
			-0.56	
trust_new			0.1685315	0.1852223
			(2.22)**	(2.97)***
Conservative_new			0.0115682	
			-0.93	
Constant	0.3039493	-0.1582223	-0.2192253	-0.3100174
	(4.20)***	-0.72	-0.95	-1.56
Observations	228	191	191	199
R-squared	0.28	0.35	0.39	0.37

Robust t statistics in parentheses

** significant at 5%; *** significant at 1%

Table A-32: Telephone drivers in Stage 2&3

	-1	-2	-3	-4
ln_telephones_1	-0.0348919	-0.0620326	-0.0564014	-0.0726945
	(2.36)**	(3.83)***	(3.40)***	(5.07)***
GDP	0.0000018	-0.0000013	-0.0000024	-0.0000007
	-0.88	-0.54	-0.92	-0.34
Electricity	0.00001	0.0000059	0	-0.0000004
	-1	-0.48	0	-0.03
manufacturing	0.0010146	0.0035121	0.0035609	
	-0.92	(2.52)**	(2.47)**	
Services	-0.0003317	0.0015433	0.0024387	0.0008383
	-0.4	-1.58	(2.46)**	-1.16
urban_pop	-0.0005869	-0.0000309	0.0000935	
	-1.12	-0.05	-0.16	
Trade	-0.000643	-0.0004215	-0.0003347	-0.0003044
	(4.07)***	(1.93)*	-1.55	-1.45
sec_complete	0.0001982	0.0019777	0.0010158	
	-0.19	-1.65	-0.81	
governance_index	0.027676	0.0208891	0.0168817	0.0296256
	(2.93)***	-1.5	-1.07	(2.49)**
Credit		-0.0001971	-0.0004848	-0.0003459
		-0.84	(2.10)**	-1.58
Television		0.0000411	0.0000844	0.000046
		-0.45	-0.9	-0.59
pop_15_64		0.0047792	0.0076591	0.004839
		(1.84)*	(2.72)***	(2.17)**
tertiary_complete		-0.0070766	-0.0060131	-0.0058204
		(3.74)***	(3.13)***	(3.44)***
free_mktx			-0.0015196	
			-0.18	
trust_new			0.1097435	0.1508565
			(1.71)*	(2.94)***
Constant	0.1292796	-0.0490734	-0.3295835	0.0322896
	-1.52	-0.26	-1.56	-0.22
Conservative_new			0.0147249	
			-1.62	
Observations	191	158	158	163
R-squared	0.37	0.46	0.49	0.45

Robust t statistics in parentheses

** significant at 5%; *** significant at 1%

Table A-33: Telephone drivers in stages 3 & 4

	-1	-2	-3	-4
ln_telephones_1	-0.0534356	-0.0698636	-0.0656465	-0.0622537
	(2.19)**	(2.85)***	(2.56)**	(2.66)***
GDP	0.000001	0.000002	0.000002	0.000002
	-1.1	(2.03)**	(1.87)*	(2.12)**
Electricity	0.0000002	0.0000003	0.0000003	0.0000005
	-0.26	-0.29	-0.31	-0.56
manufacturing	0.0002095	-0.0000671	0.0000665	
	-0.25	-0.09	-0.09	
Services	0.0004124	0.0005125	0.000732	0.0004772
	-0.55	-0.72	-1.05	-1.05
urban_pop	0.0001389	0.0002076	0.0002558	
	-0.35	-0.5	-0.58	
Trade	-0.0001155	-0.0001671	-0.000197	-0.0001447
	(2.17)**	(2.68)***	(2.48)**	(2.54)**
sec_complete	0.000066	0.0004277	0.0003486	
	-0.21	-1.22	-0.77	
governance_index	-0.0017136	0.0034722	0.0046139	-0.0008036
	-0.21	-0.35	-0.39	-0.09
Credit		-0.0000453	-0.0000739	-0.0000336
		-0.65	-0.98	-0.48
Television		-0.0000466	-0.0000452	-0.000032
		-1.55	-1.5	-1.09
pop_15_64		0.0025181	0.0027736	0.0032617
		-1.29	-1.38	-1.6
tertiary_complete		0.0001413	0.000164	-0.0001243
		-0.19	-0.22	-0.17
free_mktx			-0.0003541	
			-0.08	
trust_new			0.010121	0.0217013
			-0.33	-0.99
Conservative_new			0.0064598	
			-0.81	
Constant	0.3081053	0.2125285	0.1541118	0.1411163
	(2.54)**	-1.64	-1.06	-1.29
Observations	153	129	129	130
R-squared	0.28	0.37	0.37	0.37

Robust t statistics in parentheses

** significant at 5%; *** significant at 1%