TECHNOLOGY ADOPTION AND THE ROLE OF GOVERNMENT:
Examining the National Information and Communication Technology Policies in Developing Countries

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Abstract

Nicholas C. Maynard: Technology Adoption and the Role of Government: Examining the National Information and Communication Technology Policies in Developing Countries

(Under the direction of Michael Luger, Harvey Goldstein, Sudanshu Handa, Nichola Lowe, and Gunther Maier)

With this dissertation, I seek to provide an in-depth understanding of the role developing country governments can play in accelerating ICT adoption. By analyzing the institutional, technology, and market factors, this study seeks to provide a solid foundation for examining the design and implementation of successful ICT strategies. This research uses a combination of empirical and case study evidence to highlight the key challenges of reforming ICT policies and institutions within developing countries. Further, this study clarifies the role of national governments in sponsoring and promoting ICT access and usage.

Currently, there is a growing disparity between those developing countries that have successfully integrated ICTs into their economies and those that have not. Many developing countries have created national ICT policies and institutions to bolster technological deployment with the goal of supporting productivity gains and new business development. However, for many countries, these initiatives have not translated to higher levels of ICT adoption or improved economic development. This has left developing country governments with a great deal of uncertainty over what policies to implement and which initiatives to fund.

The case study analysis within this study has identified several key barriers to accelerating ICT adoption within developing countries. These barriers include a lack of

affordable services, low levels of local expertise, and poor infrastructure, which combine to prevent latecomer countries from developing self-sustaining demand within the sector. This study's results suggest that the critical determinant for overcoming these barriers is a high level of government involvement after ICT market privatization.

Those developing countries with accelerated growth in their ICT sectors tend to have institutions capable of adapting their policies and institutions to the rapid pace technological and market evolution. This is also confirmed by my empirical research, which showed a positive and significant relationship between ICT institutions and levels of ICT adoption, while controlling for economic and social factors. In contrast, those developing country governments without an active role in regulating ICT competition or supporting ICT adoption and innovation have been unable to sustain rapid growth of their sector.

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I would like to dedicate this dissertation to the memory of my father, Charles Maynard. He provided me with the strength to see this effort through to the end – without losing the sense of curiosity and excitement that I possessed at the beginning.

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Section 1: Introduction

Research Problem and Hypothesis

The creation of an information and communications technology sector has become a key component of a country's economic development process, along similar lines to infrastructure sectors such as transportation, power or water. However, ICTs are different from these other infrastructure services due to the rapidly evolving technology and ability to easily share assets across operators; making the sector markedly different from other infrastructure. These differences allow the ICT market to become more competitive than these other infrastructure sectors and therefore more appropriate for private sector ownership rather than public sector monopoly. Despite this shift from a government ownership, the state must continue to play a vital role in the diffusion of ICT adoption and supporting innovation within the sector. Those developing countries without a strong role for the state are typically unable to leverage their latecomer advantages to accelerate their ICT adoption. Instead, this emergence of private sector ownership should lead to a more complex relationship between the government and the sector that includes an active balancing market competition through ICT regulation. This role of the state should also include striving to attain rates of ICT adoption and utilization similar to those achieved in advanced economies while coordinating public-private-academic efforts to support R&D initiatives.

Many developing country governments have attempted to bolster their markets through a wide range of policies only to see them fail, while a large number of developing countries have yet to even begin the process. Despite these risks, there are a number of developing countries that have successfully initiated and sustained a rapid ICT adoption rate. While there is no single approach to successfully accelerating ICT deployments within developing countries, there are a number of commonalities across these successful developing countries. These include policy and institutional reforms that are focused on remaking the ICT sector by opening the market to new operators, investment, and technologies. These national institutional and policy reforms are vital to diffusing ICT adoption across a population, creating economic benefits for a larger share of the developing country.

To help ensure that these ICT investments translate into diffused economic benefits, developing country governments have designed their ICT policies within the larger context of their economic development efforts. This ensures that those technologies adopted by the developing countries are the most appropriate to the local context and economic needs of the population. These difficult technology choices require a coordinated effort by the government, ICT sector, and the target population to determine the appropriate ICT goals and policies.

The research approach is broken into four sections described below, with each focused on the proper role of the state in the development, deployment, and usage of ICTs. This dissertation hopes to answer the following key questions:

- How does the state's role evolve as a developing country transitions toward a more advanced ICT sector and overall economy?
- What are the determinants for the successful implementation of a national ICT policy within developing countries?
- What are the major impediments facing developing countries as they attempt to accelerate the adoption and utilization of ICTs?

To understand the ICT policy choices of national governments, it is first important to note three major trends identified by the literature within the telecommunications sector. The first is the development of mobile and Internet technologies in addition to fixed line telephony (Baliamoune-Lutz, 2003). The second shift is the global trend away from monopoly operators to competitive carriers across these fixed, mobile, and Internet technologies (Wilson, 2003). The third shift under way is from governmental control to private ownership, or a mix of public and private with independent regulatory agencies (Levy, 1994). Steinmuller suggests that ICTs, which can lower transaction costs, may be able to offer developing countries a conduit for avoiding stages that require high levels of capital and fixed asset concentration, as defined by Rostow's "stages of development" (Rostow, 1960), and moving directly to a knowledge-based economy (Steinmueller, 2001). As a result, many developing countries now view these technologies as an important conduit to fostering both productivity gains (McGuckin, 1998; Baumol, 1998) and economic development (Saunders, 1994).

This research examines the evolving role in the ICT sector for developing country governments within the context of the technological, institutional, and market factors described above. Previous efforts have focused heavily on a single factor or country when assessing the role of the state in bolstering ICT adoption. An approach that focuses on a single factor will face severe explanatory limitations due to the extensive interaction across these factors. A singular focus on technology ignores the challenges of the developing a competitive market and the necessary institutional structure. At the same time, examining only the institutional factors may miss key technological changes such as the introduction of wireless and the Internet, which have completely remade the government's role within the market.

Similarly, studies that focus on a single country are useful, but will miss the commonalities across developing countries in their advancement of ICT adoption and utilization. Within the ICT sector, most developing countries must adhere to technological and institutional gating factors in the development of their ICT market and industry. In addition, national statistics and empirical studies alone cannot discern the key institutional mechanisms behind a government's successful effort to bolster ICT adoption and utilization within a developing country. This dissertation will overcome these limitations by using a combination of methodologies, including cross-country empirical and case study analyses, to highlight the technological, economic, and political determinants of successful national ICT strategies.

Methodology and Contribution to the Literature

The goal of this research is to build a cohesive understanding of national ICT policies in developing countries, which integrates the existing literature with my own primary research on the role of governmental ICT institutions and policies directed at supporting rapid adoption. This study's generalizability is strengthened by creating a national ICT policy framework for developing countries and using this framework as a foundation for both the statistical regression and the case study analysis – weaving these two methodologies together to examine the determinants of successful ICT strategies. My research uses a combination of secondary data from international sources on ICTs and extensive primary sources to develop a framework outlining the stages of ICT adoption, a global regression model, and an in-depth case study analysis of Malaysia and Thailand.

The framework that describes the five stages of ICT development provides a new way of examining ICT adoption in developing countries. There are few examples in the literature of this approach, where the goal is to highlight the commonalities and themes of the governmental, market, and technological stages across developing countries – describing in great detail the evolutionary reform process that must be completed by national governments (Milne, 1998). This section offers both the quantitative and the qualitative metrics for understanding the evolution of ICT policies, markets, institutions, and infrastructure within countries. Rather than focusing on a single metric, or gating factor, it is important to understand how these four factors evolve in concert – interacting with one another to either accelerate or hamper ICT adoption rates within a country.

To create a strong delineation between stages, the framework employs several key metrics that are based on an extensive literature review with numerous country examples. These metrics include both quantitative and qualitative metrics to understand the adoption process through the institutional, market, and policy factors. For the quantitative factors in particular, the five stages are delineated using the trajectories of the country examples as well as the infrastructure requirements of expanding the national network to connect the population included within each stage of adoption. These network infrastructure requirements are common across developing countries, resulting in similar patterns of adoption despite the wide variation of technologic, economic, and political factors within these countries. These five stages also provide a framework for examining the outputs of the cross-national regression model and the case studies, offering a new context for understanding the commonalities of the ICT adoption process across developing countries.

The cross-national model provides empirical support to the argument that institutions and policies play a vital role in accelerating ICT adoption. It is important to examine both economic and policy variables in combination when assessing the variation in adoption rates. Previous studies of the disparity in ICT adoption have predominately focused on economic factors, overstating the connection between high-income levels and ICT adoption rates. This study expands on current research by including institutional indicators in addition to economic and infrastructure trends to understand those critical factors that have led to higher ICT adoption rates.

The variables within the global model are based on the New Economic Growth theory and New Institutional Economics to determine the key explanatory and control variables. This model expands the institutional factors included in global regression models to more fully capture the role of the state in ICT adoption, while also highlighting the limitations of national statistics, for institutional effectiveness and ICT adoption. The institutional variables include privatization of the state-owned telecommunications monopoly and the creation of an independent regulatory agency. The explanatory power of these variables is inherently limited because there is no way to consistently and thoroughly quantify the effectiveness of national ICT institutions across countries. By relying on national statistics, this model is a broad tool and cannot account for the design and implementation of ICT policy and institutional reforms, which is critical to successfully initiating and sustaining rapid ICT adoption. This requires a combined effort of empirical research along with case study analysis to define the critical success factors within the stages of ICT adoption.

The case study research is divided into two sections. The first focuses on ICT adoption and regulation as the foundation of all other governmental ICT efforts, while the second section examines government support for bolstering ICT utilization. Both of these sections focus on Thailand and Malaysia. Therefore, the generalizability of these case studies is limited to middle-income countries because low-income countries face a different set of institutional and technological challenges. For countries that have begun their privatization and regulatory reform process, it is not enough to simply create a new regulator and sell off the state-owned incumbent. National governments must ensure that these market and regulatory reforms are designed and implemented based on international best practices that demand transparency, organizational restructuring, evaluation and monitoring, and proper budgeting – which are designed to ensure that the market power of the incumbent monopoly is well balanced in the newly competitive market.

Without these efforts, the incumbent is likely to continue its dominance of the market, driving prices higher and hampering network infrastructure deployment. In the first case study section, this continuing market power of the incumbent can be seen vividly within Thailand, which has implemented both privatization and regulatory reforms without proper organizational or political controls. This has left the country with a stagnating ICT market while its neighbors continue to experience rapid ICT adoption.

The second case study section shifts focus to the ICT institutional reform efforts in Malaysia and Thailand as these countries seek to expand their levels of ICT integration into the economy. The development of a domestic ICT industry within a developing country requires the creation of specialized institutions that carefully coordinate their initiatives with the private sector. My case study research shows that this institutional and policy reform process is directly influenced by cross-border activities, as countries seek to match their regional peers for ICT development. This effort to support ICT utilization requires governments to rapidly alter their policy goals and initiatives in response to shifts in technologies, global market demand, international investment, and local workforce capabilities.

Few countries have successfully managed this reform process, particularly over the long term. Malaysia has experienced significant challenges because it initiated its domestic efforts to bolster the ICT industry in the 1990s. However, my case study research suggests that the country has benefited enormously from coordinated efforts by the public and private sectors to adapt international technologies to the local environment. Thailand has also made significant progress over the past five years, adopting many of the same policies and institutional reform efforts as Malaysia according to case study interviewees. Yet the country has lagged behind in its development of a local ICT industry. Although the ICT utilization efforts are supported by similar institutions and policies in both countries, only Malaysia has successfully funded, implemented, and evaluated these efforts.

Current ICT research focuses heavily on economic and market factors behind ICT adoption and utilization, and its impact on economic growth. Many of these studies have found significant benefits to developed countries of the Organization of Economic Co-operation and Development (OECD) and Newly Industrialized Economies (NIEs), but have not been able to conclusively demonstrate a correlation between ICT investment and economic growth in developing countries (Wilson, 2003). Rather than working to quantify the impact ICTs have on macroeconomic conditions, this research focuses on the process through which policies to support ICT adoption are successfully implemented across a range of emerging economies. This research aims to demonstrate the important role the state plays in improving ICT adoption rates across developing countries and the benefit these technologies have on the economic development process (James, 2003). To accomplish this, it is necessary to understand the economic and institutional theory base within economic development literature prior to examining technology policy development and implementation. The methodology for my dissertation is discussed below in conjunction with the theory base – with the goal of offering a framework for understanding how countries progress through stages of ICT development and how ICT adoption can benefit the country at each stage (North, 1992; Pierson, 2004; Ranis, 1989; Sengupta, 1993; Zysman, 1994).

Methodology

In completing this study, I used three research methods to gain a deeper understanding of the ICT adoption rates and policies of developing countries. The first section develops a policy framework for understanding the various categories of national ICT strategies. The second section of the study, the statistical model, examines the relationship between government institutional and policy changes and ICT adoption while controlling for economic and social factors outlined in the new economic growth theory. To understand the design and implementation process of these ICT policies, the third section of the research study includes two case study countries: Malaysia and Thailand. Using primary research, these cases explore the economic and political factors that support or hinder national ICT policy implementation. This section relies on the primary research and secondary policy sources to analyze national ICT policies of developing countries while assessing their potential for accelerating ICT adoption. Together, these four sections offer insight into national ICT adoption rates and policies – seeking to target an under-explored area within the current literature.

Section 2: ICT Analytical Framework

This section uses New Institutional Economics, which is outlined below, as the foundation for creating the national technology trajectories specific to ICT adoption within developing countries. This is a new approach to understanding the key determinants of ICT adoption within technological, institutional, market, and policy factors. This section offers a contribution to the literature by applying these trajectories to a single technology sector rather than an economy as a whole and by focusing on institutions and policies as the key metrics for delineating the five stages.

Literature Review

New Institutional Economics describes a unique institutional structure and technological specialization within countries that determine the national trajectory of development and a country's ability to operate at the frontier of innovation. The government, as the actor for innovation, supports capital investment in developing technologies and knowledge in a given specialization within the rules created by the institutional structure. Through the sunk costs and high cost of reversal, this investment locks in a technological commitment for the country. As investment, knowledge, and institutional rules evolve over time, these countries have a competitive advantage over other countries that are not choosing the same technologies and playing by the same rules. While not without flaws, institutionalism in combination with endogenous growth theory gives a solid foundation for understanding both development and technological change within countries.

Several key political and economic factors have a direct influence on ICT adoption, including institutional development, market liberalization, and socio-economic development. Using the theory base of technological trajectories and path dependency created by John Zysman, Douglas North, and Paul Pierson, this research focuses on the institutional development of the national structures within developing countries that choose and support technology investments.

New Institutional Economics uses the economics theory of scarcity as its foundation, but then adds institutions and transaction costs as further limits on an actor's choices (North, 1992). Countries with weak institutions have higher transaction costs and therefore inefficient markets. One of the more prominent theories has been put forth by John Zysman (1983), who suggests that there is no single form of capitalism that works for all countries. Rather, each development success story is determined by the institutional frameworks responsible for choosing and supporting technological adoption within the market. Zysman argues that countries need to develop a technological specialty and that through this specialization a country will be able to develop a global trade niche. Zysman later argued that these technological, firm-level, and institutional factors will influence how the historical trajectories of a country's economic and technological development will evolve (Zysman, 1994). These trajectories are shaped by the historically rooted national institutions that channel the investment choices of individuals and firms.

Building on the notion of these national trajectories, North (1994) argues that an analytical framework is needed to understand the changing dynamics of economic performance across time. North also suggests that neoclassical economics is not suited to understanding economic development because it is only concerned with market operation and not market development and does not account for time or institutions. He then suggests that when applied to developmental issues, new economic growth theory focuses on the technology and human capital investment but fails to include the incentive structure within institutions.

Economic and political institutions develop the incentive structure within an economy and as such are the determinants of that country's economic success (North, 1994). These institutions include the formal and informal structures to regulate human interactions and become legitimized by the societal norms of a given country – as a result, changing only slowly over time. Due to these institutional and cultural constraints, North argues that transferring formal structures of Western countries will not be sufficient for improving economic performance in developing countries globally.

Within this framework of path dependence, Pierson argues that the sequencing of events is another key factor for institutional development (Pierson, 2004). Similar to the sunk costs of technology choices, early decisions made by political actors have a larger influence on the institutional structure that is created. These actors are able to consolidate power and resources, giving them the opportunity to set the "rules of the game" to increase their advantage and sustain it.

As Pierson points out, individual reforms or institutional structures operate within an environment that constantly shifts over time (Pierson, 2004). The most effective sequencing of policies and reforms supporting national technological efforts varies widely across countries, forcing governments to determine the most appropriate technological trajectory that can lead to accelerated economic growth. In terms of Zysman's national technology institutions, these technology structures may not be suitable until a country has reached a certain level of development within the national trajectory – low-income countries may find it more beneficial to focus on other areas of development, such as health and education, rather than ICT adoption. Even when a country does attain a development level that requires national technology institutions, the structure of those institutions will continue to change dramatically over time as the country develops.

This theory base argues that institutional factors dominate technological development and developing countries' ability to converge. North rests his argument on the institutional ability of developed countries to build a stable enforcement environment that can lower transaction costs and speed development. However, this argument fails to account for governmental cooperation with the private sector to bolster national competitiveness, as has been done by the North Atlantic and Japanese governments and has been emulated by successfully converged developing countries (Amsden, 1997). The theory base also avoids contemplating the central role market structure plays in ICT deployment within a country, with competitive forces many times outweighing governmental controls or institutional failures. This section works to address the influence of public-private coordination and market conditions on ICT strategy outcomes within developing countries.

Methodological Approach

Developing countries have accelerated their efforts to deliver affordable ICT access and improved utilization rates among their residents through a range of ICT policy initiatives (Graham, 2000). The two goals of increased access and utilization are important in enhancing a developing country's ability to compete globally for jobs and investment (Ford, 2005). Although these goals are touted frequently, they are not always tailored for a given country (Cohen-Blankshtain, 2003). Policymakers must ask themselves how they define affordable access and improved utilization within the geographic, competitive, and political environment of the country (Javary, 2002). Once these goals are defined, a set of policies can be implemented and a decision on the optimal ICT solutions can be made.

ICT infrastructure and applications will be adopted by a developing country in five stages, with policymakers shifting their goals from supporting increased access, to developing a robust private sector, and finally to creating a globally competitive ICT industry (Grubesic, 2004). Although these goals are not mutually exclusive, there is a progression in policy and technological complexity as countries move away from directly supporting access infrastructure through a state-owned enterprise, to directing market competition through a regulatory agency, and then to indirectly supporting access through a ministry of ICT. In countries that support a domestic ICT industry, the government's role shifts to becoming a coordinator and advisor to the private sector. To overcome these changing priorities and governmental roles, countries are forced to reevaluate their goals on a regular basis, adjusting their policies and technology choices accordingly. As a result, ICT goals within a developing country will not be static; in fact, they must be flexible enough to adapt to the changing technological and economic conditions to achieve an optimum outcome (Strover, 1999).

This framework addresses the commonalities in ICT adoption across developing countries by constructing five stages of communications technology development. These commonalities are across several factors influencing ICT adoption: regulatory environment, technology choices, market competition, ICT policy, and ICT institutions. Combined, these components create the five stages of ICT adoption within developing countries. This framework also highlights the major attributes of national ICT strategies implemented within those ICT development stages. In the literature, the current analytical models on the stages of ICT adoption within developing countries have not been updated to account for the rapid changes in technology and the rise in importance of the Internet and mobile telephony (Milne, 1998). Instead, they focus too heavily on fixed line access and miss crucial factors that should be included in an assessment of the stages of ICT adoption (James, 2005). This component of the framework is based on secondary research of national governments to determine how these developing countries progressed with their technology adoption investments and policies.

This national ICT framework also examines a range of developing countries that have created policies at each of the major stages of ICT adoption. There are almost 50 countries with national ICT strategies, 35 of which have been approved (Docktor, 2004). These countries represent a wide range of economic and political contexts, and the framework section examines the outcomes of these policies across these countries. This is not an exhaustive list of all program options, but rather an overview of the various categories of initiatives that address the requirements outlined for the stages identified in the framework. This section also examines the appropriate level of government involvement required to achieve success in these initiatives (OECD, 2002). Within a given country, the level of public involvement differs across the various ICT services, such as high-speed Internet or video (Kvasny, 2006).

In the national ICT programs that I have studied, three linked attributes determine the structure and scope of a country's ICT strategy: market, technological, and institutional structure, in addition to stakeholders and policy mechanisms of these ICT strategies (Wilson, 2003). Using secondary sources from national studies and policy papers, the framework includes a range of ICT strategies that depend on the competitive landscape of the country. These strategies may only target the low-income and rural regions in countries with robust market competition or they may encompass a national deployment and utilization plan. From secondary research conducted, increases in market scope may also raise the complexity of organizing ICT strategies, which in turn can lead to problems in maintaining these efforts. In finding the right role of the state within the market environment, stakeholders must include economic and political limitations as well as technological considerations (Frieden, 2005).

Infrastructure development for ICT policies ranges from expanding the use of existing infrastructure to developing new networks, training facilities, and ICT research centers. ICT access programs usually include the rollout of a fiber network and last-mile access equipment to fill the gaps of existing telecommunications infrastructure. Many communications technology training programs simply use existing facilities at local firms or universities to minimize the impact on their budgets. However, ICT strategies call for additional facilities in rural or low-income areas (Mariscal, 2005). Infrastructure improvement can also include developing national IT research capacity, which can involve the construction of a research park or the creation of higher education degree programs. This research capacity assists developing countries in supporting technology development and innovation tailored for domestic use.

Institutional structure is defined as the level of institutional, legal, and regulatory structures put in place to support the creation of a national ICT strategy. Depending on the focus of the national policy, there can be a wide range of institutional structures across developing countries. For policies focused on indirect support to the market, such as financial subsidies to the private ICT sector, there are few institutional or regulatory hurdles for sustaining the effort. However, to fund and operate an ICT research park and the requisite infrastructure, similar to Malaysia's Multimedia Super Corridor (MSC), a governmental institution or other organization may need to be created that has the necessary authority to fund and coordinate these policies. This institutional structure requires significant governance capabilities on the part of the new organization as well as a sustained financial commitment.

Institutional structure is also linked to market and infrastructure requirements. For ICT strategies that are truly national in scope, rather than a regional effort, this may add a layer of bureaucracy for the ICT institution to coordinate. As stated above, an increase in the complexity of the infrastructure for the strategy – for a national network, for example – will increase the institutional and regulatory hurdles for the ICT policy.

This framework is used to benchmark the case study countries in Section 2, assessing their position within the five stages for ICT policy implementation. This serves to guide the ICT policies a country should adopt, depending on where they were located within the ICT stages laid out by the framework. This result could serve as a road map for government policy makers as well as private sector decision makers aiming to make an investment in the technology adoption of a given country. This framework could also become useful in the long term across developing countries aside from Malaysia and Thailand, once it is adapted for the local environment of additional countries.

Section 3: Cross-national ICT Regression Model

This section relies on New Institutional Economics to determine the key explanatory variables along with New Economic Growth theory, which is discussed below, to establish the necessary control variables. This cross-national model offers a more in-depth examination of the institutional factors that influence ICT adoption rates, including both privatization and regulatory reform variables, while controlling for those economic indicators that are outlined by endogenous growth theory.

Literature Review

New Economic Growth theory offers a compelling structure for understanding economic development, suggesting that growth is driven by the creation of globally competitive products within the export sector, which in turn bolster human capital development and efficient reallocation of resources (Romer, 1992). Within this framework, ICTs improve the competitiveness, enhance human capital development, and streamline resource allocation. First, ICTs become a factor of production for a country's export sector, increasing firm productivity and increasing the reach of export firms by connecting them seamlessly to global markets. Second, ICTs offer key infrastructure for human capital development, creating knowledge networks that can be accessed by students and workers to bolster technological capabilities within the country. Third, ICT infrastructure can be a conduit for efficiently reallocating capital resources while making governmental and firm resource tracking easier to accomplish.

This approach to economic developed offered by New Economic Growth theory is supported by the economic histories of East Asia's newly industrialized economies, which are the focus of this case study research and have been used as a test for new growth theory (Sengupta, 1993). Sengupta offers three components to the new economic growth theory. First, non-rival inputs should generate increasing returns for the export sector, which is key to generating technology innovations. Second, human capital investments have a strong and positive externality within the economy. Third, the export sector is able to draw labor and resources from the non-export sector through a dynamic reallocation process supported by government policies as well as a reduction in economic regulations from earlier import substitution policies. Sengupta's research results suggest that the South Korean economy followed this model very closely during its development in the 1980s.

Methodological Approach

This cross-national regression model utilizes cross-sectional time-series data to examine the key determinants of ICT adoption across 154 countries. This model builds upon the current literature, which includes a wide range of cross-sectional models that investigate the economic variables that influence the wide variation in cross-national ICT adoption. Previous studies have tended to rely on economic data in determining the variables to include, failing to include the role of the state (ITU, 2003). In contrast, this model utilizes variables identified by the theory base discussed above, including market liberalization variables, economic development variables, and institutional indicators (Baliamoune-Lutz, 2003; Dutta, 2004).

Many developing countries have completed a market liberalization process of their economies, which can include increased trade and international investment and enhanced market competition (Steinmueller, 2001). Because this process cannot be quantified as such, this model uses several key indicators, such as trade and foreign direct investment (FDI), to account for the relative openness of an economy (Blomstrom, 1998). The second set of variables includes three metrics to measure economic development, accounting for the strength of an economy as well as the socio-economic development that is necessary for robust ICT adoption (Kapur, 2002). The final set includes variables that control for the institutional and regulatory evolution that takes place within developing countries. This includes privatization of state-owned enterprises and creating national ICT policies (Frieden, 2000).

Variables

The model uses a dependent variable that is the combined penetration rate of fixed and mobile subscribers per 1,000 inhabitants within each study country. Each indicator is weighted equally within the dependent variable despite the rapid rise of mobile utilization. Fixed line access is still necessary for many broadband and other services, and it is given equal weight within the model. This data is based on results from the International Telecommunication Union (ITU).

The independent variables include market liberalization variables, economic development variables, and institutional indicators:

- The first market liberalization variable is foreign direct investment, which is the total amount international firms have invested in a country's corporations – either through stock ownership or joint ventures – and it is measured as a percentage of gross domestic product (GDP) in the model. As a country liberalizes its market, it opens itself up to international investment in the process. Increased FDI can also lead to technology transfer from international firms to domestic companies. These transfers speed up the telecom adoption rate and were hypothesized to have a positive influence on the dependent variable.

- The market liberalization variables also include trade as a percentage of GDP, foreign direct investment, and privatization. Trade is measured as the total output and input of goods and services as a percentage of GDP. Countries with high levels of trade, controlling for those with lower levels of development, have higher adoption rates on average.

- The first economic variable measured was GDP per capita based on purchasing power parity. GDP is the total economic output for a country in a given year. Purchasing power parity measures that output in terms of buying power, rather than in dollars, to control for fluctuations in international exchange rates.

- The countries' population density is also included, which is measured as the number of people per kilometer. Technology adoption rates face the practical issue of running telephone wires and connecting computers. Telecom adoption in small, urban countries such as Singapore will happen at a faster pace than in large, more rural countries such as Thailand. Population density acts as a proxy for this issue.

- The total output of the services sector as a percentage of GDP is included to control for the advancement of the national economy. As a country moves away from agricultural- and manufacturing-based economic activities, the demand for

ICTs was shown to increase. Firms and workers in advanced services sectors are more likely to adopt, utilize, and customize these technologies than users in other sectors (Jomo, 2003). As a national economy shifts toward services, there is a positive correlation with ICT adoption.

- The first institutional variable controls for a country's level of government expenditure, measured as a percentage of GDP. As developing countries shift from focusing on state-owned enterprises to forming and budgeting for a welfare state, the size of the government begins to increase faster than GDP. This variable is used to control for this shift in governmental position within the economy and act as a proxy for national political development. This indicator is positively correlated with the dependent variable.

- Privatization of the state-owned telecom monopoly is included as a dummy variable, with those years after privatization marked with a 1. This reform is defined and tracked by the ITU, which completes an annual survey of all of its member countries.

- Creation of an independent regulatory agency has a positive and significant correlation with the dependent variable (Ure, 2003) and is also included as a dummy variable, with those years after development of the agency marked with a 1. This reform is defined and tracked by the ITU, which completes an annual survey of all of its member countries.

Data and Analysis

The data for the dependent and independent variables was collected from the ITU and the World Bank, from its World Development Indicators database. The data collected includes 16 years within the study period, from 1990 to 2005, which was long enough to encompass the ICT market liberalization process that many countries underwent in the 1990s and early 2000s.

These pooled time-series cross-sectional data were used in a fixed effects model to estimate the correlation between income, liberalization, and development, as well as ICT penetration rates across 154 countries. Fixed effects are the most common models used with pooled time-series cross-sectional data sets, particularly in cases where a vast majority of the study population is observed, as is the case with my cross-national data, rather than a sample set of countries. I utilized these data to analyze the variance across time and across countries – which, according to the theory base, is essential to understanding the impact of institutional factors on ICT adoption rates.

Section 4: ICT Adoption Case Studies

This section focuses on the large body of literature devoted to explaining the rapidly industrializing economies of East Asia. This development literature is used as a basis for understanding the role of the state within the economy at large and the ICT sector in particular. These past studies from the literature provide a foundation for understanding the critical role the government plays in technology development even after a sector has been privatized. My research for this section adds to this literature by examining the importance of institutions in the development of the ICT sector within the larger discussion surrounding the role of the state in economic development.

Literature Review

There has been a lengthy debate within economic development literature over the reasons behind the success of the East Asian Newly Industrialized Economies, including Singapore and South Korea (Ranis, 1989; Lim, 2000). There have been significant hurdles and setbacks; but as Ranis points out, these countries have successfully transitioned from an agrarian economy, to an import substitution, and finally to a technologically advanced economy (Amsden, 1989).

A key component of this success has been the creation of Zysman's national institutions, discussed above, which have successfully supported technology adoption within these countries. Moving beyond Zysman's definition, these institutional structures consist of both governmental and non-governmental organizations that direct, support, and regulate national technology initiatives. By advancing national technological capacity, a country's technology institutions are an important contributor to larger economic development efforts (Feinson, 2003).

One of the most important institutions to support ICT sector development is the national telecommunications regulator. Levy (1994) argues that while performance of the telecommunications sector can be satisfactory under a wide range of regulatory conditions, these conditions must be stable to allow long-term investment into the sector. With arbitrary or volatile regulatory conditions, and without a credible commitment to enforce and maintain the regulatory regime, the necessary long-term investment will not be available to the telecommunications industry (Weingast, 1995). In this highly volatile regulatory environment, public ownership may be the only feasible option to achieve this credible commitment, given a country's economic and political environment (Levy, 1994).

Under a more stable regime and private provisioning, Levy suggests there is a need for an independent regulatory agency to sustain a competitive market and ensure the benefits of ICTs are diffused throughout the population. An independent institution in the sector increases market certainty and long-term stability, which in turn opens the sector to investment and increases its potential for benefiting the country's economic growth. Private telecommunications operators invest heavily in their infrastructure if the necessary regulatory constraints are in place; otherwise, the private investment is minimal (Levy, 1994).

Policy and institutional reforms are the critical success factors for growth in ICT penetration rates within developing countries, whose governments currently face a myriad of policy options (Wilson, 2003). These regulatory policy issues include public versus private initiatives, monopoly versus competitive markets, domestic versus foreign ownership, and centralized versus decentralized administrative controls. Until 10 years ago, a vast majority of countries opted for public provisioning of telecommunications services. Wilson suggests that today a vast majority of governments have, to greater or lesser degrees, begun to shift toward more private, more international, more competitive, and more de-centralized management of their ICT sectors. However, compared to developed countries, developing country governments are not moving at the same pace nor have they developed the same level of institutional support (Wilson, 2003).

Methodological Approach

Several developing countries, such as Malaysia and Thailand, have announced their national policies within the last ten years (Ramasamy, 2004). Because both were modeled after Singapore's national ICT policies and institutions, the national plans and ICT institutions of both countries are very similar. However, the implementation and success of the two countries have differed considerably. A series of interviews were completed with government, private sector, and university stakeholders in Thailand and Malaysia during three months of in-country research in 2006 to help determine the cause behind these two differing experiences. This research found that key factors for both countries included transparent telecom privatization and regulation, strong political institutions and leadership, and sustained public-private coordination.

Both countries are at a crossroads in their development. Neither can safely rely on manufacturing alone to spur economic growth. Exhibit 1.1 summarizes key national indicators for the two countries plus Singapore's indicators for comparison. All figures within this dissertation are reported in US dollars. The national ICT policies are at the center of the government's attempt to create new economic opportunities while improving the country's ability to compete globally.

Exhibit 1.1: Economic and ICT Indicators by Country, for Thailand, Malaysia, and Singapore.

Economic Indicators 2004	Thailand	Malaysia	Singapore
GDP per capita, PPP (constant 2000 international $)	$7,435	$9,444	$25,804
Services, etc., value added (% of GDP)	46	40	65
Foreign direct investment, net inflows (% of GDP)	1	4	15
Urban population (% of total)	32	64	100
Technology Indicators 2004			
Fixed and mobile telephone subscribers per 1,000 inhabitants	537	766	1,350
Internet users per 1,000 inhabitants	109	397	571
Broadband subscribers per 1,000 inhabitants	0.2	10	121
ICT expenditures (% of GDP)	4	7	10
High-technology exports (% of manufactured exports)	30	55	59

Source: World Development Indicators, 2005.

Malaysia is a great example of a developing country that has focused almost singularly on technology development through foreign investment. While attracting a great deal of FDI, the country's economy has grown dependent on exporting multinational corporation (MNC) products to foreign markets (Blomstrom, 1998). Industry is moving slowly toward designing and innovating its own products. However, many of Malaysia's manufacturing facilities are still low-skilled components within the global supply chain.

Many developing countries have shifted their focus from deploying fixed lines to wireless penetration. Malaysia has managed to maintain a relatively high level of wireline adoption while driving wireless infrastructure, with average penetration for wireline doubling during the 1990s before reaching a plateau. Despite a slowdown in overall economic growth during the Asian crisis, wireless access grew rapidly, outnumbering landlines in less than a decade. Unfortunately, some areas within the country have been neglected during the rapid increase in teledensity. This lack of telecommunications infrastructure in these areas also highlights a larger problem of concentrated investment and governmental support to Kuala Lumpur to the detriment of the rest of the economy (James, 2003). This situation also reflects Porter's hypothesis on cluster development in developing countries that is warped by the political process, as discussed above in the cluster theory section (Porter, 1998).

Thailand has closely studied its neighbors to benchmark its own ICT policies and institutional structure. When Thailand was implementing structural reforms in 2002, Malaysia was undergoing a similar effort – causing Thailand to mirror its ICT institutional restructuring closely after Malaysia's. Now that Thailand is working on a second round of ICT reforms, it has looked to Malaysia again for guidance on evolving its ICT structures. In the ICT-related industries, such as hardware and software, Thailand is currently competing with countries that have low-cost labor, such as China, as well as countries with high levels of skilled labor, such as Singapore. Unlike Malaysia, Thailand does not have the high levels of governmental coordination and marketing required to compete against these other Asian economies.

Fixed line telephony penetration and broadband penetration are below average for Thailand, given its level of economic and technological development. This situation was significantly worse in 2000, when the government began working to catch up through its ICT Master Plan. Although broadband rates are improving, it may not be due to government intervention but higher demand by more affluent customers.

The case study section outlines and compares the policy and implementation trajectories of these two countries as well as the hurdles that impeded government implementation. Data sources for these country studies include international indices, secondary surveys, governmental reports, and third-party research on ICT industries, government regulations, and ICT policies. The research also includes fieldwork in Thailand and Malaysia, completing 21 interviews with key officials responsible for design and implementation of the national ICT strategies. Using the results of these interviews, I examined the commonalities between Thailand and Malaysia in their ICT strategies and implementations. The common success factors across the national ICT policies of these two countries include the supporting institutional structure, technology choices, target beneficiaries, funding mechanisms, and implementation hurdles.

My interviews for this research were completed with a wide range of stakeholders in the public and private sector. These government interviewees included officials at ministries of communication, the technology policy agency, and the telecom regulator. These government interviews helped to clearly define the policy evolution that has taken place as well as highlight successes and failures within the implementation process. From the private sector, these interviews focused on local telecommunications firms to understand their plans for ICT investment and their support for the national strategy. In addition, my interviews were completed with outside experts and additional officials, including those in the Ministry of Finance.

Section 5: ICT Utilization Case Studies

As with the case study research above, the research for this section also uses New Institutional Economics and East Asian development literature to determine the key factors for bolstering ICT utilization through specialized institutions. This research contributes to this literature by demonstrating the outcome differentials across countries despite similar technological, institutional, and policy inputs. The creation of the specialized institutions described by New Institutional Economics is necessary but not sufficient to produce a sustained increase in ICT utilization. The implementation of national ICT strategies is the key determinant in the success of ICT efforts by developing countries. This section's research relies on a methodology of primary and secondary sources similar to the case study analysis described above.

Literature Review

Despite the increased international competition for high-skilled workers and investment, several East Asian countries including Malaysia and Thailand have managed to build globally competitive sectors that require high levels of technology adoption and utilization. This advancement has come through a combination of indigenous capacity building and international investment from MNCs, both of which were closely directed by the national technology institutions. Due in part to this success, many East Asian NIEs, including Singapore, have now moved from middle-income to high-income countries (Hsiao, 2003) and have become the models for other Asian countries, notably Malaysia and Thailand.

As countries privatize their monopolies, governments must work to open the market to new entrants, support infrastructure deployments to low-income and rural areas, and increase the utilization rates of ICT infrastructure – in short, helping to drive demand while supporting the development of the ICT industry (Gasmi, 2000). However, the regulation and policy reforms underpinning these utilization efforts must be precisely sequenced to support a thriving ICT sector within a developing country. Gasmi suggests that successful governments have closely coordinated their ICT market policies with those of the private sector. These governments have also managed to support regulated competition to increase supply while directly bolstering demand.

This aspect of government involvement in the ICT sector includes supporting the increased utilization of communications technologies across a broad range of sectors within the economy (Schreyer, 2002). Schreyer suggests that this would include increasing the availability of ICT applications to individuals and organizations within the public, business, and educational sectors in the economy. National penetration rates for telephones and the Internet can increase steadily within a country. However, utilization rates among the poor and rural areas for these technologies may not expand without government initiatives. In addition, developing countries may not experience the productivity and economic benefits of ICT adoption (which have been measured within OECD countries) without public sector support (Schreyer, 2002).

By focusing on ICT utilization in addition to access, government efforts can support productivity gains across economic sectors within developing countries. This institutional support for increased utilization can take many forms, including government-supported technology training; aggregating demand and serving as an anchor tenant; fostering e-government, e-health, and other services; universal service funds; and governmental safeguards for services such as e-commerce (Frieden, 2005). Frieden also argues that communications services will need to be adapted to the needs of the local economic, political, and cultural environment, particularly if these services are originally introduced by an international entity. To meet local requirements, these national efforts require public-private-academic coordination to successfully adapt ICT services imported internationally and to innovate those services created indigenously (Balaji and Keniston, 2005).

When discussing these national ICT policies, it is important to distinguish between countries operating on the technology frontier and those that are transferring and adapting technologies from other countries (Steinmueller, 2001). The major issue with developing countries attempting to catch up technologically is when the skill sets of the workforce developing under one economic stage are not adequate to adapt to the new stage (Steinmueller, 2001). ICTs can assist in the knowledge transfer and the lowering of required skill sets for employees. However, adoption still requires a baseline level of capability (David, 1997). In addition to a lack of local expertise, progress in technology adoption can also be slowed by market structures that limit innovation and competition, reliance on poor local infrastructure that hampers technology adoption (such as relying on low-quality phone lines for Internet access), and distribution challenges caused by geographic and market constraints.

Supporting ICT utilization requires government intervention to ignite and support the innovation process within the country. In addition to public-private cooperation, this effort requires governmental intervention to ensure spillovers between MNC branch sites, free trade zones, and entrepreneurial incubators and the rest of the economy. This process is easily susceptible to concentrating investment as well as the societal benefits and positive externalities, as discussed above in the section on cluster development.

In support of this notice, Porter (1998) suggests that clusters in developing countries can form within the capital city due to political considerations rather than interconnections across firms. This can result from governmental constraints that cause firms to locate near the "seat of power" as well as a lack of infrastructure in outlying areas. Rather than increasing a country's economic growth and development, these developing country clusters extract high costs for productivity due to their inefficiencies within the market. In contrast to these developing country clusters, Porter suggests that countries in Western Europe and North America have created multiple clusters within multiple cities.

As developing country clusters mature, they need to move beyond offering lower cost labor and compete on the quality of their goods and their ability to flexibly react to changes in market demand. To achieve this, local firms within the cluster will have to increase their coordination vertically with suppliers and retailers, and horizontally across multiple regions and countries (Cortright, 2005). Cortright argues that regional policymakers should focus on creating a sufficient environment for the formation of these expanded industry clusters while nurturing those that are already have high-quality producers within the region.

Developing country firms must also be able to employ flexible specialization to meet demand while increasing productivity (Sabel, 1989). Flexible specialization as defined by Sabel means mass-produced specialized goods from general-purpose inputs. To achieve this, firms required higher levels of worker and supplier collaboration than were previously required in traditional manufacturing sectors. This requirement pushed the development of networked firms that utilized ICTs to work within their own areas of specialization while sub-contracting non-essential activities to each other.

Within this context, a government needs to focus on accelerating innovation, increasing utilization, and diffusing benefits simultaneously to receive the full economic impact of ICTs on a country. So far, few developing country governments have demonstrated they are capable of launching an effort like this, let alone making it politically and economically sustainable for the long term.

Methodological Approach

As discussed above, a key component to the success of ICT strategies has been the creation of national technology institutions that have successfully supported technology adoption within these countries (Zysman, 1983). These institutions exist in both Thailand and Malaysia. However, Malaysia has been more successful in coordinating these entities to support its national ICT policy implementation. These structures consist of both governmental and non-governmental organizations that direct, support, and fund national technology initiatives. They include advisory boards, business development and training agencies, research and development (R&D) institutes, and commercialization programs. Malaysia's technology institutions, by advancing national technology capacity, are an important contributor to economic development (Feinson, 2003).

Although Thailand has an institutional structure similar to Malaysia's, the country's agencies do not have the budget, authority, or monitoring capabilities to implement its ICT policies transparently. In addition, the country has volatile regulatory conditions, leaving ICT operators without a credible commitment from the government to enforce and maintain the regulatory regime. This commitment is essential to the long-term investment environment, which is key for the capital-intensive telecommunications and IT industries (Weingast, 1995). In contrast, an independent regulator, which is only now being formed, in the sector increases market certainty and long-term stability. The ICT sector will invest heavily in its infrastructure only if the necessary regulatory and institutional structures exist (Levy, 1994). These countries have both developed ICT strategies that contain three key areas: ICT infrastructure deployment, ICT industry development, and human capacity building. Malaysia and Thailand have taken these basic ICT initiatives and adapted them to the needs of their local economic, political, and cultural environments.

Malaysia and Thailand's network infrastructure deployment plans were based on South Korea's very successful government initiatives to support ICT network expansion. These plans focus on increasing access, deploying fiber networks, and expanding universal service obligations. Some of these efforts have been successful, depending on the demand for ICT services that already exists within each country.

The second key area, IT industry development, was the primary focus for the private sector and the two national ICT strategies. In 2003, the government created Software Park Thailand and the Software Industry Promotion Agency to bolster its fledgling industry. In Malaysia, the IT sector has grown rapidly through the involvement of foreign capital and MNCs, both of which are coordinated through the Multimedia Super Corridor. Through the MSC, the government was able to attract a range of software and IT MNCs. The country is now focused on increasing the technology transfer and training from these global IT firms into its local ICT industries.

The third area includes workforce skill development to assist in ICT knowledge transfers from MNCs while increasing local technology innovation capabilities. Thailand has moved to support training and skills development through its Ministry of Education and Ministry of Industry. However, Malaysia has made it a primary focus for its national development strategy. With support from the prime minister, the country has identified several high-tech sectors that offer Malaysia a niche to compete in the global market. These sectors will benefit from a public-private effort to coordinate training and R&D efforts to bolster local capacity in these areas. Although this policy was only recently announced, it is a vital step in Malaysia's national strategy to utilize ICTs and develop a knowledge-based economy.

The policy implementation hurdles faced by Thailand have included a lack of government coordination and leadership, conflicts of interest among key officials, no program monitoring, and limited policy enforcement. From the beginning, Thailand has had a very top-down ICT strategy – with programs and policies driven by government ministers rather than by the needs of the private sector. The goals set within the plan were also ambitious, particularly with a five-year time frame, and would have required careful coordination within the government to follow the national ICT plan. Instead, the various ministries used the ICT Master Plan for initial budgeting only, failing to use the plan for program design or evaluation – resulting in overlapping and siloed efforts across the ministries.

Leadership issues and conflicts of interest have both been major impediments to policy implementation in Thailand. The country's National Information Technology Committee (NITC) is officially headed by the prime minister, but this position was typically delegated to a deputy minister. As a result, the ability of the Committee to develop and implement ICT policies would vary widely depending on the personal interests of the deputy assigned. Policy implementation would suffer a slowdown under deputies who were not interested. More recently, the prime minister headed the NITC himself but was also found to have a conflict of interest, potentially steering the Committee to benefit his personal business interests.

Another major hurdle for ICT policy implementation in Thailand is the lack of program evaluation. ICT programs are developed by ministerial CIOs and evaluated only at the project level, and this limited monitoring is completed in a vacuum. The evaluation work focuses on gathering quantitative data on hardware deployment, not on qualitative data on utilization and the impact of the ICT initiative on the economy. Most important, there is no overall benchmarking or evaluation effort by the government against its own master plan, an essential component to ICT strategy success (Docktor, 2004).

In Malaysia, the ICT policies focus on infrastructure, ICT industry support, and human capacity development. The Malaysian government needs to focus on accelerating innovation, increasing utilization, and diffusing benefits simultaneously to receive the full economic impact of ICTs on a country (Jomo, 2003). Malaysia has taken the policy step of focusing on government intervention to ignite and support the innovation process within the country. This means working with universities, the private sector, MNCs, and non-profit organizations to bolster technology transfer, FDI, and technology training.

Section Summaries

This dissertation research includes four research sections. The first section offers an ICT policy framework tailored for developing country governments. This framework outlines the sections of ICT adoption, the gating factors between those sections, and the key policies governments will implement within each stage. This research addresses some of the important questions that other researchers are not investigating, while using a combination of research techniques to explore the stages of ICT adoption and economic development. These stages of ICT adoption and policy reform are then used to frame the results of a global regression model and a two-country case study, both discussed below.

The second section includes a pooled time-series cross-sectional regression model of country-level data examining penetration rates for ICT adoption. Within the regression model, I include policy and institutional factors in addition to social and economic factors that influence adoption rates. A pooled time-series cross-sectional model of these factors is now possible due to the range of data on ICT adoption from the World Bank, the ITU, and other sources. Several recent studies have put forth models for examining the relationship between ICT penetration and various economic, social, and political explanatory variables (Hawkins, 2005; Levy, 1994; Schreyer, 2002; Wilson, 2003). These studies have included many of the same factors, but few have incorporated a wide range of communications technologies or tracked ICT adoption over time. More important, few of these studies examined the impact of ICT policy and institutional reforms on penetration rates. Most were simply attempting to draw a correlation between penetration and macroeconomic indicators, such as GDP per capita, and high-level political factors, such as political freedom. Although this can be enlightening when comparing the relative successes across countries, it is not as helpful to developing countries that will need to understand the key policy factors that must be in place to accelerate ICT adoption.

The case study analysis is split into the third and fourth sections, which explore the individual factors for ICT policy implementation across Malaysia and Thailand. The case study research effort focuses on the sequencing of events and policy shifts involved in rapid ICT adoption across countries (Wallsten, 2002). The hypothesis is that once ICT adoption is spurred by a combination of policy changes and economic factors, it must then be institutionalized to sustain this accelerated growth rate (Edwards, 2002). This institutional process must include the creation of an independent regulatory agency and a ministry of ICT that both have the authority, budget, and enforcement capabilities necessary to sustain national ICT policies focused on ICT adoption and utilization (Wenders, 1992). This process of economic development and institutional shifts spurring ICT adoption is repeated through several stages of technological development, with each stage requiring a new set of policies and institutional reform (Fink, 2003). I hypothesized that growth is not sustainable for developing countries that cannot complete the institutional reform process within each stage.

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Section 2: ICTs in Developing Countries – The Stages of Adoption

Introduction

One of the key policy goals for developing country governments is to diffuse ICTs across their nations through a combination of government intervention and private sector growth (Mariscal, 2005). In recent years, these technologies have become a focus for governments hoping to accelerate their economic development through ICT-driven productivity gains, enhanced educational capabilities, and expanded innovation capacity (Brynjolfsson, 1996; McGuckin, 1999; Siegel, 1997). Through the inherent advantages of being latecomers, many developing countries can begin a rapid process of expanding their ICT penetration rates – quickly reaching or even surpassing developed country adoption rates (Rouvinen, 2006). Achieving rapid acceleration in ICT adoption requires a coordinated effort by the government, the private sector, and academia to reach the pent-up demand that exists within the developing country by harnessing the existing foundation of communications services and injecting new competition and technologies (De Boer, 1999). Without this public-private coordination, developing countries cannot sustain their ICT growth paths, leaving many regions and sectors within the country underserved by ICTs.

To accelerate their ICT adoption rates, developing countries undergo similar processes of institutional, policy, and market reforms that can be delineated into five distinct stages. To highlight the similar processes across developing countries, this section describes five stages marked by evolving technology options, institutional frameworks, national ICT policies, and market structures (Milne, 1998). Within these five stages, these four factors affect the development of the ICT market, creating new opportunities or challenges for policymakers as they attempt to quickly adapt national policies and initiatives to the ever-evolving ICT environment. These stages are based on common patterns of development within these four factors across developing countries, offering a new framework for understanding ICT sector development. For a given country, its stage of adoption is determined by its level of ICT penetration as well as its progress across three qualitative factors: institutional, policy, and technological development.

One of the most important and most difficult factors is the required reform of the national ICT institutional structure and policy framework (Levy, 1994). Developing countries tend to reform their institutions and policies through several of the five stages, altering the state's position to find its most appropriate role within the market (Bortolotti, 2007; Mariscal, 2005). This process can prove to be very difficult for most developing country governments, given political and financial disincentives for reform, including the sunk costs of early stage policy choices as well as regulatory capture by operators (Levy, 1996). As a result, only those developing countries that have successfully navigated this process can sustain rapid growth in their ICT adoption rates.

I have based these five stages of ICT adoption, and the evolving role of the state, on Rostow's ideas on the stages of economic development (Rostow, 1960). These ICT stages use Rostow's concept as a guide for outlining and highlighting the transition countries make from a traditional communications market to a highly competitive and innovative ICT sector. The chart in Exhibit 2.1 outlines the five stages of ICT adoption and utilization as well as the corresponding ICT policies, institutional structure, and competitive environment. The boundaries for these phases do not overlap. However, there are no hard lines between stages. Rather, these are meant to be estimated transition points in a country's ICT development. For example, a country's four ICT metrics may be slightly below the boundary for stage four, but the overall ICT sector within this country may demonstrate all the attributes of stage four due to its institutional, policy, and market reforms. Although this may not be reflected in the four metrics, this advanced level of ICT sector development would be seen in the other, qualitative measures outlined in the table below in Exhibit 2.1. In addition, countries may also have attributes from more than one phase at a given time. The goal of this research is not to pigeonhole a country into a given stage, but to outline broad stages of ICT development, illustrating the adoption process while demonstrating how these four factors change with a country's development.

Ranges were set for the four ICT metrics in each stage. The table below includes fixed line, mobile, Internet, and broadband penetration rates. These are representative estimates based on the patterns of growth seen across developing countries as their ICT sectors have grown. Depending on the metric and the underlying technology, there are differing ranges set for each ICT sector. For example, because the network deployment costs and time frames are significantly higher for broadband versus mobile telephony, the penetration rate between stage one and two is much lower for broadband (Jensen, 2005). A similar difference in network costs is true for fixed line versus Internet access, which is reflected in the ranges of penetration set for those metrics as well. These ranges for each of the stages represent the inflection points in penetration rate growth for many countries. Moving from one stage to the next will require a new level of network deployment, enhanced market competitiveness, and expanded end-user demand. It is unlikely that any two countries will go through these stages in exactly the same manner. Instead, many will have their own inflection points. In addition, not every country will have the same inflection points and not all transitions between stages will cause a country to experience a change in the slope of their adoption rate. However, these penetration ranges set for each stage broadly represent the patterns of adoption seen across developing and developed countries as their ICT sectors mature.

It is important to note that in this section, I am using the World Bank's definition of low-, lower-middle, upper-middle, and high-income countries; definitions and examples are included below. When referring to developing countries, I am including low-, lower-middle, and upper-middle income countries while counting high-income economies as developed countries.

- *Low-income countries*: These developing countries have a 2006 gross national income (GNI) per capita of $905 or less. Within the 185 World Bank member countries, this category includes 53 economies, such as Cambodia, India, Haiti, and Ghana.

- *Lower middle-income countries*: These developing countries have a 2006 GNI per capita from $906 to $3,595. The World Bank classifies 55 countries in this category, including Algeria, China, Colombia, Jamaica, and Ukraine.

- *Upper middle-income countries*: Developing countries in this category have a 2006 GNI per capita from $3,596 to $11,115. There are 41 economies in this category, such as Argentina, Hungary, Oman, Russia, and Turkey.

- *High-income countries*: These developed countries have a 2006 GNI per capita of $11,116 or more. This category includes 60 countries, such as Australia, Finland, Japan, Singapore, and the United States.

Exhibit 2.1: Overview of the Five Stages of ICT Adoption

	Traditional market	**Pre-conditions for takeoff**	**Takeoff**	**Drive to mass market**	**Age of high consumption and innovation**
Fixed line penetration rate (per 1,000 inhabitants)	0 to 100	100 to 200	200 to 350	350 to 500	Over 500
Mobile penetration rate (per 1,000 inhabitants)	0 to 100	100 to 200	200 to 600	600 to 800	Over 800
Internet penetration rate (per 1,000 inhabitants)	0 to 100	100 to 200	200 to 350	350 to 500	Over 500
Broadband penetration rate (per 1,000 inhabitants)	0 to 10	10 to 50	50 to 150	150 to 200	Over 200
Residential and business ICT usage	Limited residential use; business users in urban areas	Urban fixed line and mobile growing, but few rural users	Accelerated growth for residential and business users	Internet and mobile phone widespread with residential	Market has reached saturation
Income level	Low income	Lower-middle income	Upper-middle income	High income	High income
ICT industry	Importer of ICT technology	Part of the global ICT supply chain, but little value added	Local ICT industry begins to take off, in a few target markets	Reliant on ICT imports, but a larger industry develops	ICT products and services globally competitive

Competitive environment	Monopoly	Competitive mobile and Internet, but limited fixed line	Competitive urban fixed line; robust mobile competition	Cable, wireless, and fixed all compete against one another	Market reaches saturation; heavy price competition
National ICT policy focus	Privatization; tech transfer liberalization; network deployment	Expand connectivity; investment and tech transfer	Support to local ICT industry; training; e-Government initiatives	Coordinate public-private R&D; expand tertiary education	Public-private coordination to speed ICT innovation
Universal service policy focus	Metro center networks; payphones and village phone	Expansion beyond urban areas; universal service fund	Rapid expansion of universal service fund for rural users	Universal service for Internet and broadband services	Universal service fund continues to subsidize rural or low-income users
ICT institutional structure	Regulator; ministerial power rests with state-owned PTT	Authority split across agencies; larger private sector role	Creation of Ministry of ICT; implements national policies	MICT shares authority; government's role is reduced	MICT broken up again across many agencies
Major hurdles	Difficult to take control from a PTT and its revenue source	Reforms that will create takeoff difficult to start	Difficult to sustain; requires institutional reforms and support	Manage competition; expand broadband networks	Few countries have been able to become ICT innovators

Theory Base

Exhibit 2.1 uses the general framework of five stages presented by Rostow as a framework for understanding the economic, political, and technological changes that occur within a developing country. Development economists have supplanted Rostow's theory due to the lack of empirical evidence for rapid economic "takeoff" within developing countries (Easterly, 2006). However, as this study will discuss, there are excellent examples of developing countries that have experienced rapid acceleration in their ICT adoption rates – making Rostow's framework a good complement to ICT development theory. Combined, Rostow and ICT sector research serve as an important tool for understanding the rapid changes developing countries undergo in their ICT sectors. To augment the framework presented by Rostow, I have also used several articles with ICT-specific frameworks, including the telecommunication adoption framework presented by Milne (1998) that outlines five stages of policies and the corresponding penetration rate for fixed line access. This was an important first step in developing an ICT adoption framework. However, it leaves out new technologies, such as Internet access and mobile phones, and focuses predominantly on universal service policies. The adoption phases discussed within this study have been expanded to include additional technologies and are more comprehensive in their approach to ICT markets, policies, and institutions. The section below defines the four major factors that influence ICT adoption: institutions, policies, markets, and technologies.

There has been a lengthy debate about the connection between economic growth and ICT adoption (Edwards, 2002). Although this research does not contend directly with this issue, several previous studies have shown that there is a causal link between the deployment of ICTs and economic growth (Roller, 2001). Based on a study of 21 high-income countries, Roller suggests that countries begin to see the economic benefits of ICTs once their adoption rates approach universal service. This suggests that developing countries may not experience measurable economic growth benefits until they reach stage three or four. However, there are other economic benefits from adoption at earlier stages that are not reflected in national statistics.

In contrast, other studies have shown that returns on IT-related investments made by developing countries are not statistically significant (Dewan, 2000). However, Dewan's study simply may not have enough data points with years of high IT spending because it was completed in 2000. Dewan agrees with Roller's contention that developed countries have statistically significant returns on their IT investments. Another recent study by Jorgenson tracks higher returns on IT investments across all regions, particularly in developing Asia (Jorgenson, 2005). This may suggest that countries in stages one and two should focus on basic communication services, rather than investments in bolstering domestic IT usage. A focus on IT usage may become more beneficial in stage three, but certainly in stages four and five.

While ICT adoption follows its own path within countries, there are similarities in diffusion patterns between ICTs and other technologies. A recent study of technology diffusion across countries examined several sectors including ICTs (Comin, 2004). This study by Comin suggests that the key determinants of technology adoption include human capital, type of government, trade liberalization, and adoption of predecessor technologies. The first three factors are all reliant on government policy for successful implementation, suggesting that the role of the state is a vital component for technology diffusion across a wide range of sectors including ICTs.

Comin also argues that technologies begin with high-income countries first and then trickle down more quickly to developing countries. Because developed countries have already adopted these technologies and built successful business models around delivering them, developing countries can access technologies that have already been vetted by the market. This adds credence to the hypothesis that developing countries are better suited to rapid ICT adoption than developed countries because they are latecomers and not operating at the technology frontier. In another study on latecomers, Perkins examines several technology sectors including fixed lines to determine the latecomer advantages for developing countries in following the adoption curves of developed countries (Perkins, 2005). Perkins argues that openness to international trade – and, in turn, technology transfer – will positively affect technology adoption within developing countries.

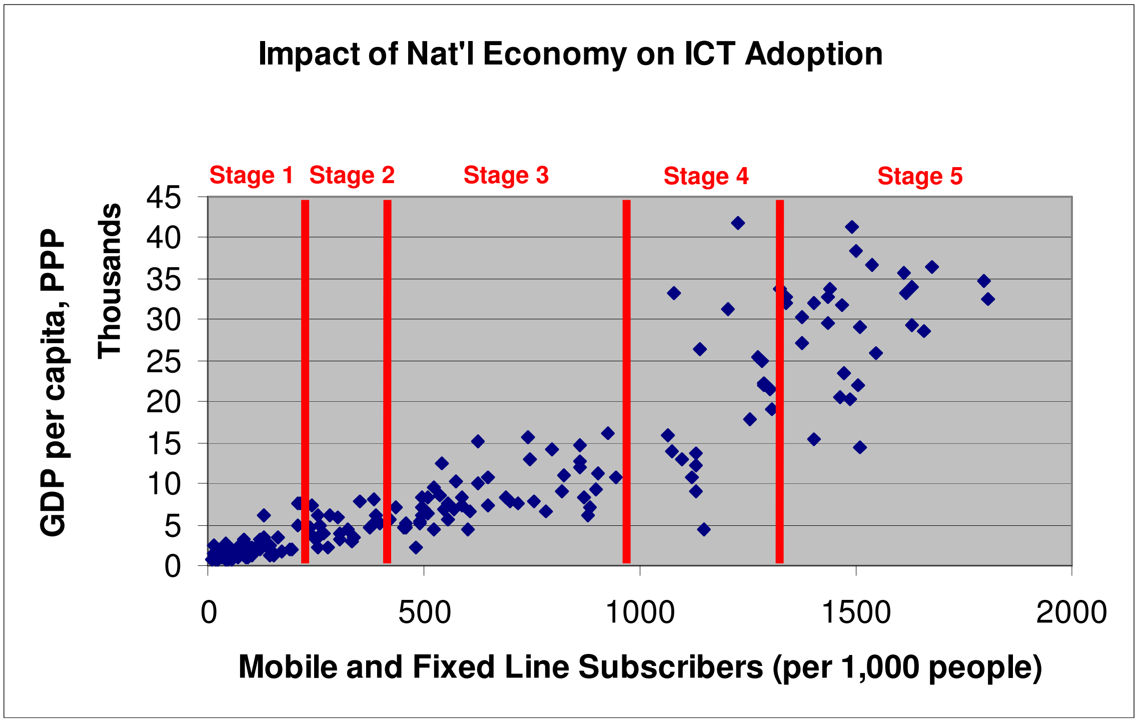
These concepts of latecomer advantages in technology adoption, the benefits of technology transfer on adoption, and the vital role of the state are incorporated into the five stages. The section below outlines the four major components influencing ICT adoption rates: institutional structure, national ICT policies, market competitiveness, and network infrastructure. This section explains the four key concepts within the framework, which will be examined stage by stage and in more detail in the rest of this study.

Key Concepts within the Adoption Stage Framework

Although countries are commonly divided into developed and developing categories, there are in fact many levels of ICT development within each category. These different levels of ICT sector maturity are then reflected in the national ICT adoption goals and the key policies and public support given to ICT development (Albadvi, 2004). By categorizing the ICT adoption levels, ICT goals, and policies, we can more clearly understand the factors that strongly influence the successful acceleration of ICT adoption rates within developing countries.

The chart in Exhibit 2.2 depicts the GDP per capita and the ICT adoption rate for 174 countries across all five stages. For the sake of simplicity, ICT penetration is measured only as the total fixed and mobile lines per 1,000 people and does not include Internet access or broadband subscribers. The thresholds of the five stages have been placed to reflect the averages for the penetration rates outlined above in Exhibit 2.1. As countries move from one stage to the next, there are patterns to the development and evolution of their ICT goals, institutions, policies, and technology platforms. Each has separate gating factors that will be met by many governments as they reform their institutions, policies, and markets to address the challenges of the new ICT sector environment (Milne, 1998). For many countries in stages one through three, the policy will remain focused on deploying basic network access to support telephony and data services. Countries that have reached stages four and five will tend to focus more heavily on ICT innovation rather than simple access. The section below outlines the key reforms and market changes that transpire within each of the five stages.

Exhibit 2.2: The Relationship between GDP per Capita and ICT Adoption



Source: International Telecommunication Union, 2006.

Institutional Organization and Regulatory Structure

The role of the state in the development of an ICT sector is defined by the regulatory and institutional structure that is created by the central government. These institutions include a national regulator, ministries of communications and innovation, and – for countries that have yet to privatize – a state-owned operator (Li, 2005). The regulatory and institutional structure of a developing country is the foundation for all other governmental efforts to accelerate ICT adoption – from direct actions, such as network deployments, to indirect supports that include market subsidies. The successful creation of an independent regulator, separated from the political influence of the government, is the typical starting point for accelerated ICT adoption (Baudrier, 2001).

Similarly, the creation of a ministry with a critical mass of ICT expertise, budget, and authority improves the likelihood of successful implementation of ICT policies (Hawkins, 2005). Countries with a weak national regulator or poor ministerial organization will hamper any ICT policies or initiatives that are designed to achieve national adoption goals. As countries develop their ICT sectors, the institutional structure of the regulator and ministries changes to match the evolving role of the state across the five stages of adoption. Evolving from a centralized parastatal with regulatory and monopoly power, developing countries work to carefully construct a new set of institutions based on international practices that can balance the market power of competitors, ensure universal access, and drive ICT innovation across the public and private sectors (Gasmi, 2000). Few developing countries have been able to achieve this balance, but those that have offer a template for other governments to customize to their own national environment.

National ICT policies

In both developed and developing countries, many central governments have created national ICT strategies to bolster ICT adoption (Hossain, 2003). These strategies tend to include an assessment of the key challenges in terms of ICT utilization and innovation along with proposing a series of initiatives to address these issues. These strategies are typically created by a ministry of communications or science in coordination with the private sector and academia. This public-private coordination helps to ensure that realistic goals are set and that the initiatives will address demand for ICT services. Policies and initiatives divorced from the realities of the national market will become financially unsustainable and limited in their implications for accelerated ICT adoption rates.

The goals and policies chosen by governments tend to change quickly to adjust to the new sector environment across the five stages of ICT adoption (Fink, 2003). For governments in the early stages of adoption, there may be no critical mass of private sector operators or networks for the market to use as a foundation. As a result, the policies and goals set at these stages tend to rely on direct government involvement in infrastructure deployment, price setting, and service creation. As the ICT networks and operators can begin delivering services independently, the policy goals and programs shift toward more indirect supports. These indirect initiatives can include a range of operator subsidies, training, and incentives as well as financial supports for end users. Developing countries pursuing a catch-up strategy for their ICT adoption rates must carefully reform their national policies, quickly altering the role of the state to fit the market and the technological environment as they rapidly evolve during the five stages.

Competitive Market and Indigenous ICT Industry

Similar to the changing role of the state, the ICT market environment will quickly change as the country moves through the five phases. Under a government monopoly, there may be little network deployment or technological innovation within the sector. Once developing countries move from the first to the second stage, several sectors will begin to see competition, price declines, and service quality improvements. Although privatization is not sufficient to create a competitive market, a successful privatization process can release market forces to service pent-up market demand and accelerate the sector (Fink, 2003).

The private sector can be divided into two components that include the national communications market and the domestic ICT industry. The national communications market includes all of the service providers delivering telephony, data, video, applications, and other services to residents and firms within the country (Kraemer, 1996). This market does not evolve smoothly or uniformly. Instead, the competitive landscape undergoes periods of stability followed by bouts of rapid change. In addition, some market sectors become more competitive than the rest due to technological and cost differences. The most notable example is the mobile services sector, which has drastically lower deployment costs than a fixed line network. These lower costs have allowed the mobile sector to accelerate rapidly within dozens of developing countries. The technological advantages of the mobile sector, along with Internet access, have led to developing countries where one or two sectors race ahead of the rest of the market in terms of investment, subscribers, and innovation. This creates uneven levels of market competitiveness, which forces national regulators to apply policies and regulations across sectors that vary widely in their market challenges.

The local ICT industry includes hardware, software, and IT firms that adapt international technologies or develop their own solutions. As a country moves through the stages of adoption, this domestic ICT sector moves quickly toward a critical mass of firms capable of serving the domestic market first before moving to international export. These local firms help ensure that there are sufficient applications and technologies that are tailored to the local ICT market and policy environment. Developing countries that rely strictly on imports may find themselves without the necessary technology options to support a sustained growth in ICT adoption (Madanmohan, 2004). The ICT policies and institutions of developing countries must focus on the creation of both a sustainable communications market and an innovative ICT industry to achieve its national adoption goals.

Network Infrastructure

A wide range of technological solutions is now available to developing countries that are seeking to accelerate their ICT adoption rates. These technologies enable developing countries to leapfrog over the traditional infrastructure that took developed nations decades to build out and move immediately to options tailored to rapid diffusion of access (James, 2005). National ICT networks can be divided into three broad components: access networks, national backbones, and international connectivity. Access networks provide fixed lines and mobile phones with last mile connectivity for telephony and data services. When assessing ICT adoption rates within developing countries, there is a tendency to focus strictly on the number of access lines or mobile subscribers within a country (Chinn, 2006). Although these metrics demonstrate the relative success of ICT diffusion within the country, they ignore the vital role national and international backbone networks play in this effort.

National backbones provide the foundation for ICT access adoption and include fiber optic, satellite, and wireless connections between cities. These networks interconnect calls and data transmissions across the country and can significantly lower costs for delivering services and applications. Without a strong backbone, national efforts to improve ICT adoption will be hindered by high costs and unreliable services (Jensen, 2005). International connectivity includes submarine and terrestrial fiber optic cables that interconnect a country with global networks. A developing country with strong international networks will have lower Internet and transnational capacity for its end users. National governments, in conjunction with the private sector, should support each of these three components simultaneously to ensure they can rapidly progress through the five stages of adoption.

Approach to Determining the Five ICT Stages

The goal of these ICT stages of development is to provide new insight into the interaction across multiple factors, including technologies, policies, market environment, and institutions that influence national ICT trajectories. These stages are based on patterns developed through the interpretation of global ICT data sets tracked by the ITU along with extensive use of existing literature and developing country case examples. The global data includes 16 years of ITU and World Bank data for over 150 countries, including the four main metrics of fixed lines, mobile phones, Internet users, and broadband lines. The existing literature provides previous efforts to categorize the stages of ICT development, research on the interaction across the four key factors influencing ICTs, and the evolution of ICT policies and institutions across time. The literature also includes a number of country examples that focus on the evolution of ICT networks, policies, and institutions within a developing country. Using this combination of data, existing studies, and case examples enables my research to focus on the interaction and coordination across the four factors that are necessary for developing countries to progress within their ICT trajectory. I am not claiming statistical or formal generalizability for this study. However, this section relies on a large foundation of global data and country examples to carefully determine the boundaries of these five stages.

Stage One: Traditional Market with Limited Coverage

Developing countries at this first stage of ICT adoption are predominately low-income and tend to have only basic telephony services offered by a monopoly provider. These monopolies are typically government-owned, offering slow deployment of infrastructure and unaffordable services, creating low penetration rates for both fixed and mobile services along with limited Internet access. This confines the availability of services to a small portion of the population and results in little ICT infrastructure deployment (Martins, 2003). The typical exceptions for telephony and Internet access include government facilities, large businesses, and high-income residents. Although access is limited, telecommunications parastatals typically become politically powerful by raising government revenues through high rates charged for international calls and business services. This political power, coupled with the monopoly's existing market power, severely limits the number of new entrants allowed to compete in the market. Developing countries at this stage tend to undergo significant market and regulatory reforms to transition to the next level of adoption.

The chart in Exhibit 2.3 includes several countries that are currently at stage one overall for their adoption rates. The metrics are based on the number of users per 1,000 inhabitants for fixed, mobile, Internet, and broadband services, which are then combined into an index to determine the proper stage for each country. I have weighted the index evenly for all four metrics, rather than weighing one or two more heavily than the others. Although narrowband Internet and fixed lines will be supplanted eventually by mobile and broadband service, today both metrics are important components in understanding the evolution of a country's ICT sector. As discussed above, these metrics should be used in conjunction with the other major factors included in the framework, such as institutional and policy reforms. However, it would require additional case study and primary research into each of these countries to determine the staging of each qualitative measure. For the purposes of this study, the primary determinants for a country example to be included in a given stage are its four ICT metrics.

Exhibit 2.3: Examples of Countries in Stage One of ICT Adoption

	Mainlines	*Stage for Mainlines*	Mobile users	*Stage for Mobile*	Internet users	*Stage for Internet*	Broadband users	*Stage for Broadband*	**Stage Index**
Ghana	14.5	*1*	128.5	*2*	18.1	*1*	0.1	*1*	**1**
India	45.5	*1*	82.2	*1*	54.8	*1*	1.2	*1*	**1**
Kenya	8.2	*1*	134.6	*2*	32.4	*1*	0.0	*1*	**1**
Nigeria	9.3	*1*	141.3	*2*	38.0	*1*	0.0	*1*	**1**
Tanzania	3.9	*1*	51.6	*1*	8.9	*1*	0.0	*1*	**1**
Turkmenistan	80.1	*1*	10.5	*1*	7.6	*1*	0.0	*1*	**1**

Source: World Development Indicators, 2006. Number of users in thousands for all four indicators.

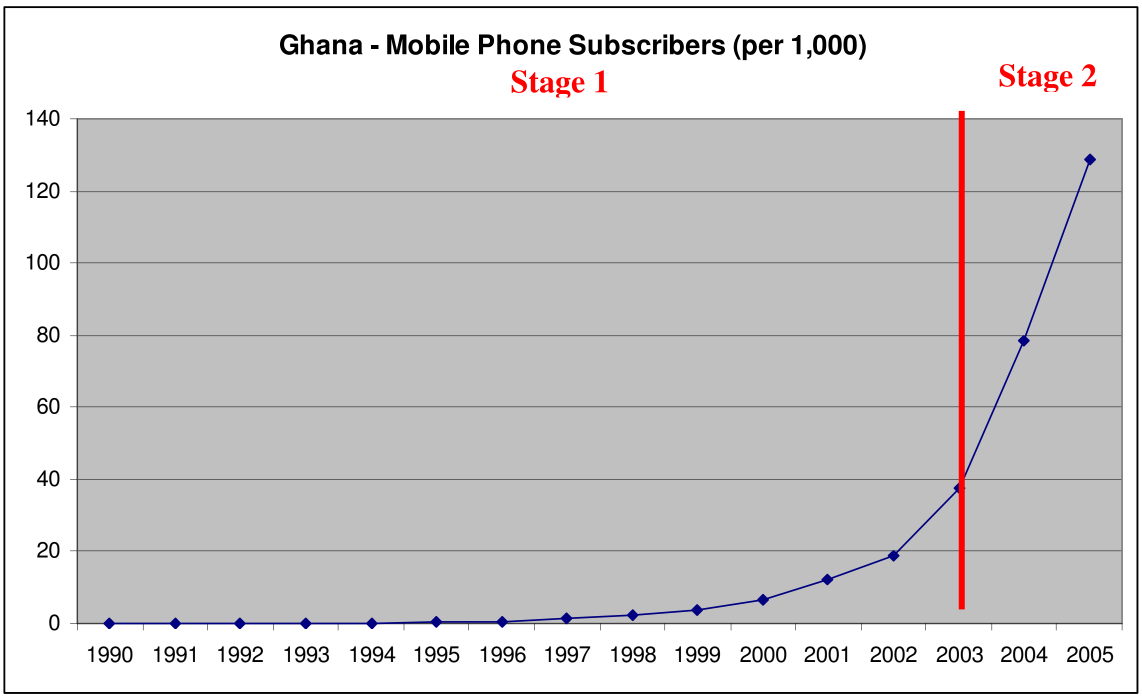
The columns to the right of these metrics include the given stage for that sector. For example, Nigeria has reached stage two for its mobile phone services while remaining in stage one for the other three sectors. This list is not intended to be exhaustive, but illustrative of the countries that are currently in stage one. Several other countries, such as Ghana and Kenya, have also seen their mobile user adoption rates increase ahead of their other three sectors. In addition, some of these countries, such as India, have begun to see regulatory and institutional reforms – a strong signal that the country has begun the transition toward the second stage. However, variations in the qualitative components of the stage framework are not incorporated into this chart, or the other charts included for the other four stages.

ICT Adoption

At this stage, many developing countries have not begun the process of integrating ICTs into their economies or governmental services. In addition, there tends to be a lack of indigenous ICT industry, forcing the country to rely on imported ICTs from developed countries. Developing countries at this stage focus their national infrastructure deployments on universal access rather than universal service. Universal access is defined as creating ICT access opportunities for the entire population, although the nearest access point may be miles away for a potential user (Moschella, 1998). Universal access goals for developing countries tend to include ICT services that are deployed within major cities but limited to a per-village basis in rural areas. This differs from the services deployed on an individual basis found in countries that have achieved universal services. For each developing country, the definition of universal access varies widely depending on its geography, population density, and economic development (Navas-Savater, 2002). For countries facing geographic challenges, the distance between access points will be much greater than for densely populated countries. For many countries at this stage, fixed line access consists of fewer than 200 lines per 1,000 inhabitants while broadband data services are almost non-existent. Some stage one countries, as mentioned above, have been able to increase their mobile phone adoption. However, these users tend to be located the largest urban center, leaving other regions with limited service.

Exhibit 2.4 demonstrates the rapid growth of Ghana's mobile phone market, which has recently reached stage two while the other three quantitative metrics – fixed line, Internet access, and broadband – are all still in stage one. Ghana was able to begin the telecom liberalization process in the late 1990s. However, the levels of competition have varied widely within the ICT sector.

Exhibit 2.4: ICT Adoption Stages Applied to the Ghanaian Mobile Sector



Source: International Telecommunication Union, 2006.

Competitive Landscape

For developing countries at this stage, there is little competition for fixed, mobile, or Internet services aside from a monopoly provider that is either owned or controlled by the government (Wallsten, 1999). The government is either providing services directly through a state-owned enterprise or has given a private sector company monopoly status in the market. This private sector arrangement was common among many Caribbean islands, with the private company Cable & Wireless of Britain serving as the monopoly provider for many of the UK's former colonies. Without price and service competition, there is little incentive for the monopoly to offer reliable, affordable services, resulting in a flat number of fixed line deployments. For many of these countries, mobile phone services are just beginning to be licensed and deployed under the monopoly (Proenza, 2006). Typically, countries with monopoly operators will see only limited mobile phone success due to unaffordable services. For most of these countries, this lack of mobile service is not remedied until the monopoly is privatized and the regulator allows new entrants. There may be competition within the ISP sector, either through dial-up services or Internet kiosks, but these providers will be at the mercy of the monopoly operator for both access and backhaul capacity.

As mentioned above, the monopoly can secure sizable revenues from international and business services, which are used to cross-subsidize local services (Laffont, 2000). Although these revenues may allow the monopoly to meet minimal requirements for universal access, they leave international and business services unaffordable for most users. Data services in particular are made more expensive within these countries by the high costs of international connections, which may make the ISP business model unsustainable due to the lower margins (Jensen, 2005).

Network Infrastructure

Developing countries at this stage often face a wide range of backbone and access issues that limit infrastructure deployment. Geographic hurdles, such as mountains, or a dispersed population can push up the costs of laying copper or fiber-based assets, forcing operators to rely on satellite or fixed wireless to reach customers. These alternative network solutions are not cost-effective for widespread deployment and support only voice and narrowband data services (Crandall, 2003). Similarly, national backbones may not reach beyond a handful of large cities, limiting the capacity of the network to support any rapid increases in demand. In addition to these technological and geographic challenges, developing countries also face capital shortages. Without a critical mass of users or a steady revenue stream, many operators within these countries cannot find the necessary capital to build out their network infrastructure (Indjikian, 2005). This creates a vicious cycle where neither the user base nor the network can expand due to market constraints, many times requiring government intervention and guarantees to trigger new rounds of investment.

National ICT Policies

Many national governments at this stage do not have a national ICT policy designed to increase adoption rates (Mbarika et al., 2005). In addition, many of these countries do not have any efforts under way to liberalize the market or reform their regulatory structures to create a competitive environment. For countries that do begin the regulatory and market reform process in this stage, the policy effort typically focuses on privatizing the state-owned monopoly, liberalizing the trade restrictions on imported technologies, and deploying a national fiber backbone (Parker, 2005). This backbone effort is particularly important to lowering costs in countries where the private sector has yet to build out its own national networks. Universal access policies are also included as part of these initial deployments of telecom networks to population centers while expanding access to payphones and one-phone-per-village programs to expand connectivity access to rural and low-income areas.

Institutional and Regulatory Structure

The ICT institutional structure within the country is highly centralized, with the government's role within the ICT market dominated by the ministry of communications (Acemoglu, 2005). This single government entity typically operates both the national carrier and the regulator, giving the ministry direct control over the ICT sector with little input from other government ministries. With a monopoly operator and a weak regulatory structure, developing countries find themselves with significant instability in the market due to political influences (Smith, 1999). This instability can be caused by sudden changes to licensing or foreign ownership rules, which can shift due to political considerations and significantly increase the risk in an already high-risk market. With a weak regulatory framework and high levels of risk, the market attracts only a limited amount of domestic and international investment – further hampering efforts to expand the national networks and markets.

Challenges

There are several challenges facing countries attempting to move out of this stage and into the next. Economic, geographic, and political conditions can all conspire against even the most strident efforts to accelerate ICT adoption within a low-income country (Selwyn, 2004). In addition to these macroeconomic and political conditions, there are several ICT market-specific hurdles that prevent reform efforts. One of the largest hurdles is the political and market power of the state-owned enterprise, which has little reason to support an ICT reform process that would reduce its role in the sector. In addition, the operator's large profit margins can develop into a steady stream of government revenue, limiting incentives for the central government to take action and making it politically and financially difficult to move into the second stage.

Stage Two: Pre-Conditions for Takeoff

It is important to note that many developing countries have not experienced the rapid growth in ICT adoption due to political or economic instability (Quinn, 2001). However, once the process has begun, these developing countries can grow their ICT markets very quickly, with some countries (such as Malaysia) moving from stage one to stage three in as few as five years. Developing countries have completed several pre-conditions prior to reaching the second stage. For most developing countries, these pre-conditions include regulatory reform, market liberalization, and increases in public and private sector investment (Briceno-Garmendia, 2004). This section will examine the necessary pre-conditions for developing countries to support a takeoff in their ICT adoption rates.

There are several other developing countries that have also begun the process of rapid ICT adoption and are currently working toward the pre-conditions for this acceleration. Although governments at this stage are moving away from monopoly authority, they are still the primary driver of investment within the sector. With this primary role, governments should balance the larger revenue commitments to the country's economic and social needs against their spending in the ICT sector (Kozma, 2005). As a result, developing countries should carefully assess the risks of directly supporting their ICT markets. These governments should also determine which ICTs are most appropriate for accelerating adoption based on the current sector environment and the available technology options.

The chart in Exhibit 2.5 contains several countries at stage two. These countries have a wider range of adoption rates across the four sectors (i.e., mainlines, mobile, Internet, and broadband) than was seen in the stage one countries. Several countries have reached very high levels of mobile phone usage, including South Africa, which has a mobile sector in stage four. However, South Africa and many of these other countries have been slow to build out their fixed line infrastructure, as demonstrated by the mainline, Internet, and broadband penetration rates listed below. Another example of this is the Philippines, which has reached stage three for its mobile sector but is mired in stage one for the other three sectors. This lack of infrastructure has prevented the Philippines and other countries from experiencing accelerated adoption rates outside of the mobile sector.

In contrast, countries such as China have already achieved penetration rates that are very close to the boundaries to stage three across several sectors (Tang, 2003). China has already seen rapid increases in adoption in its fixed and mobile sectors as well as in its broadband sector, albeit from a very low base. The country is also a good example of a developing country with wide disparities between rural and urban regions, with a large majority of broadband users in urban areas. National statistics hide the low rates of penetration in rural areas, which in turn may limit future growth as China's urban centers reach saturation points.

Exhibit 2.5: Examples of Countries in Stage Two of ICT Adoption

	Mainlines	*Stage for Mainlines*	Mobile users	*Stage for Mobile*	Internet users	*Stage for Internet*	Broadband users	*Stage for Broadband*	**Stage Index**
Botswana	74.8	*1*	466.3	*3*	34.0	*1*	0.0	*1*	**2**
China	268.6	*3*	301.6	*3*	85.1	*1*	28.7	*2*	**2**
Indonesia	57.9	*1*	212.7	*3*	72.5	*1*	0.2	*1*	**2**
Jordan	119.2	*2*	303.6	*3*	117.7	*2*	1.9	*1*	**2**
Mexico	189.3	*2*	460.4	*3*	180.6	*2*	22.4	*2*	**2**
Philippines	40.5	*1*	418.7	*3*	53.9	*1*	0.7	*1*	**2**
South Africa	100.9	*2*	724.3	*4*	108.8	*2*	3.5	*1*	**2**
Thailand	109.5	*2*	429.8	*3*	110.3	*2*	0.7	*1*	**2**
Ukraine	255.9	*3*	365.7	*3*	96.9	*1*	0.0	*1*	**2**

Source: World Development Indicators, 2006. Number of users in thousands for all four indicators.

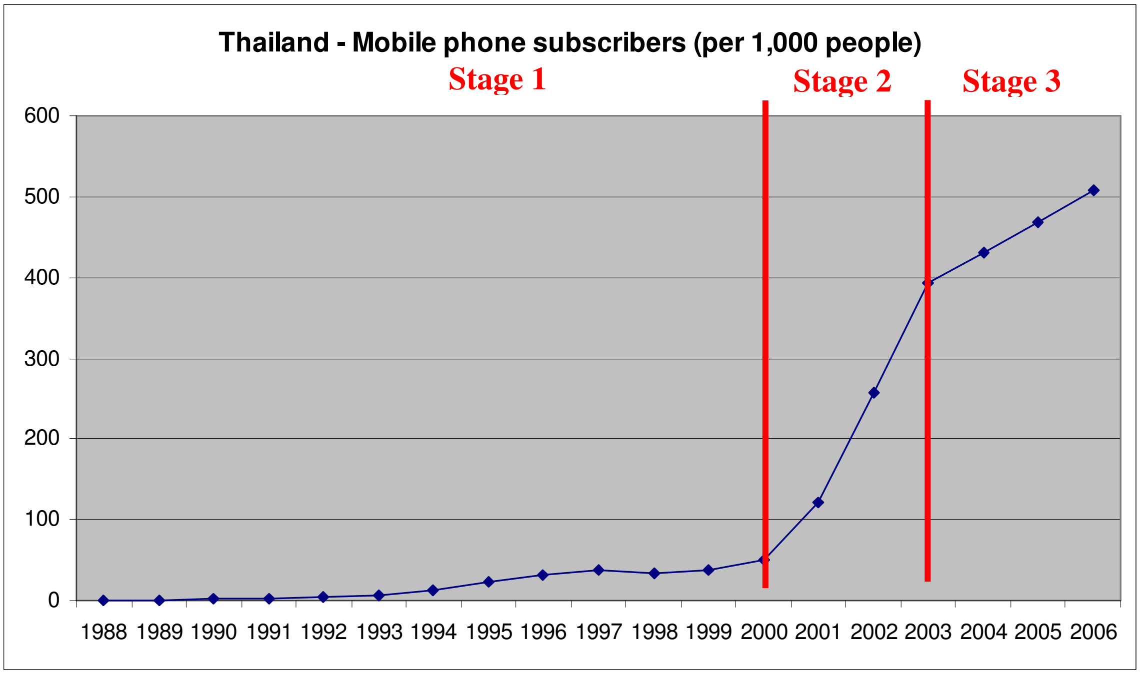
ICT Adoption

Countries at this stage tend to be low-income or lower-middle-income countries that have pushed their monopoly to expand services while beginning to introduce some policy reforms and mobile sector competition. However, socio-economic and demographic conditions within low-income countries can become a significant challenge for accelerating ICT adoption (Baliamoune-Lutz, 2003). Potential ICT subscribers in these countries typically have limited income to devote to telecommunications services, while local businesses within the agricultural and manufacturing sectors may have little need for ICTs. There are also thresholds where countries are simply too politically or economically unstable to see a rapid ICT adoption. However, it is important to remember that income levels alone do not determine the success of an individual country. Developing countries that have already seen their ICT sectors take off display a wide variety of socio-economic characteristics, but countries that can meet minimum thresholds for economic development can move quickly through the five stages.

Additionally, there are no hard limits on how far or fast a country may see its ICT market progress. Currently, South Korea has a per-capita income that is several times lower than the US or Western Europe, but the country has quickly moved toward the top globally for broadband, fiber access, and mobile services – surpassing the US in all three of those metrics (OECD, 2007; World Bank, 2006). This suggests that the most important factors are not simply economic, but rather market-specific: strong ICT regulation and support, healthy competitive environment, and robust network infrastructure.

Exhibit 2.6 depicts the mobile services adoption rate for Thailand, demonstrating that the country's mobile telephony penetration rate began to stall almost immediately after reaching stage three. At the same time, three of the four ICT metrics for Thailand are either in stage one or two – with an average at stage two overall for the country's ICT sector. The boundaries for the phases have been placed where the mobile penetration rates accelerated, pushing the country rapidly from stage one to two. Once reaching stage three, Thailand's mobile phone operators could no longer reach a steady base of urban customers, forcing them to either slow their subscriber growth or increase their network investment. Based on interviews with the mobile operators, these private companies were reluctant to increase their investment due to the unstable regulatory and political environment. Instead, they chose to reduce their capital investments, which in turn caused the country's adoption rate to stall in stage three.

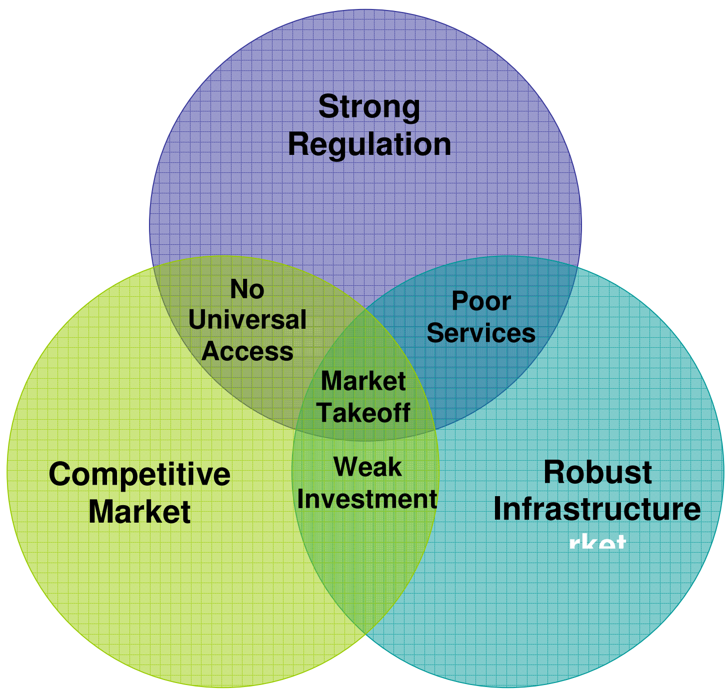
Exhibit 2.6: ICT Adoption Stages Applied to the Thai Mobile Sector



Source: International Telecommunication Union, 2006.

The figure below in Exhibit 2.7 depicts the problems facing developing countries that only have two of the three components mentioned above. Markets with a strong regulator and competitive market, but with geographic challenges that limit network reach as in the Philippines, can still have rural or low-income areas without access. Countries without a strong regulator, such as South Africa, face a weak investment environment due to the heightened risk associated with an unstable regulatory regime (Acemoglu, 2003). For developing countries without a competitive market, the current network infrastructure may provide universal access. However, the lack of competition will still result in expensive and often unreliable services, as we have seen in the Gulf States (Keivani, 2003). Only countries with a strong regulator, competitive market, and robust infrastructure such as South Korea can initiate rapid acceleration within the market (Lee, 2004).

Exhibit 2.7: Rapid ICT Adoption Requires Strong Regulation, Market Competition, and Robust Infrastructure



Competitive Landscape

Another important challenge facing latecomer countries prior to takeoff is an ICT market with large pent-up demand for basic voice and data services. This demand comes from both consumer and business sectors, which had previously been unable to afford services under the monopoly operator. As a result, penetration rates within these markets have been kept artificially low by this lack of price competition, resulting in excess demand that can be quickly tapped by competitively priced services from new market entrants.

Once new entrants introduce this competition into the market, services will be improved almost immediately while access will be quickly expanded – causing rapid growth in the size of the market (Gruber, 2001). This market growth also creates opportunities for new services such as mobile services, applications, and video, adding to the initial wave of telephony and narrowband data services. At this stage, fixed lines have become increasingly common in the urban areas, but there are still long waits for connections and few rural users. Mobile phones have become more prevalent in urban and high-income areas.

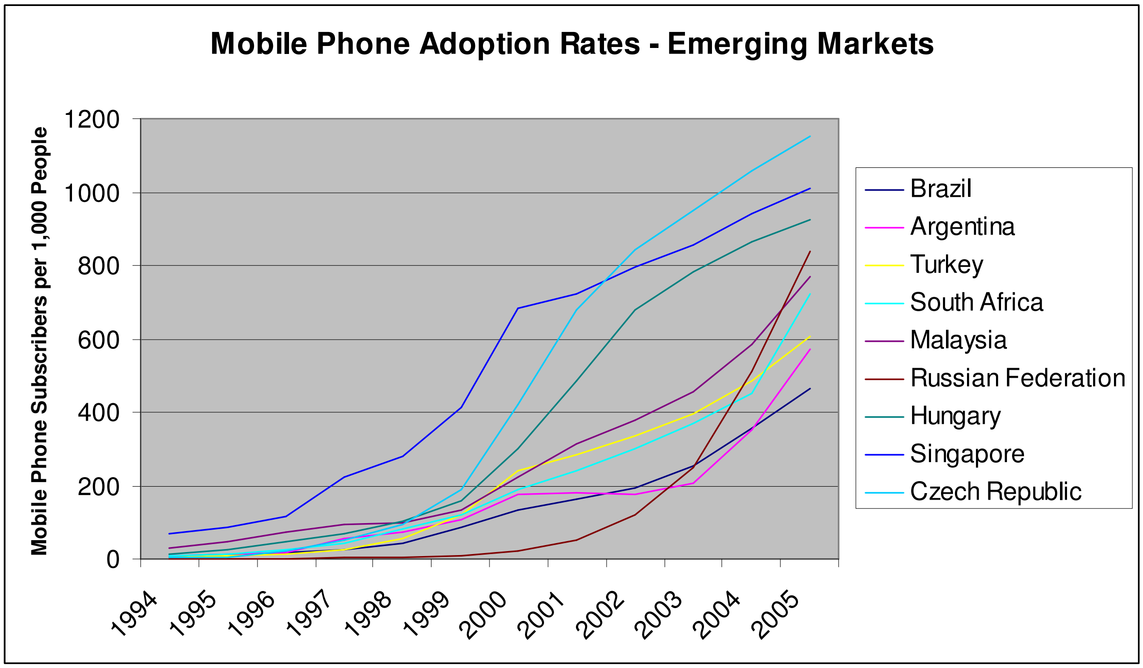
Even as competitive players are introduced into the market, they tend to be limited to mobile and Internet services while restricting their services to high-income and urban areas – regions where competitive operators can find a concentration of users capable of supporting financially sustainable margins (Proenza, 2006). In contrast, there is still limited or no fixed line competition with the governmental Postal, Telegraph & Telephone (PTT) within the fixed line sector at this stage. This situation of uneven competition can lead to mobile phone penetration accelerating early in stage two and quickly surpassing fixed line penetration.

Network Infrastructure

At stage two, there is little existing network infrastructure and those few network deployments that are completed under the monopoly tend to focus on government facilities, large enterprises, and urban consumers (Smith, 1995). Although this limits available services, it forms a baseline of access and core network infrastructure that can be expanded to offer new services. National networks within these markets tend to support 10 to 20 percent of the population, which is a small base but large enough to create a backbone network to support the rapid expansion of services once the market is liberalized. Developing countries without this baseline of infrastructure lack a necessary pre-condition for takeoff, and will have a significantly longer ramp-up period as they build out new infrastructure to support the rapid increase in demand.

Exhibit 2.8 includes several developing countries that have undergone rapid acceleration of their markets, as demonstrated by their mobile phone sector in particular. The countries included below are not inclusive of all developing countries that have undergone this acceleration, but Exhibit 2.8 demonstrates that market takeoff is not limited to one region or one level of economic development. It also demonstrates that countries that start the process later can still catch up and even surpass markets that accelerated earlier. This is demonstrated by the growth in the Russian market, which did not begin until 2002 but has now quickly outpaced countries such as Turkey that saw their markets accelerate in the 1990s.

Exhibit 2.8: Mobile Sector Growth across Developing Countries



Source: International Telecommunication Union, 2006.

Regulatory Structure

The traditional regulatory structure within developing countries included both their national regulator and monopoly operator within the Ministry of Communications, which in many cases resulted in a heavy bias of competitive regulation in favor of the incumbent. This has made balanced regulatory oversight and the introduction of new competitive operators within a country's market very difficult. With the privatization of the operator and the creation of an independent regulatory agency, a developing country can become a market that supports competition across the range of technology platforms and services.

The institutional reform process begins slowly in this stage with the creation of an independent regulatory agency (Melody, 1997). This agency is separate from the rest of the government ministries, with commissioners confirmed by the legislature and often not directly reporting to the Ministry of Communications. This national regulatory agency becomes responsible for setting tariff prices, determining the universal service obligations of carriers as well as the proper mechanism for disbursing these funds, spectrum and service licensing, and other regulatory functions that were previously housed in the parastatal.

National ICT Policies

At this stage, universal access efforts are the highest priority among the national ICT policies. This will continue through the takeoff stage and then become a secondary concern during market maturity in the fourth and fifth stages. Universal access efforts are focused on expanding services beyond major urban areas and adding data to existing telephony services. This also includes government-financed efforts to ensure connectivity to ministerial offices, schools, hospitals, and other socially important facilities. Although not common, several countries at this stage have introduced a universal service fund (USF) (Garcia-Murillo, 2005). More often, countries will wait until the next stage, where there is a critical mass of competitive operators and users, to introduce a USF. These funds use a percentage of operator revenues to build out network access infrastructure while placing obligations on operators to serve rural and low-income areas. These obligations are typically part of spectrum and service licensing arrangements between operators and the regulator.

Another key component of the ICT policies at this stage are governmental initiatives that seek to bolster the adaptation of imported ICTs by local technology firms for use domestically (Oyelaran-Oyeyinka, 2006). As these lower-middle-income countries become more integrated into global supply chains, they are seeing corresponding increases in trade, international investment, and technology transfer. Although increased integration into global business and ICT networks can accelerate this technology transfer, these countries still tend to have limited ability to customize imported ICTs to meet local market requirements (Archibugi, 2003). Governments can work with their private sectors to bolster their ICT innovation capabilities and increase their necessary skill sets to innovate international technologies for local consumption (Hoekman, 2004).

Institutional and Regulatory Structure

Governmental authority for supporting ICT access and industry development is also shifted from the Ministry of Communication and is split among several agencies including communications, science and technology, industry, finance, and this new regulator (Makhaya and Roberts, 2003). With this liberalized telecommunications sector, the government can avoid the heavy responsibilities of directly commanding the market. Instead, the government can then focus policy efforts toward expanding both supply and demand across the country through indirect initiatives, such as universal service funds and targeted access programs.

Benefits and Challenges

Lower transaction costs are one of the largest benefits for developing countries as they begin the process of diffusing ICTs. Firms with little or no access to market supply and demand information have significantly higher transaction costs (Furman, 2004). This lowers firm productivity and reduces responsiveness to the market, which in turn can hamper economic growth within the country. By deploying telephony and narrowband data services, countries can begin the process of improving firm-level productivity. Expanded access for firms and residents can also help create a critical mass of local users that can launch local content and innovation (Bar, 2000). By moving to this second stage, countries may begin to see individuals and firms expanding the range and depth of available local content. Prior to this stage, Internet users would have to rely on international sources, which may not be in the correct language or be tailored for local consumption.

Other areas that benefit from expanded access and lower prices are the healthcare and education sectors (Akinsola et al., 2005). Both require access to online resources, either from domestic or international facilities, to improve their services to local residents. Within the healthcare sector, these efforts can include connections for rural clinics to consult with urban hospitals. In the education sector, facilities can gain access to materials and trainers domestically and internationally to expand course offerings. These are just two examples of many public sectors that can benefit from affordable access to voice and data services.

This transition in regulatory and institutional structure creates an opportunity for the private sector to take on a larger role in the ICT industry and begin to exert greater influence on government policy reforms (Bortolotti, 2002). Countries that move on to stage two can harness this private sector participation to collaborate on reforming national ICT policies and goals. This public-private coordination will be vital for successful acceleration of ICT adoption within the third stage as well. However, few developing countries can successfully manage this process (Bortolotti, 2007). Other major hurdles at this stage include successfully executing the privatization of the monopoly, which can be hampered by political and financial considerations. Governments should also ensure that the regulatory agency has the necessary independence and authority to counter-balance the market power of operators so that it can successfully monitor and adjust the competitive landscape.

Stage Three: Takeoff with Expansive Growth

Developing countries within stage three are typically middle-income and are undergoing a rapid acceleration of ICT adoption. This stage is predominately kicked off by governmental efforts to create a liberalized ICT service market with competitive providers that both expand services and lower prices. These developing countries also have a solid foundation of fixed, mobile, and Internet utilization across the population. Developing countries at this stage can utilize their existing base of backbone networks and mobile infrastructure to rapidly expand their adoption rates in the mobile phone and Internet access sectors. It is important to note that upper-middle-income countries are also included in this stage due to their relatively poor ICT infrastructure, policies, and regulation. In both upper- and lower-middle-income developing countries, these newly competitive ICT sectors can finally meet the pent-up demand of consumers and firms, propelling many of these countries to market saturation levels in as few as five years.

The countries listed in the chart below in Exhibit 2.9 have reached stage three, although the levels of variation across the four sectors are similar to those in the second stage. Several countries have dissimilar ICT metrics, including the Czech Republic, which has reached stage five in its mobile sectors but has only reached stage two in broadband adoption. This disparity in penetration rates is due primarily to the low marginal costs of adding new mobile subscribers versus the costs and deployment times of broadband networks. It is also important to note that when determining a country's stage and trajectory, quantitative ICT metrics should be considered within the larger context of institutional, policy, regulatory, and market reforms that a developing country may have undergone. Others, such as Costa Rica, have reached stage three for three of the sectors, but have also been slow to adopt broadband services. Still others, such as Malaysia, have reached stage four for mobile and Internet usage, but only stage two for fixed and broadband services.

Variations in penetration rates like these are caused by a number of factors, including regulatory and market competition, but the underlying costs of the technology for these four different sectors also play a key role (Cava-Ferreruela, 2006). The cost for fixed and broadband networks is dramatically higher than mobile and Internet networks. This drives operator costs higher, which in turn can limit new entrants in the market. In addition, these higher costs also make end-user prices unaffordable, which can limit adoption rates within developing countries for that sector.

Exhibit 2.9: Examples of Countries in Stage Three of ICT Adoption

	Mainlines	*Stage for Mainlines*	Mobile users	*Stage for Mobile*	Internet users	*Stage for Internet*	Broadband users	*Stage for Broadband*	**Stage Index**
Argentina	227.1	*3*	570.4	*3*	177.1	*2*	21.7	*2*	**3**
Brazil	230.4	*3*	462.5	*3*	195.0	*2*	17.7	*2*	**3**
Chile	210.9	*3*	648.6	*4*	171.8	*2*	43.5	*2*	**3**
Costa Rica	320.9	*3*	254.4	*3*	254.2	*3*	6.6	*1*	**3**
Czech Republic	314.4	*3*	1150.7	*5*	269.5	*3*	43.7	*2*	**3**
Malaysia	172.2	*2*	771.1	*4*	434.6	*4*	19.4	*2*	**3**
Poland	309.3	*3*	764.2	*4*	262.0	*3*	32.6	*2*	**3**
Russian Federation	280.2	*3*	838.5	*5*	152.3	*2*	11.1	*2*	**3**
Turkey	263.3	*3*	605.1	*4*	222.0	*3*	22.1	*2*	**3**

Source: World Development Indicators, 2006. Number of users in thousands for all four indicators.

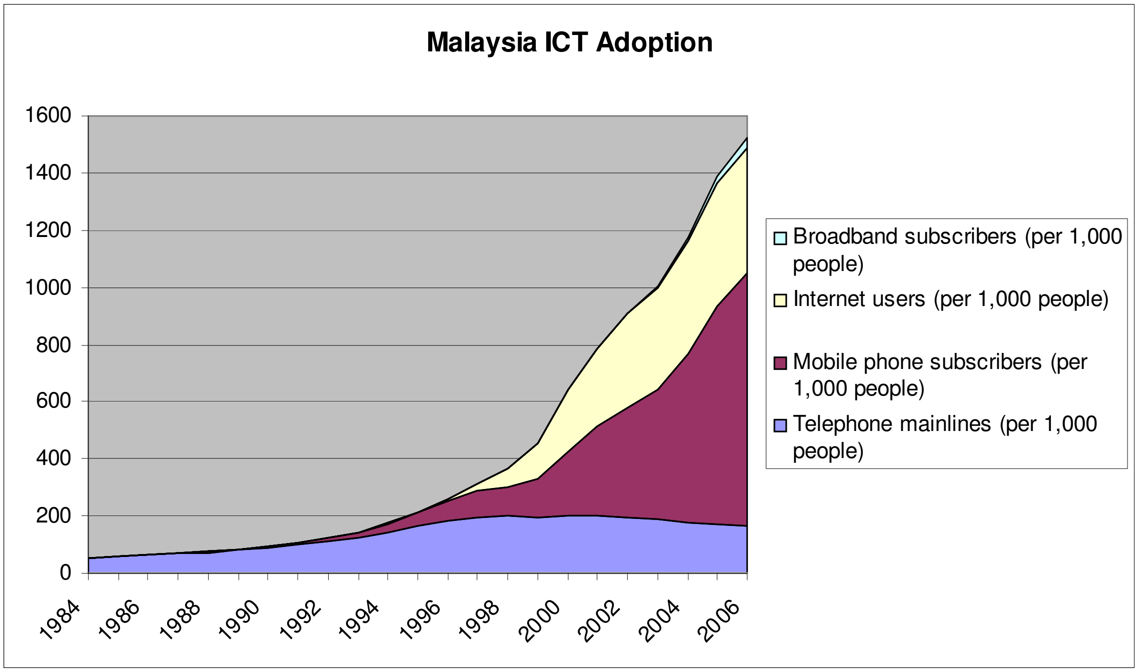
ICT Adoption

During this stage, there is rapid expansion of both residential and business users, particularly in dense urban areas. Fixed line voice and data services are available to a majority of firms while mobile phone service becomes commonplace among residential users. Typically, countries in this stage see their narrowband and broadband Internet access services lag behind a surge of mobile users. This is due to the limited deployment of fixed line services to households, which are required for most narrowband or broadband residential services.

The mobile penetration rate for many of these countries quickly outpaces the fixed line services of the incumbent, moving from less than 10 percent penetration to over 50 percent. The graph in Exhibit 2.10 shows the fixed, mobile, Internet, and broadband adoption rates of Malaysia, which transitioned to a developed country penetration rate for mobile services in five years. Although broadband Internet access is still small at the household level, and limited to the village level in rural areas, Internet access through dial-up is still growing quickly, especially in areas with competitive providers. Fixed line services have still been slow to change, with little investment in this infrastructure. As broadband begins to take off within Malaysia and other countries during this stage, these countries may experience an increase in fixed line capital spending. Exhibit 2.10 below presents Malaysian adoption rates across the four key areas within the ICT sector. The mobile phone and Internet access sectors both have seen rapid growth due to market liberalization in the 1990s that resulted in the privatization of the monopoly and the creation of an independent regulatory agency. As a result of this liberalization process, these two sectors also saw increased levels of competition, lower prices, and a rapid rise in demand. In contrast, the fixed line telephony and broadband sectors were slow to reform, resulting in limited competition and lower levels of demand.

As demonstrated below, Malaysia's mobile phone adoption rate has reached almost 80 percent, surpassing mature markets such as Japan in 2005, while its fixed lines have actually declined from 20 percent down to 17 percent. In response to saturated mobile markets like Malaysia's, several developing country operators have begun to invest internationally to grow revenues and maintain margins – a strategy similar to that of the mobile carriers in the saturated European markets. Examples include Telekom Malaysia and Singapore Telecom, which have both grown into regional powerhouses by expanding from their saturated home markets (which reached over 100 percent penetration in Singapore by 2005) into neighboring countries such as India and Indonesia.

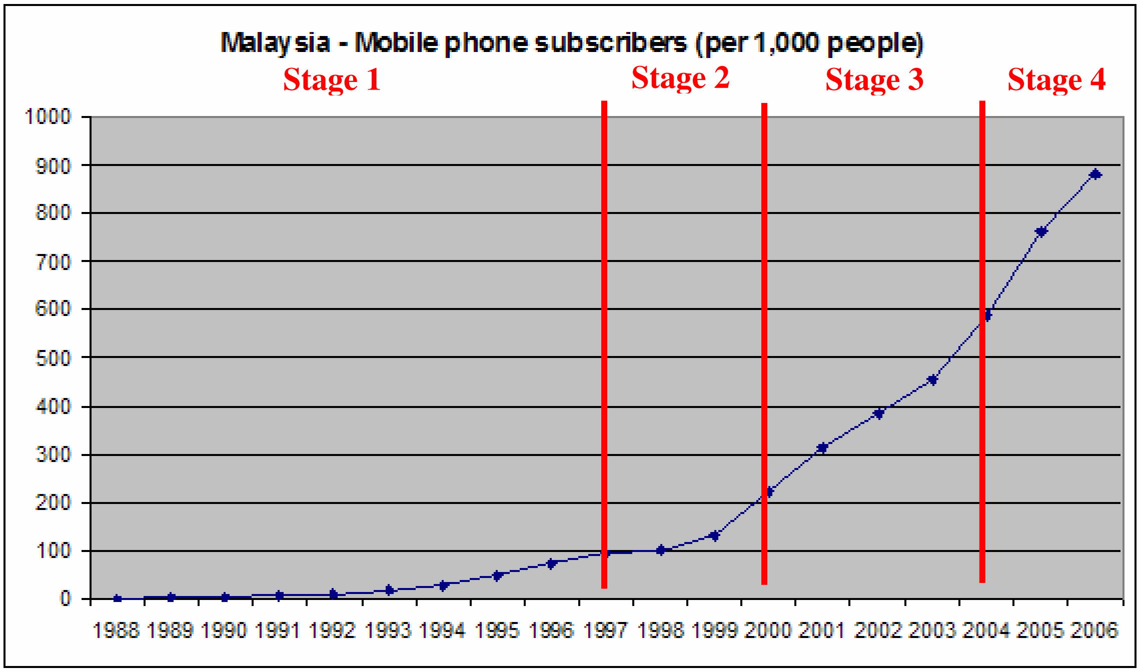
Exhibit 2.10: Malaysian ICT Adoption Rates



Source: International Telecommunication Union, 2006.

Exhibit 2.11 depicts the growth of the Malaysian mobile phone market, which has seen tremendous growth since entering stage two in the late 1990s and has now surpassed Japan in its penetration rate. The market liberalization process and the introduction of competition into the sector created the necessary environment for accelerated adoption of the technology. In addition, a transparent institutional and regulatory reform process has allowed for a more stable political and macroeconomic context, which has increased domestic and international investment into the sector. This has given Malaysia's mobile sector the capacity to quickly cycle through stages two, three, and four, and it is forecasted to enter stage five based on 2006 estimates. Similarly, Internet access has grown quickly within the country, as seen in the country table in Exhibit 2.9. In contrast, fixed lines and broadband penetration have lagged behind in stage two, with little growth in either market.

Exhibit 2.11: ICT Adoption Stages Applied to the Malaysian Mobile Sector



Source: International Telecommunication Union, 2006.

Competitive Landscape

The competitive levels across the four sectors within these countries are very uneven. Countries are currently experiencing limited or no competition in some sectors, such as broadband, and heavy competition in others, such as mobile. Developing countries with heavy competition and strong regulation in the mobile phone and Internet sectors will see price competition between these operators beginning to emerge as service adoption rates take off and carriers scramble for new customers (Nunn, 2004). This higher level of competition for customers also drives carriers to quickly expand their networks, offering coverage for 70 to 90 percent of the population, while also enhancing the range of service offerings.

With a majority of fixed line options still limited to the former monopoly, ISPs still have difficulty finding a sustainable business model at this stage. ISPs are forced to use wholesale services from the incumbent operator to reach their customers. Without a strong regulatory structure around these wholesale tariffs, it is easy for the incumbent to leverage its market power to price out competitive providers. Despite these hurdles, countries in this stage can begin to experience expanding Internet and broadband services (Osterwalder, 2004). Narrowband competition is much stronger among ISPs because only a local telephone line is required, whereas broadband competition is typically only in urban areas due to limitations in access networks.

Network Infrastructure

With this rapid service expansion, operators move quickly to transform their backbone and access networks to support a range of voice and data services, along with planning for upgrades to allow for new capabilities, such as video applications. To address these network requirements, developing country operators have moved toward next-generation solutions that lower capital costs and operational complexity – leapfrogging the legacy infrastructure that has hampered network transformation by incumbents within developed countries. Providers that deploy these next-generation solutions include fiber-based platforms and mobile broadband solutions in the access network and next-generation protocols in the backbone.

National ICT Policies

For many countries in this stage, there is a transition from universal access to universal service as the focus for national ICT policies (Gasmi, 2000). While universal access focuses network deployment at the village level, universal service aims to deliver mainline services at the household level and mobile services at the individual level. This shift toward universal service requires a significant increase in infrastructure deployment to ensure that the network has the necessary capillarity to reach individual users. In turn, this requires a rapid expansion in the universal service effort, including additional funding, an expanded number of target regions, and additional services beyond telephony. The USF continues its traditional role of targeting rural users with voice services, but the fund also increases its support for Internet services as well as low-income urban regions (Garcia-Murillo, 2005).

Looking to increase demand for ICT services, governments will increase their training programs to expand ICT utilization in these target areas (Rahman et al., 2005). These training programs also increase the supply of skilled workers for local and global technology firms. e-Government initiatives are also prevalent as governments seek ways to streamline their inefficiencies as well as expand citizens' access to government programs and information (Lehr, 1998). The policies also support increases in voice and data services coverage for business users as well as expanded competition and lower prices for international capacity, which becomes increasingly important with expanded trade and international investment in ICT sectors.

National ICT policies also focus on supporting the local ICT industry, which can begin to reach a critical mass at this stage (Kraemer, 2001). Although most of these local businesses are not globally competitive, they are beginning to take a share of the local ICT market for hardware, software, and communications services. This is particularly true of technologies that need to be tailored to meet the demands of the local market. Advanced ICT sectors in some countries may begin to focus on a few niche industries where they have a global competitive advantage, seeking to expand their ICT exports with a coordinated effort by public, private, and university resources. One example of this is the creation of a software industry in Brazil that has begun to expand beyond the domestic market and that has been supported by both public and private sector efforts (Arora and Gamnardella, 2004).

Institutional and Regulatory Structure

Countries that have not transitioned their market regulation from a government ministry to an independent regulatory agency tend to begin this process at this stage. This formalized structure makes the regulatory environment more stable, opening the market to additional domestic and international investment. In addition, once the monopoly provider has been privatized, the former incumbent will see its market power and political clout reduced, helping to rebalance the competitive environment. This new regulatory environment creates more favorable conditions for new entrants, including easier access to capital, government support through universal service funds, and affordable wholesale access. As mentioned above, wholesale access is a key component to opening up the ICT sector to competition, especially for competitive providers without the network reach to offer widespread services. In response, many governments have moved to open up the former monopoly's backbone with favorable wholesale rates. However, wholesale regulation remains a contentious issue in many markets, including developed countries such as the United States, where regulators struggle to find effective regimes and rate reductions to support competitive players.

Developing country governments also begin to alter their role as adoption accelerates during this stage and the private sector begins to take the lead in investment and technology choices (Bortolotti, 2007). At this stage, the ICT institutional structure will often be combined into one ministry, such as the Ministry of ICT (MICT) in Malaysia, which has the ministerial authority to lead national ICT policy design and implementation. Although the MICT does not have the centralized power of the former parastatal, it does offer middle-income countries the critical mass of expertise and budget to design and execute national ICT policies. In many instances, a middle-income country may have its ICT experts spread among four or more ministries, limiting their coordination and effectiveness. The creation of the MICT can be an important step to initiating and sustaining the accelerated ICT adoption process.

Benefits and Challenges

During this third stage, infrastructure will begin to be more widely deployed in rural areas and adoption rates for basic services will take off. Although there tend to be wide disparities between urban and rural adoption rates, access levels will reach a point where rural services finally have gained traction. The main difference between stages two and three is the scale of deployment. In stage two, rural users must rely on village-level connections and may have no access to the Internet. In the third stage, a larger number of rural users finally can gain access to telephony and the Internet at the household level, helping to reduce the high transaction costs common in these areas. As discussed in the previous section, this can be a large benefit for rural users and firms that have previously been without affordable access.

Another important benefit of reaching this stage is the appearance of a local ICT industry. Prior to this stage, most countries have few ICT clusters and instead rely on foreign imports for equipment and expertise (Thompson, 2002). This limits the economic benefit of adopted technologies because they are not tailored to the local environment nor are they integrated into the economy beyond those firms that are MNC suppliers. With the advent of a local ICT industry, information technologies can be customized for local use, which in turn can accelerate the development of local expertise.

Another benefit to countries at this stage is their expanded e-governance programs, which can streamline government operations while increasing citizen access to government services. To improve government operations, many countries begin internal programs to interconnect government facilities with networks while standardizing software and database application to improve efficiencies (Banerjee, 2004). e-Governance efforts focused on expanding citizen access to government services include kiosks and online portals for government forms, records, and taxes. For countries that had previously required in-person visits to the capital, these efforts can save citizens in rural areas several days of travel to complete required paperwork (Kyem and LeMaire, 2006).

This acceleration requires a quick evolution of national ICT policies and institutions to support the continued development of a competitive market and local ICT industry. This stage is very difficult to sustain, particularly with the political considerations that may slow the pace of reform and hinder the development of the sector. Many developing countries that could not sustain the reform process have seen their adoption rates plateau prematurely, leaving many segments of the country without affordable access.

Another challenge for countries in this stage is the higher cost of deploying infrastructure in sparsely populated areas, which cannot be easily overcome even with these new ICT network solutions. This sizable cost difference results in a significant split between the network infrastructure deployed to urban versus rural regions, leaving rural areas with limited network access. This is due to the higher rural costs, which drive operators to use alternative solutions, such as satellite and fixed wireless, to reach their customer base. This disparity in technology options and network costs between urban and rural areas will continue to exacerbate gaps in ICT access across developing countries.

Stage Four: Drive to Mass Market

Countries that have reached the mass-market stage typically include upper-middle-income and high-income countries that have substantial ICT markets servicing a majority of their populations covered by fixed, mobile, and Internet services. Once developing countries have reached this stage, they have markets, regulatory structures, and technologies that are relatively similar to those of developed country ICT sectors.

This enables them to quickly move past some mature markets in the adoption of new technologies, such as mobile services, opening up new opportunities for the domestic ICT industry. For some middle-income countries that have reached this stage, there still may be a lag in fixed line penetration rates. In fact, this fixed line sector may never reach market saturation levels due to the substitution of fixed line services with mobile services. This relative dearth of fixed line infrastructure may impact countries in this stage as they move to expand broadband and fiber access networks. However, it does not hamper the countries' ability to increase ICT utilization or to develop a local ICT industry.

The chart below in Exhibit 2.12 contains several of the countries at stage four of ICT adoption. At this stage, there is less variation between countries in their adoption rates across the four sectors. Several developed countries, such as Japan and Ireland, are near the cusp between stages four and five. Japan is very close to the threshold for stage five in its mainline, mobile, and broadband usage, and it is a global ICT exporter with a strong institutional and regulatory structure. Overall, this would place Japan in stage five despite the slightly lagging adoption within some of its ICT sectors. Countries such as Japan highlight the blurring between stages four and five as well as the importance of using these four metrics only as guidelines.

Exhibit 2.12: Examples of Countries in Stage Four of ICT Adoption

	Mainlines	*Stage for Mainlines*	Mobile users	*Stage for Mobile*	Internet users	*Stage for Internet*	Broadband users	*Stage for Broadband*	**Stage Index**
Hungary	332.7	*3*	924.0	*5*	297.4	*3*	64.6	*3*	**4**
Ireland	488.8	*4*	1012.2	*5*	275.7	*3*	65.1	*3*	**4**
Japan	460.0	*4*	741.5	*4*	667.5	*5*	175.0	*4*	**4**

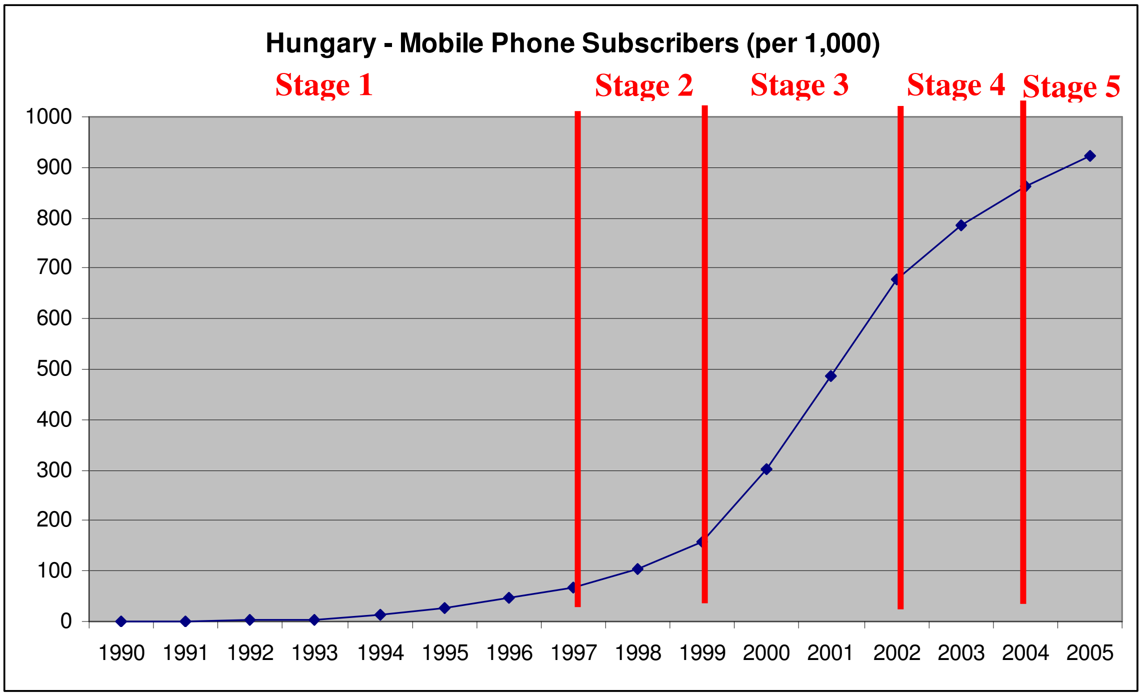
Source: World Development Indicators, 2006. Number of users in thousands for all four indicators.

ICT Adoption

For countries that have reached this stage, ICT adoption rates are very similar to those of mature markets. Internet access becomes widespread in this stage, with narrowband and mobile phone coverage reaching over 90 percent of the population and usage rates exceeding 50 percent. Businesses, even small and medium enterprises (SMEs), have widespread adoption of voice and data across the country. However, rural or low-income regions and low-skilled industry verticals will continue to lag behind the national average. Countries such as South Korea have already surpassed most Western European and North American markets in terms of mobile, fiber, and broadband metrics (OECD, 2007). Other developing countries at this stage may not match South Korea's success across three sectors, but instead have a single sector, such as mobile phones, where it has surpassed mature markets and reached market saturation.

Exhibit 2.13 depicts the almost perfect s-curve slope to the growth of the Hungarian mobile market. The market was able to move from the early adopters of stage one in 1997 to the market saturation of stage three by 2003. This growth was initiated by a telecommunications reform process in the mid-1990s and a maturation of mobile infrastructure that lowered costs and enhanced service quality. The mobile market has seen tremendous growth, outpacing the fixed line, Internet access, and broadband markets, which are all still within stage three.

Exhibit 2.13: ICT Adoption Stages Applied to the Hungarian Mobile Sector



Source: International Telecommunication Union, 2006.

Competitive Landscape

Despite reaching ICT market saturation in some sectors, developing countries at this stage will still face uneven ICT competition across their various regions and service sectors (Gasmi, 2000). Rural areas and fixed line services will continue to see few investments made by competitive operators, resulting in higher prices and fewer services. In contrast, urban areas and mobile services will experience the highest levels of competition and will receive pricing and service benefits. The mobile sector in particular will see several competitive players competing heavily on price, quality, and new services. In addition, as mobile broadband services are deployed, these mobile operators will begin to compete directly with the fixed line incumbent. As a result, wireless and fixed line carriers compete with one another for the same customers with similar service portfolios (Proenza, 2006). Although adoption of mobile broadband technology is still nascent, it has the potential to remake the competitive landscape, creating new avenues for broadband adoption in developing countries. In addition to the mobile sector, the ISP sector will also become intensely competitive as Internet access services begin to reach a majority of households.

In contrast, broadband networks and services in many countries still have very limited deployments, covering only a small portion of the population. However, areas with service have begun to see significant competition on service and price between the former monopoly and new market entrants (Baer, 1995). Competitive broadband providers in these markets use a combination of wholesale arrangements to offer services as well as their own next-generation networks in select areas. Several developing countries, including Singapore, have developed national network deployment plans to support greater broadband access and competition while accelerating the supply of fiber access infrastructure.

Network Infrastructure

As discussed above, the reliance on mobile telephony at the expense of fixed line infrastructure can leave many developing countries without adequate broadband access. This limited fixed line infrastructure leaves carriers without the necessary last mile access to deliver widespread broadband services (Crandall, 2003). As a result, mobile broadband, such as third generation (3G) wireless, and alternative wireless solutions, such as WiBro in South Korea, have become much more attractive to developing country operators to deliver broadband services. These wireless solutions reduce capital and operational expenses and are becoming more reliable for delivering high-capacity services (Proenza, 2006). Without extensive copper assets to maintain, fiber deployments can also be cost effective, with their reduced operational costs and expanded set of data and video services to drive operator profits.

National ICT Policies

For countries at this stage, universal service undergoes a second transformation after shifting from universal access in the third stage. Although rural telephony access will always remain a policy goal, the majority of the government's initiatives will now focus on expanded broadband access and boosting utilization (Lee, 2004). Expanding end-user utilization will require public-private coordination to develop content and applications that are customized for the local market and high-capacity connections. These policies can include a national deployment strategy, like Singapore's, along with budget for subsidizing broadband network rollout through operator and end-user universal service fees.

Another key policy goal for countries within this stage includes bolstering national capacity and innovating ICTs while increasing the competitiveness of local businesses through higher utilization rates. To achieve this goal, governments require a tightly coordinated public-private-academic ICT R&D effort that seeks to commercialize ICT research for domestic consumption (Amsden, 1997). This is a difficult process that few developing countries have successfully implemented and sustained. In addition, this also requires an expansion of tertiary ICT education to increase the number of highly skilled workers available to local business and R&D facilities for this effort.

Institutional and Regulatory Structure

Once the accelerated adoption rate begins to flatten due to saturation in the market, the institutional structure begins to reform again. During this stage, the MICT may begin to share more of its authority with the other ministries, such as the ministries of education or health. This diffusion in turn reduces the government's direct role in the industry while expanding the government's focus across a wider set of support efforts in public, private, and academic activities.

Within this stage, the focus of the national regulator shifts from introducing market competition to enforcing the competitive balance. Regulators work to ensure carriers offer affordable and reliable services without amassing excessive market power that could hamper competition. As mentioned above, these universal service efforts have evolved from simple telephony services to include broadband as well. In response, the government moves to support expanded broadband access in rural and low-income areas. Developing country governments, such as those in Singapore and South Korea, are also launching fiber initiatives while supporting growth of traditional broadband infrastructure.

Benefits and Challenges

One of the largest economic benefits of ICT adoption at this stage is increased productivity and faster economic growth. The level of impact on developing countries at lower stages of adoption is still debated. However, the economic benefits of ICT investments at this mature stage have been more widely accepted for both developing and industrialized countries (Indjikian, 2005). As a developing country begins to reach this stage of adoption, it begins to experience clear economic benefits that are measurable in national statistics (Kenny, 2003).

These saturation levels are needed so that a majority of the country is connected and has integrated ICT usage into their daily lives (Senteni, 2006). Although this integration is more common in developed countries, it requires a significant transition process for many developing countries – requiring them to reach stage four prior to experiencing the mass integration of the technology. These saturation levels also create a virtuous circle within the ICT services, where prices continue to decline due to heavy competition within the sector. Once the country reaches saturation, operators must price competitively to attract new subscribers. This lowers costs for residents and firms, increasing each year the range of services they receive for the same price or less.

Countries that have reached stage four typically have begun the process of developing a domestic ICT sector. This local ICT industry can produce tailored products and services for the domestic market, expanding the opportunities for further integrating ICTs into the economy. This means many developing countries are no longer reliant on international vendors or MNCs for their technology options. However, this is not to suggest that these developing countries will not import ICTs; but that many countries at this stage are no longer beholden to global equipment companies for their technology choices. This shift to a combination of domestic and international ICTs will lower a country's reliance on MNCs for technology transfer, resulting in fewer ICT choices based solely on their appropriateness for a global supply chain. In turn, this will lower developing countries' risk of using imported technologies only to see them no longer supported by their global firms. This may result in flattened ICT adoption if the sunk costs are too high for the developing country to switch to another technology option.

Many developing countries within this stage face a difficult task of managing the competitive balance coupled with the expense of rolling out broadband networks. The market power of the operators can be large, easily distorting the ICT sector and requiring the regulator to make an immediate response. Finding the right role for the regulator to ensure continued growth in the market is difficult for both developed and developing country governments. In addition, the expansion of universal service to include broadband access brings its own set of challenges. The budgets required for broadband network deployment are so large that few countries can successfully implement the policy.

Another challenge is the creation of R&D capabilities and ICT innovative capacity, which few middle-income countries, or even high-income countries, have been able to achieve despite years of government support. Middle-income countries at this stage are still reliant on technology transfer and ICT imports, but some have seen a larger industry beginning to develop within the local market (Baldwin, 2005). Countries in this mass-market phase have begun to tailor foreign technology to local requirements and increase support for ICT R&D efforts. However, these countries still can compete only in a few global niches with their indigenous technologies. A national, coordinated effort between the public and private sectors is required to transition to a global ICT competitor – particularly a successful competitor across multiple industry segments. Only a select number of developing countries, such as South Korea and Taiwan, have been able to gain entry into this exclusive club (Amsden, 1989; Wang, 1995).

Stage Five: Age of High Consumption and Innovation

Countries that have reached this stage are marked by their high levels of ICT adoption along with an extensive and innovative ICT industry that is globally competitive. Few countries have reached this stage, with key examples including several European and North American countries as well as Japan (as discussed in stage four) – all of which have a strong domestic market and exporting ICT industry (Steinmueller, 2001). Although very few developing countries have reached this stage, almost all of them have a GDP per capita high enough for OECD membership in addition to their high levels of ICT adoption, such as South Korea. It should be noted that while ICT penetration tends to develop before an exporting ICT industry is created, it is not a hard requirement. Even the US, with its low population density, has not reached all of the ICT penetration benchmarks to qualify for stage five. However, the country is the dominant player across several ICT industries internationally. The chart below in Exhibit 2.14 outlines the four metrics for a selection of countries that have reached stage five.

Exhibit 2.14: Examples of Countries in Stage Five of ICT Adoption

	Mainlines	*Stage for Mainlines*	Mobile users	*Stage for Mobile*	Internet users	*Stage for Internet*	Broadband users	*Stage for Broadband*	**Stage Index**
Canada	565.8	*5*	513.9	*3*	520.1	*5*	207.6	*5*	**5**
Korea, Rep.	491.7	*4*	793.9	*4*	683.5	*5*	252.4	*5*	**5**
Singapore	424.8	*4*	1009.9	*5*	571.1	*5*	153.3	*4*	**5**
Sweden	717.0	*5*	934.9	*5*	763.5	*5*	214.0	*5*	**5**
United States	606.0	*5*	680.3	*4*	630.0	*5*	166.6	*4*	**5**

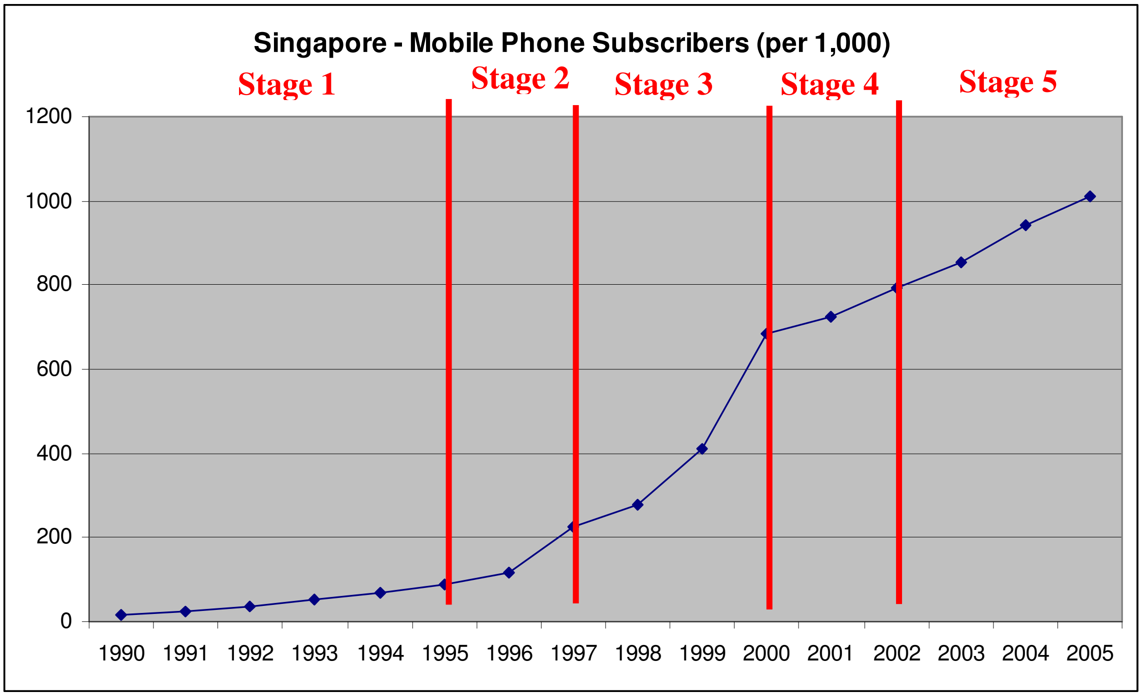
Source: World Development Indicators, 2006. Number of users in thousands for all four indicators.

ICT Adoption

For countries within this stage, at least two of the four ICT sectors have reached a saturation point. This saturated sector, such as mobile phones, potentially reaches over 100 percent penetration, with many individuals owning multiple phones. In addition, both fixed and broadband services are available to a vast majority of residential and business users, even if usage is still well below 100 percent of households (Burkart, 2007). It should be noted that these four metrics are merely a snapshot of current technologies and that communications platforms will continue to evolve, potentially including new forms of access such as fiber-based or mobile broadband data services. As these technologies mature and are deployed across developed and developing countries, the primary metrics for the stages of ICT development will have to be expanded beyond these original four. The list of countries in Exhibit 2.14 includes those that have reached market saturation, according to the ITU's figures. Many of these countries have seen their mobile adoption rates spike, overtaking their landlines and pushing their mobile markets beyond 100 percent penetration, as in Singapore. At this level of ICT diffusion, strong competition exists between several providers, pushing prices to affordable levels for a broad majority of the population.

Exhibit 2.15 presents the growth rate for the Singaporean mobile market. Although Singapore is no longer a developing country, the mobile market was still forced to catch up to Western Europe during the 1990s. Once Singapore attained the same level of mobile adoption as countries such as Sweden in 2000, the country's growth rate changed as it shifted from adapting international mobile technologies to operating on the technology frontier. The national mobile growth rate also slowed as the market began to near saturation.

Exhibit 2.15: ICT Adoption Stages Applied to the Singaporean Mobile Sector



Source: International Telecommunication Union, 2006.

A country's inclusion in this stage suggests that it has developed an internationally exporting ICT industry. Countries such as South Korea (home of global equipment manufacturers Samsung, LG, and others) have become hotbeds for software, IT, and communications innovations. Other countries, including Singapore, have increased their roles in MNC global supply chains, creating export centers while leveraging their telecommunications capacity and English capabilities to initiate an increased role in the global ICT industry (Koh, 2006).

Competitive Landscape

Both developed and developing countries at this stage have extensive competition within their markets across all major sectors. Providers compete heavily on price, service quality, and network reach for their residential and business end users. However, uneven levels of competition will continue due to the high capital costs of fixed line infrastructure. These higher costs will still limit competitive operators versus the relative ease of entering the mobile sector for a new operator. This sector competition also exists across infrastructure modes, also called multimodal competition, with providers using fixed line, fiber/coax cable, mobile wireless, alternative wireless, and other network technologies to compete head-to-head (Proenza, 2006). This multimodal competition is vital to preventing a monopoly or oligopoly from leveraging its market power in one sector to dominate the ICT market.

Network Infrastructure

As mentioned above, the network infrastructure within these markets includes a wide range of access technologies, including mobile wireless, fixed line, fixed wireless, and cable. This range of options enables operators to flexibly choose more cost-effective platforms for delivering high-capacity services to end-user locations. This can lower overall capital and operational costs while speeding delivery of new services and applications over the broadband connections. Countries at this stage are also beginning to deploy fiber access networks, which can connect users at high speeds while additionally lowering operational costs. These fiber networks are also highly scalable, reaching 1 Gbps or more, which helps operators future-proof their networks as end-user capacity requirements continue to grow. To make these increases in access capacity, backbone infrastructure and international connections are also expanded. These networks are a key component to the national infrastructure and must be scaled along with the access networks to meet growing demand.

National ICT Policies

Another key feature of the developing countries listed above is that they are densely populated upper-middle-income or high-income markets. To reach saturation levels of ICT adoption, there are significant advantages to being a small, fairly wealthy developing country. These demographic advantages and the level of economic development have combined to enable many countries to reach market saturation quickly, outpacing some developed countries, and to attain some of the highest levels of ICT adoption. Network deployment costs are lower because there are fewer rural areas to build out to and fewer low-income regions that require government intervention to bolster adoption. However, these countries also require governmental initiatives to sustain ICT adoption, such as universal service funds. Even though these markets have reached saturation, USF programs continue to subsidize access for rural or low-income users.

Institutional and Regulatory Structure

Ministerial authority within countries at this stage continues the trend of decentralizing authority and budget across many agencies as government takes a secondary support role within the sector. Despite this decentralization, there is extensive coordination across government agencies, the private sector, and universities to speed ICT innovation (Lee, 2005). As part of this effort, there is a significant increase in ICT

R&D funding from ministries of science as well as programs to speed commercialization and entrepreneurship within the sector from ministries of industry. National policies also continue to increase support for training and tertiary education within the sector from the ministry of education, among others.

Benefits and Challenges

The economic benefit for countries that move to this final stage in ICT adoption is the shift from domestic ICT producer to global ICT exporter. As a global ICT R&D leader, ICT products and services are globally competitive across a range of industry sectors. As discussed above, this capability is supported through extensive funding of research and commercialization efforts by government, industry, and academic facilities. These countries are also key components of the ICT global supply chain, providing value-added product development and innovation capabilities to high-technology products.

To compete globally on quality and price, a country requires significant capital and expertise as well as strong clusters of local ICT firms. This shift to ICT exporter also requires expanded R&D cooperation among public-private facilities to develop, innovate, and commercialize technologies. This cooperation can also lead to additional sectors, such as biotechnology, benefiting from the establishment of public-private partnerships. This stage can also result in expanded productivity gains as ICTs become more integrated into a wide range of sectors in the market (Gust, 2004). This stronger integration has been seen in the financial, logistical, retail, professional services, and other sectors in developed economies. Similar experiences can be expected in developing countries, such as South Korea, that are still maturing economically but that have reached the final stage of ICT adoption.

Globally competitive ICT sectors can support a significant expansion in a country's global competitive niche. However, it is highly difficult to remain competitive (Archibugi, 1992). Archibugi and Pietrobelli (2003) suggest that few developing countries have been able to reach this level of globally competitive ICT innovation and it is difficult to maintain once reaching this stage. There are even recent concerns within the US and in other developed countries over their global ICT leadership position and their ability to maintain their innovative capacity. This demonstrates how precarious ICT global leadership can be. For developing countries that have attained global leadership within the ICT industry but are still developing economically, the risk of slipping back to stage four is even greater.

Conclusions and Implications for Policymakers

There are many moving parts to the five stages outlined above that require a coordinated response by developing country governments – with the most vital component of this process encompassing the evolving role of the state. This governmental evolution across the five stages alters the state from monopoly operator, to direct supporter of the sector (through network deployments and subsidies), and then finally to indirect contributor (through training and ICT innovation efforts). Although the government's role in ICT sector development is significantly altered by the end of this process, the government still plays a vital role in providing nuanced responses to complex policy and market challenges as the ICT sector develops toward maturity.

Most developing countries tend to overcome several gating factors before moving from one stage to the next, including regulatory, policy, and institutional reforms as well as expansions in network infrastructure and market competitiveness (Bortolotti, 2002). In addition, a country's progress on the gating factors in one area, such as institutional reforms, may be hampered severely by failure to reform other areas, such as national regulation. For example, Malaysia was able to create an effective Ministry of ICT to design and implement ICT policies. However, limitations in the regulatory regime have hampered competition in the fixed line sector, which has now led to shortages in network infrastructure suitable for expanding broadband services. This uneven reform may be serious enough to hamper a country's ability to increase its ICT adoption or utilization. One of the most important pre-conditions is the privatization of the monopoly and liberalization of the ICT market, a lengthy process that typically takes place during stages one and two. Although some countries are able to grow their markets without undergoing these reforms, including several oil-rich Gulf States, these countries are not representative of the process most developing countries experience as they implement their national ICT policies.

The goal of the section is to outline the five stages of ICT adoption and reinforce the idea that even as policymakers carefully gauge and refine the role of the state, the government continues to have a prominent role across all five stages of the ICT adoption process. It is important to note that although there are commonalities in ICT development across these countries, the experiences of individual countries have varied widely across these five stages. As a result, developing country policymakers must use this framework as only a starting point when determining the most appropriate policies for their ICT sector. Despite this limitation, this framework does offer a more holistic approach than the current literature to understanding the key factors determining ICT sector development. When discussing the benefits ICTs can offer to developing countries, there is a tendency to focus heavily on the technological capabilities of ICTs rather than the governmental policies or market conditions required to support them. Rapidly evolving technologies can offer new options for access and services, but they will achieve little on their own. Developing countries must carefully balance both the market regulation and competitiveness to move to the next stage.

Developing country governments must examine their current network, institutional, and market structure to determine their stage in ICT adoption across the four major sectors: fixed line, wireless, Internet, and broadband. Once the country's stage has been determined, the government should develop short-term goals focused on improving access and utilization of ICTs within the current environment. In addition, longer-term goals should be developed that focus on reaching the next stage of adoption. These government goals can include supporting the deployment of ICT networks, expanding utilization, and developing local ICT sectors. The basic aim of these goals will be similar across developing countries. However, to be successfully implemented, they must be carefully defined to fit the local ICT sector. To help ensure that this process is based on realistic assumptions concerning the national environment, the government should rely on input from public, private, and academic leaders to customize its goals.

As a country moves through the five stages of adoption, the government shifts its role and focus dramatically. In turn, these changing priorities shift policies, programs, and technologies to those most appropriate for the country. Successful governmental intervention requires the state to undergo rapid assessment and refinement of its goals, to adjust its policy and technology choices. As a result, national ICT goals and policies cannot remain static. Instead, these goals and policies must be adaptable to the changing technological and market conditions to ensure an optimum policy outcome. Developing countries that can rapidly assess and refine ICT goals and policies will be able to find a clear path to the next stage of adoption. Developing country governments must use policy interventions to jump-start the process and to correct imbalances while seeking ways to determine the most appropriate level of governmental involvement in the sector as the country advances through the five stages. To achieve this, governments must carefully manage the policy process, balancing the needs of end users with those of the operators within their regulatory and market structure.

The final step is to determine the most suitable technology option available to the country and find a financially sustainable business model to deliver this technology. Developing countries must use the goals and policies set by the government as a starting point to determine the correct technology options. Next, developing country governments should utilize their national ICT assessment to determine the influence market, economic, and institutional factors will have on the deployment of a given technology. Countries considering the various technology options available to them should also weigh the cost constraints and local geographic challenges that will influence infrastructure deployment. Fortunately, developing countries now have several technology options available to them that can cost-effectively deliver services. These new ICTs were key to making national networks and services affordable to and sustainable for developing countries.

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Section 3: The Determinants of ICT Adoption – Market Privatization and Regulation in Developing Countries

Introduction

Adoption of ICTs is a key factor in a country's economic development, as argued in the theory base discussion above. An individual country's economic performance can be linked to how well it obtains and utilizes telecommunication technologies. (Malecki, 1997). Currently, a growing disparity exists in the levels of ICT adoption between countries that have successfully integrated ICTs into their economies and those that have not. Previous studies of this adoption disparity have predominately focused on macroeconomic factors, overstating the connection between telecommunications adoption rates and economic growth. This study will expand on current research by including privatization and institutional interventions, in addition to economic indicators, as treatment variables that trigger higher ICT adoption rates.

My hypothesis is that ICT adoption, as measured by the number of landline and mobile phones per 1,000 people, is spurred by policy changes, rather than solely by economic factors. Current ICT literature supports the hypothesis that countries experience rapid growth in ICT adoption through policy reforms and institutional development, such as a new national regulatory agency (Edwards, 2002). I use a regression model discussed below to test the relationship between these policy and institutional treatments and a country's ICT adoption rate.

These policy treatments include both large-scale privatization as well as partial privatization of the state-owned monopoly, where a domestic or international investor owns a minority stake in the carrier. For the purposes of this model, institutional shifts include the creation of an independent regulatory body. These policy treatments are defined and tracked by the International Telecommunication Union and have been included as key explanatory variables to account for the shift in adoption rates within countries (ITU, 2003).

This model tracks the relationship of monopoly privatization and reform of government regulation with the ICT adoption rates within a country. The results are expected to support Levy's argument that the government has an essential role to play in supporting and spurring investment in the ICT sectors (Levy, 1994). Through the use of economic liberalization indicators as control variables, this model is also intended to support Dollar's contention that an open economy is necessary for technology transfer as well as economic and productivity gains (1992). The model provides a framework for benchmarking case studies of individual countries and understanding the relationship between ICT policies and ICT adoption within a given country.

Conceptual Framework and Variables

This section highlights previous cross-country studies of the determinants of ICT adoption as well as the impact of higher penetration rates on economic development. Next, this section outlines the dependent and explanatory variables, the supports within the literature for inclusion within the study, and recent global trends for those individual indicators.

Previous ICT and Development Studies

From the 1960s through the 1980s, ICT penetration within developing countries grew slowly, with little change year-over-year (ITU, 2003). Since then, several developing countries have managed rapid increases in their ICT adoption rates, more than doubling their penetration rates on average within the last three years. This revolution within the ICT sector has dramatically shifted the number of fixed lines and mobile subscribers on a global basis, although these two technologies may accelerate at different times within the same country.

One example of a developing country with a rapidly expanding ICT market is Chile, which has been considered an economic and technological success story due to its relatively steady economic growth and creation of a globally competitive IT sector (Hawkins, 2005). Chile was able to rapidly accelerate its ICT adoption rates, increasing Internet penetration from 2 to 24 users per 100 people in four years (World Bank, 2006). Hawkins' study suggests that policy measures introduced by the government, and widely supported by the population, were instrumental in achieving similar success within the mobile sector. Policies mentioned within the study include lower telephone rates, interconnection across national networks, public access centers, and e-commerce support. Although this growth rate for mobile and Internet access was impressive, there was not a corresponding growth in fixed line penetration. The authors suggest that the fixed line market did not experience a similar growth curve because these policies were not implemented for those services.

As seen in the results of the above study, countries that have experienced accelerated ICT adoption do not require significant institutional changes to spur it (Levy, 1994). Less complex policy changes such as reduced market entry barriers, openness to domestic and foreign investment, incentives to ICT entrepreneurs, and subsidies to increase demand can begin the process. However, Levy suggests once this acceleration begins, the country will need to undergo significant institutional reform to sustain this rapidly growing market. This will include creating an independent regulatory agency, judicial reform, finalizing privatization efforts, and creating multiple, overlapping oversight bodies to reduce arbitrary governmental action.

Another recent study of regional ICT penetration differences focused on institutional reform across sub-Saharan Africa as the primary determinant in adoption rates (Wilson, 2003). The study found that although economic development and technological environment are important factors influencing penetration, the authors suggest that policy and institutional issues are the critical success factors for these countries. Unfortunately for the study, the spike in ICT penetration and institutional reforms largely took place within a two-year period in the late 1990s. This does not give the model enough data within the study period to adequately examine the relationship between these regulatory and institutional reforms and ICT penetration rates.

A model offered by Gutierrez and Sanford (2000) comes closer to incorporating the importance of tracking the impact of institutional factors on ICT adoption across time. The authors examine the determinants of telephone line density within Latin American countries across 10 years, including economic, political, and institutional factors. Their model also includes mobile telephones as an explanatory variable, acknowledging the substitutability of wireless telephones for fixed line services. The results suggest that institutional factors, including an independent regulatory agency, and political freedom indices have a significant impact on teledensity. This study's underlying theory base and attempt to address the full range of institutional variables for this study are much improved over the many other available studies.

Anselmo de Castro (2003) and Hall (2004) suggest that ICTs can have both a divergent and a convergent effect on economic development, depending on the governmental policies used to support diffusion of these technologies. Anselmo de Castro argues that developing countries with smartly regulated private telecommunications sectors will experience faster ICT adoption as well as reap the development benefits. Countries that are unregulated will see slower uptake of ICTs and will accelerate the digital divide within the country.

OECD countries have all moved to a private or mixed policy structure over the past 15 years and all of them rapidly increased their investment in ICT infrastructure (Schreyer, 2002). This ICT investment contributed to economic growth within these countries throughout the 1990s that only accelerated toward the end of the decade. Despite this relationship between ICT adoption and economic performance in the OECD countries, ICT adoption across countries does not strictly follow economic strength (Frieden, 2005). Other key determinants include geographical and demographic factors. One notable example includes small countries with urban populations, which have an easier task of deploying ICT infrastructure than large, rural countries. Although this model does not include developing countries within its study population, it does suggest that the relationship between ICT adoption and urbanization or population density deserves further investigation.

By focusing on institutional factors, this model builds on the solid foundation created by these previous studies. This model improves on the approach of these other models by expanding the time frame to include 1990 to 2005. Studies completed with data only from the 1990s are limited in their ability to determine the relationship between regulatory agencies and ICT adoption. This is a result of so many countries waiting until the late 1990s to create their agency. In addition, this model adds telecom monopoly privatization data gathered from the ITU rather than the political freedom indices, which have not been shown to have a significant relationship with ICT penetration. Finally, this model uses a full range of developed and developing countries, instead of limiting the scope to OECD countries, to determine the relationship between these institutional factors and ICT adoption rates.

Model Variables

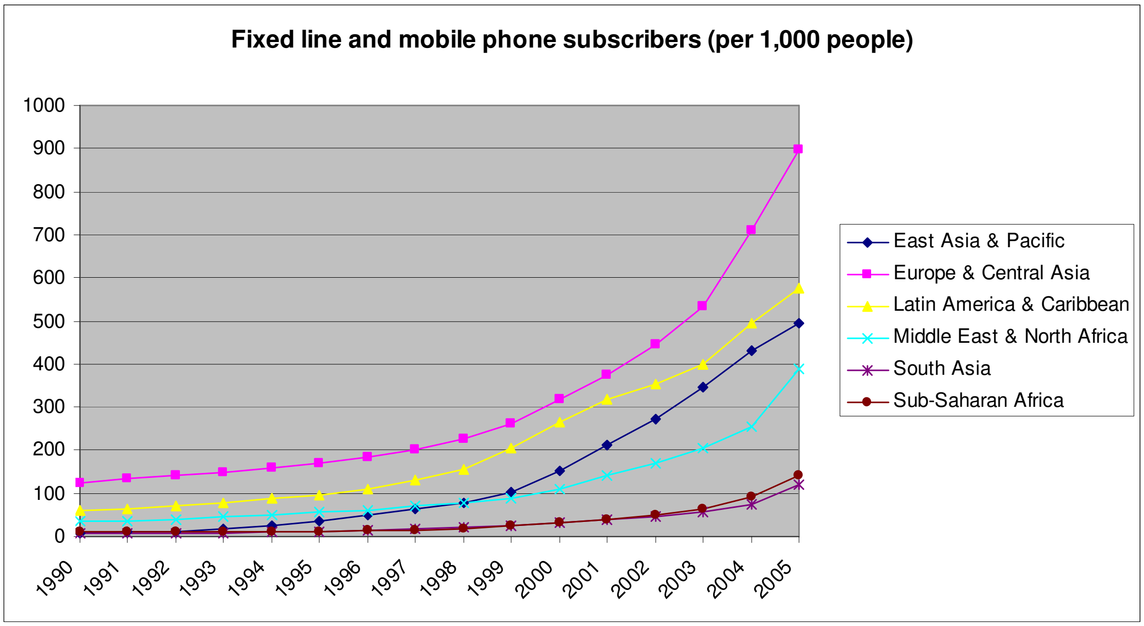
Using these previous studies as a foundation, the study below examines the relationship between ICT penetration and market privatization and regulation in developing and developed countries. Several other political and economic factors that have a direct influence on adoption are also included in this model: market liberalization, economic development, and market regulation (Dutta, 2004). The section below discusses each of these variables.

Dependent Variable

The dependent variable (DV) combines the penetration rates for fixed line and mobile subscribers, based on per-capita figures available from the ITU. I argue that these two indicators are equally important to ICT development and are to be weighted evenly when combined into a single DV. The trend in many countries has been for mobile services to quickly outstrip fixed lines. However, this is balanced by the need for fixed line infrastructure to support broadband and narrowband Internet access adoption. Therefore, growth in both technologies is required to successfully expand ICT access. This data, along with the explanatory variables, has been collected for 154 countries across 15 years, from 1990 to 2005. This time frame should capture most of the policy changes as well as starting points for accelerated ICT penetration within these targeted countries.

Fixed and mobile penetration has accelerated during the past five years, growing 11 percent annually, reaching almost 500 subscribers per 1,000 people on a global average (see Exhibit 3.1). High-income countries, including those in North America and Western Europe, lead the world with over 1,200 combined fixed and mobile subscribers per 1,000 inhabitants. With some of these markets approaching saturation, penetration rates have begun to slow. In contrast, high-growth regions such as East Asia have quadrupled their penetration rate during the last five years. The region saw rates exceed 400 subscribers per 1,000 inhabitants in 2004. Even sub-Saharan Africa has increased from 31 subscribers per 1,000 inhabitants to almost 150 in just five years. This rapid growth is fueled primarily by mobile phone adoption in most developing countries, resulting in mobile subscribers now outnumbering fixed line users within many of these regions.

Exhibit 3.1: Global Growth in Fixed Line and Mobile Services, by Region



Source: World Bank, 2006.

Independent Variables

The independent variables include per-capita income, a set of market liberalization variables, economic development variables, and institutional indicators.

Liberalization Variables

Market liberalization is the process that countries undergo as they move toward a market economy, including opening a country to international investment and trade as well as privatizing state-owned companies. Market liberalization specific to the ICT sector cannot be easily measured across countries, so national variables that measure this process in aggregate are used in the regression model as a proxy to demonstrate a country's stage of openness. This liberalization process can offer several significant benefits for the ICT adoption rates of developing countries. As a market opens to international investment, including foreign direct investment, there is an increased likelihood of technology transfer for a developing country (Addison, 2002). Increases in international trade can also expand the requirement for ICT adoption among local firms, as they become more integrated into the global supply chain (Ciruelos, 2005). In addition, a privatized telecom monopoly, when coupled with strong governmental ICT support policies, will open the country to increased domestic and international competition within the ICT sector. As a result, a larger share of the population should be able to access and afford the technology (Parker, 2007). Countries that have not liberalized their investment, trade, and telecommunications regimes should show a lower than expected adoption rate than their GDP per capita levels would suggest.

The model includes the following market liberalization variables: a dummy variable accounting for monopoly telecom operator privatization, foreign direct investment as a percentage of GDP, and trade as a percentage of GDP.

Privatization

A privatized market variable tracks whether the monopoly fixed line operator has been sold by the government, including incumbent carriers that have only been partially privatized. This reform is defined and tracked by the International Telecommunication Union, which completes an annual survey of all 189 of its member countries. For some countries, such as the United Kingdom, this is a point in time before the start of the study;

while for most developing countries, this is a more recent change. According to the ITU data, 98 developed and developing countries privatized their telecommunications monopolies during the 1990s or early 2000s, placing this transition within the range of the 1990 to 2005 study period. This privatization process is tracked as a dummy variable, with those years after privatization marked with a 1, and was expected to have a positive correlation with the DV. An interaction term with the privatization variable and regulatory agency variable, which will be described below, was included within the model. This was used to determine the joint relationship between these variables and the dependent variable.

A lagged privatization variable was considered and tested due to the long-term nature of the privatization process. It is possible that a country's monopoly would undergo privatization, yet it would take a year before the market adoption rates would react. However, this variable ultimately was left out of the model due to the long-term process before the official privatization of the monopoly; a process that take several years and would allow other market competitors to plan for its completion. For example, Thailand saw an eight-year privatization process during which both the monopoly and competitive operators were able to prepare their networks and services ahead of time. This allowed for a rapid growth to occur within the country almost immediately after the privatization (Jirachaipravit, 2007).

Privatization of the monopoly fixed line operator is a necessary but insufficient step in accelerating the ICT adoption within a developing country (Bortolotti, 2007). Bortolotti suggests that developing countries must have a strong institutional structure that can support and regulate the newly privatized operator. Countries that have a weak institutional structure may experience ICT market development hampered by regulatory capture, creating a market scenario where a privatized operator can use its market and political power to limit competition within the sector (Levy & Spiller, 1996). This is directly related to the creation of an independent regulator, discussed in the section below, but also other government institutions. These other institutions can include the ministries of science, innovation, and ICT, which have been created across many developing countries such as Malaysia, which has successfully accelerated its ICT sectors (Lee, 2002). These successful institutional structures develop politically independent ministries with the necessary budget and authority to design and implement national policy (Painter, 2004).

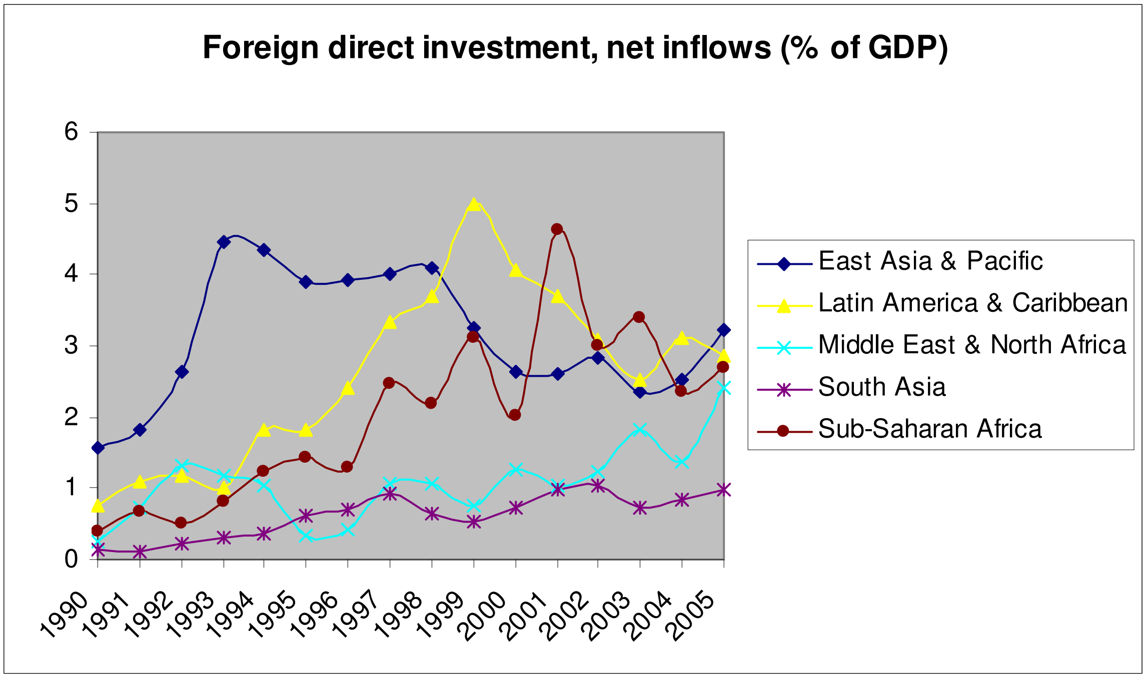
In addition to institutional reforms, Parker and Kirkpatrick (2005) suggest that privatization is simply one component of a larger telecommunications market reform process that must include the creation of sustainable competition and organizational reforms within the operator to be successful. This construction of a competition market, with streamlined carrier operations, may in fact be more difficult for developing countries to initiate and sustain than their institutional reforms. Taking this argument one step further, Singh suggests that in addition to privatization, regulatory reforms, and market competition, developing countries with strong property rights will experience rapid expansion of network infrastructure (Singh, 2000). Although the development of property rights is not tracked within this model, Singh's study does support the contention that the creation of an accelerated telecommunications market requires a sustained market, policy, and institutional reform process within a developing country – a difficult prospect and one that suggests why so few developing countries are successful in this endeavor.

Foreign Direct Investment

Gross foreign direct investment is defined by the World Bank to include the absolute values of the capital inflows and outflows and is included in the model as a percentage of total GDP (WDI, 2006). As a country liberalizes its market, opening itself up to international trade and investment in the process, foreign investment begins to rise (Campos, 2002). Foreign investment can also lead to technology transfer from international firms to domestic companies. These transfers may speed the telecom adoption rate and should have a positive influence on the dependent variable.

Exhibit 3.2 depicts global FDI inflows as a percentage of the global economy, which peaked in 2000 at 4.9 percent and then declined to only 1.6 percent in 2004 (World Bank, 2006). This decline occurred in both developed and developing regions, particularly in North America and East Asia. FDI inflows are only now beginning to recover in some areas. Notably, the United States and Europe are now starting to see their FDI return to pre-2000 levels, according to the World Development Indicators. In addition, Latin America has seen increases in its FDI inflows as a percentage of GDP, rising from just over 2 percent in 2003 to 3 percent in 2004. This investment growth was driven by expanded ties across global supply chains and improved governance structure for supporting FDI, particularly in Latin America, East Asia, and other emerging regions (Globerman and Shapiro, 2002).

Exhibit 3.2: Global Inflows of FDI, by Region



Source: World Bank, 2006.

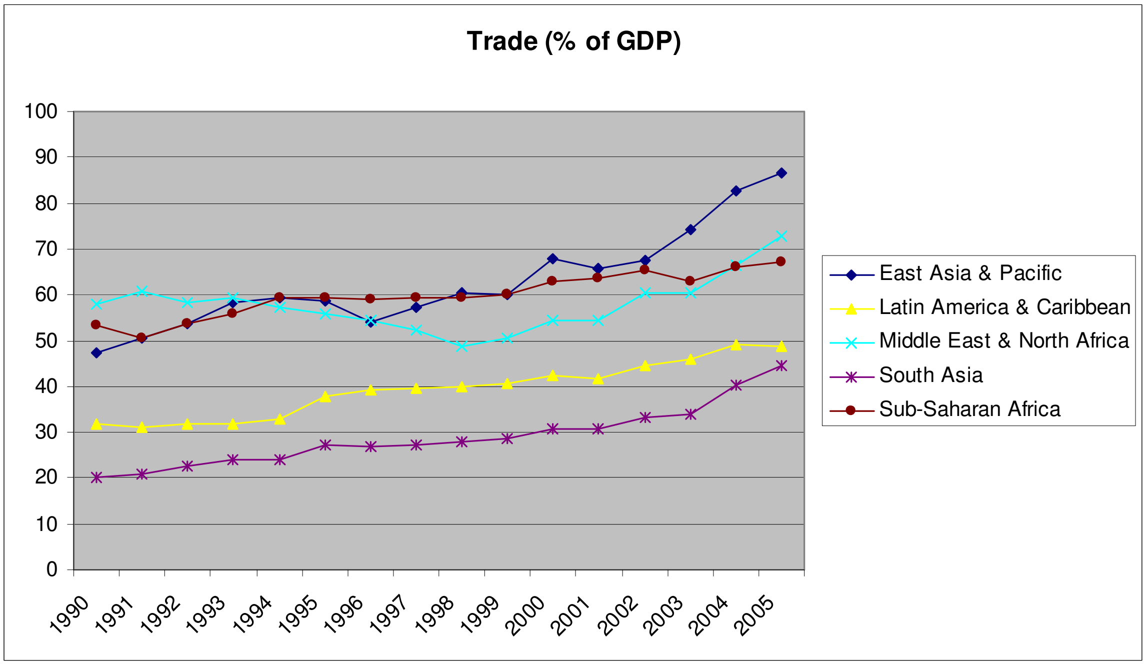
Although international investment may assist with increasing ICT demand, in many developing countries this investment can also have a negative effect on ICT adoption. Countries with high rates of gross FDI as a percentage of GDP may not experience the knowledge spillovers necessary to derive significant economic benefits (Saggi, 2002). Without knowledge spillovers, these countries will not have the necessary levels of expertise to innovate and adapt technology to their local environment. As a result, the market supply for ICTs may be limited to local sectors tied directly to MNC supply chains. Without economically viable technology options that can meet the requirements of the local environment, a developing country may experience lower levels of ICT penetration, holding all other variables constant.

In addition, results from the draft version of the model suggest that there is a nonlinear relationship between gross FDI and the dependent variable. As a result, both gross FDI and gross FDI squared are included within the model to determine the nature of this relationship. An interaction term for gross FDI and GDP per capita was also included.

Trade

During the past 5 years, global trade has grown faster than the global economy, as demonstrated in Exhibit 3.3. Trade reached almost 50 percent of global GDP in 2004, increasing steadily from 38 percent in 1990 (World Bank, 2006). During this time, East Asia became a world leader in trade, but major increases were also seen in Europe – particularly after the creation of the EU in 1992. This global increase during the past 15 years was driven largely by changes in political environments, as well as a rapid expansion of the global supply chain (Dollar and Kraay, 2002). Another major driver is the steep cuts in international tariffs within developing countries, which declined from more than 15 percent of trade revenue in 1990 to only 5 percent in 2003 in both East Asia and Latin America, according to the World Development Indicators (World Bank, 2006). While still well above the global average, South Asia also saw a significant tariff decline, from 27 percent to 17 percent, during the same period.

Exhibit 3.3: Growth of Trade as a Share of GDP, by Region



Source: World Bank, 2006.

Trade measures the total input and output of goods and services for international trade as a percentage of GDP. This variable was included to control for the level of economic strength across countries, which can influence the adoption of ICTs. Countries with high trade levels are expected to have higher ICT penetration rates on average. Baldwin et al. (2001) also argue that trade is the conduit for developing country income convergence with developed countries. A convergence in global incomes, based on the benefits of increased incomes in developing countries, would positively influence the ICT adoption rate.

Other options considered to account for economic health across the study countries included gross domestic investment and current account balance. Gross domestic investment is defined as the outlays for fixed plant, equipment, construction of national infrastructure, and net changes in the level of inventories. The gross domestic investment variable would have been used as a proxy for the amount of capital available within the country for investment within the telecommunications sector. However, this indicator did not have enough observations during the study period to be included. The current account balance includes net exports, income, and current transfers, which would include a national deficit or trade deficit that a nation may be experiencing. This would certainly impact capital available for ICT investment. However, similar to gross domestic investment, there were not enough observations.

As discussion above in the FDI section, trade can increase the level of technology transfer experienced by a developing country (Saggi, 2002). This technology transfer can increase the utilization of ICTs by local firms as they work to integrate with the IT and back-office systems of the MNCs that they supply (Urata, 2006). This ICT usage can also increase the number of experts capable of deploying and maintaining a network while workers exposed to the technologies are more likely to be able to use ICTs off the job (Baldwin, Braconier, and Forslid, 2005). Last, Verikios and Zhang (2004) argue that a reduction in trade barriers for the telecommunications sector would benefit global productivity rates. Although there has been continued debate over the evidence of enhanced economic growth in developing countries that liberalize their trade regimes, recent studies seem to support the case for liberalization (Edwards, 1993; Greenaway, 2002).

Although a developing country can receive benefits from increased international trade and investment, such as technology transfer, there can be a tipping point where this increased trade can hamper ICT adoption (Zhu and Trefler, 2005). This results in little local demand for ICTs, despite levels of trade and investment that exceed those seen in developed countries – creating a small ICT market that is highly concentrated among wealthy residents and has little prospect for accelerated growth. Based on this, I would expect a curvilinear relationship, which I explicitly test below by including trade squared as a variable.

Economic Development Variables

ICT adoption within developing countries is also influenced by the level of economic development the country has attained. Without increasing levels of development, there can be reduced levels of demand for ICTs, which will be reflected in a lower than expected penetration rate. Countries experiencing economic development will see their ICT sectors benefit directly – such as when the population shifts from rural to urban centers, lowering the costs for network deployments (Kenny, 2002). There are also indirect benefits, including shifts in economic activities that require higher utilization rates of ICTs, such as finance or software development, in comparison to low-skill manufacturing (Heeks, 2006). To account for these direct and indirect benefits, the study included several different approaches to accounting for economic development, such as measuring economic growth, rates of urbanization, and shifts toward advanced industrial sectors. Economic growth is accounted for in the model by GDP per capita while urbanization is included through a proxy indicator: population density. Although population density is not an ideal substitute for urbanization, the widespread availability of time-series data makes it more appropriate for this study. Last, shifts away from agriculture and manufacturing, toward advanced service sectors, are included as a variable measuring the share of GDP represented by the services.

GDP per Capita

The GDP per capita indicator is included to control for the relative advancement of a country's economy (Bassanini, 2002). Countries with low GDP levels are likely to have high levels of low-skilled manufacturing and agriculture within their economies, requiring slower adoption rates for ICTs. It is expected that the relative size of GDP per capita should have a positive correlation with the dependent variable. Although developing countries, such as China, have posted annual growth rates above 10 percent, this is not the norm among developing countries. Few of these countries see rapid economic growth that would cause them to change their relative economic status within the study period. Instead, the goal of the GDP per capita indicator is to stratify the relative level of economic attainment achieved by these countries; addressing the relationship between being a low-income or high-income country and ICT adoption rather than the annual variation in GDP per capita (Wong, 2002).

Per-capita GDP has grown globally and has seen historic increases in developing countries. These global gains were mainly pushed by the East Asian Tigers – China and India – as well as strong growth in the US. According to the World Development Indicators, the global average for per-capita GDP has increased from just over $5,000 PPP in 1990 to almost $9,000 PPP today (World Bank, 2006). East Asia posted gains of 9 percent annually, far higher than the world average of 4 percent, while South Asia also had above-average increases of 5 percent per year. Europe experienced only 2 percent annual growth, while the United States had twice that rate.

This global growth in GDP per capita has helped foster growth in ICT adoption across developing countries. Expanding GDP per capita can lead to rising incomes, increasing the disposable income available to residents to use toward ICT services (Bassanini, 2002). This rise in per-capita GDP does not necessarily translate into higher incomes. A developing country may have high levels of income inequality, resulting in few benefits for the ICT sector (Dasgupta, 2001). This is why additional indicators, such as institutional and regulatory reform, are included to account for the dispersal of economic benefits within a country.

No study has shown conclusively that ICT adoption in developing countries leads to GDP growth (Edwards, 2002). Several previous studies, including Roller's (2001), showed a causal link between the deployment of ICTs and economic growth. However, Roller's study only included 21 high-income countries; and the studies that did focus on developing countries showed no causal link, suggesting that developing countries may not have economic benefits from ICT adoption that are reflected in national statistics (Dewan, 2000). This is not to suggest that no economic benefits are derived from adopting ICTs in developing countries – just that they are not measured in the national statistics currently and may be limited to firm- or household-level benefits.

This GDP per capita variable is based on purchasing power parity. GDP is the total economic output for a country in a given year. Purchasing power parity measures that output in terms of buying power, rather than in dollars, to control for differences in international exchange rates. Due to the non-linear relationship between adoption and GDP per capita, per-capita GDP squared was also included.

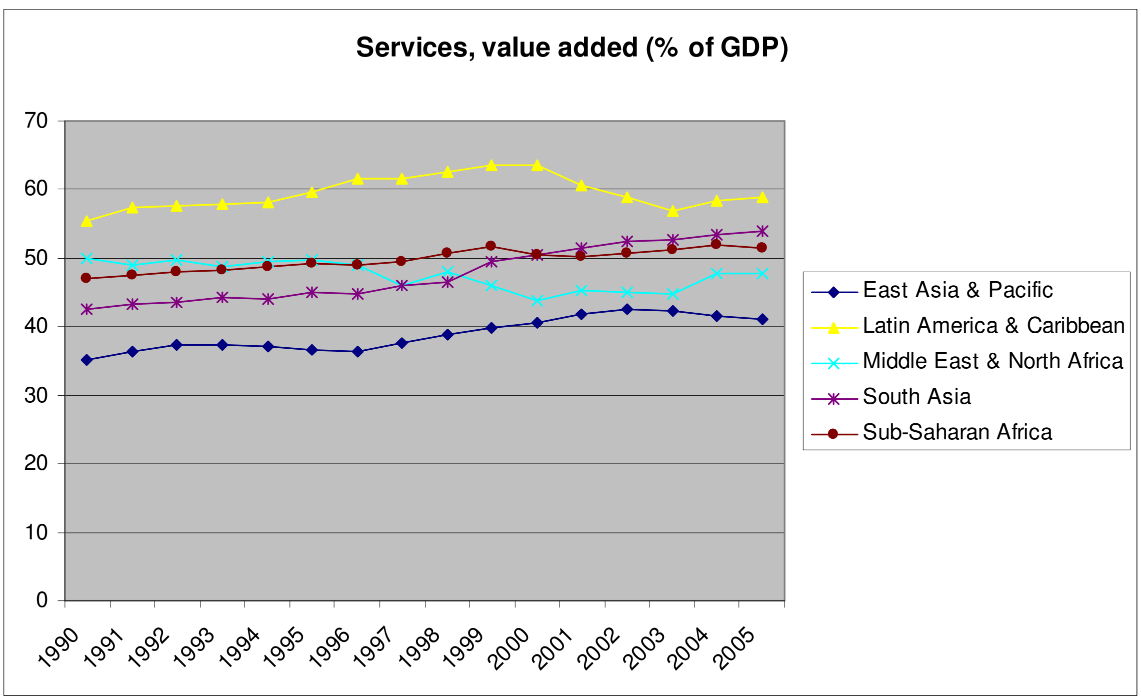
A lagged variable for GDP per capita and GDP per capita squared was included to account for the potential simultaneity bias that exists by including GDP per capita as an explanatory variable (Beck, 2001). Using a granger causality test with GDP per capita and the dependent variable, I found significant F-tests for one, two, and four lags. In this case, we reject the null hypothesis of non-causality, suggesting that there is an endogeneity problem and that the dependent variable and GDP per capita are simultaneously determined (Chong, 2000). I then substituted a lagged GDP per capita as an instrumental variable because it is highly correlated with GDP in time *t* but is not affected by the dependent variable in time *t*. Although the lagged variable does affect the dependent variable indirectly through GDP per capita, lagged GDP per capita is more appropriate than GDP per capita because it is not simultaneously determined (Hansen, 2006).

Services

The services sector indicator measures the contribution of a sector to a country's total economic output (GDP). This indicator allows the model to account for countries that have made the shift toward service sectors and are more likely to utilize ICTs than countries with an agricultural or manufacturing-based economy. As a developed or developing country shifts toward a services economy, it is more likely to adopt ICTs to increase productivity within those sectors (Furman, 2004). This is an indicator that assists in separating out countries that are still struggling to make the shift to an economy based on advanced services. The indicator measures the share of services output as the percent of GDP and should have a strong positive correlation with the dependent variable.

The service sectors in high-income countries now represent almost 75 percent of their economies, according to the World Development Indicators. The global average grew from 65 percent in 1994 to almost 70 percent today (see Exhibit 3.4). This shift has been led by the US economy, which now has more than 76 percent of its GDP generated by services (World Bank, 2006). With 71 percent, the EU is slightly behind but is beginning to converge with the US level. Developing countries, especially those that are middle-income rather than low-income, are beginning to undergo the same transition experienced in North America and Western Europe. This process will be slow, taking much longer than the study period. However, developing countries that have already begun the shift toward advanced services have already seen increases in ICT demand (Freeman, 1995).

Exhibit 3.4: Services as a Share of GDP, by Region



Source: World Bank, 2006.

The service sectors variable is included to indicate the advancement of an economy, representing a difficult shift for most developing countries to achieve. Many developing countries with relative high incomes, such as Malaysia, have been presented as development success stories. However, they are still working to expand their advanced services sectors (Jomo, 2003). Despite these difficulties, developing countries in East Asia have seen significant increases in service sector output as a share of GDP even as the region has experienced massive shifts of manufacturing capacity (Urata, 2006). The region is now generating more than 42 percent of its economy from services, which is up from 35 percent just a decade ago (World Bank, 2006). East Asian employment in services lags far behind, with more than 20 percent of workers in services. This suggests that the service sectors in these Asian economies are significantly more productive than their traditional sectors. A portion of this productivity variation across sectors can be attributed to higher ICT adoption rates in these service sectors (Hsiao, 2006).

Population Density

A population density variable is included, which measures the number of people per kilometer and serves as a proxy for the level of urbanization within a country. Technology adoption rates face the practical issue of deploying national networks and last mile infrastructure (Galperin, 2005). This deployment process in small, urban countries such as Singapore is more likely to occur at a faster pace and at a lower cost than in larger countries such as Thailand, with their rural populations. Geography also plays an important role, with mountainous countries facing significantly higher infrastructure costs than low-lying areas. Because rural, mountainous countries have a lower population concentration, population density acts as a proxy for this issue as well.

Although urbanization rates are not included within this model, population density can act as a partial proxy for this measure. Similar to population density, increases in urbanization lower the network infrastructure costs versus the costs of a rural network. In addition, urban customers may be more likely to demand higher levels of services and price competition than their rural counterparts. In his 2005 empirical study of 50 developing countries, Li argues that a large urban customer base within a democratic political system is more likely to drive the reform process by creating a strong interest group. These urban customers are more likely to push for privatization, competition, and an end to cross-subsidization because they will directly benefit from these reforms within the sector (Li, 2005).

Institutional Reform Variables

The last set of factors is market regulation and institutional reform, including the creation of an independent regulatory agency for the market. For many countries, the regulatory agency and state-owned monopoly are within the same ministry of communications, creating a conflict of interest that can lead to corruption and a slow telecom adoption rate for the country (Kirkpatrick, 2006). By creating an independent regulatory agency, along with a privatized monopoly, countries can develop a competitive environment for telecom adoption to rapidly grow. As mentioned above for the privatization variable, the regulatory reform process must be completed as part of a larger institutional reform process, which can include the creation of ministries of ICT, innovation, and science to drive the ICT policy process. Although there is no readily accessible data that tracks the structural changes of these ICT and innovation institutions, a variable that tracks the size of the government as a share of GDP has been included as a proxy. This government spending variable expands in conjunction with the expanding role of the state, particularly as developing countries shift from government ownership to actively supporting economic development, including fostering ICT adoption (Bortolotti, 2007). In addition, the level of government spending also acts as a proxy for political development within a developing country as it moves toward becoming a more expansive welfare state (Dreher, 2006).

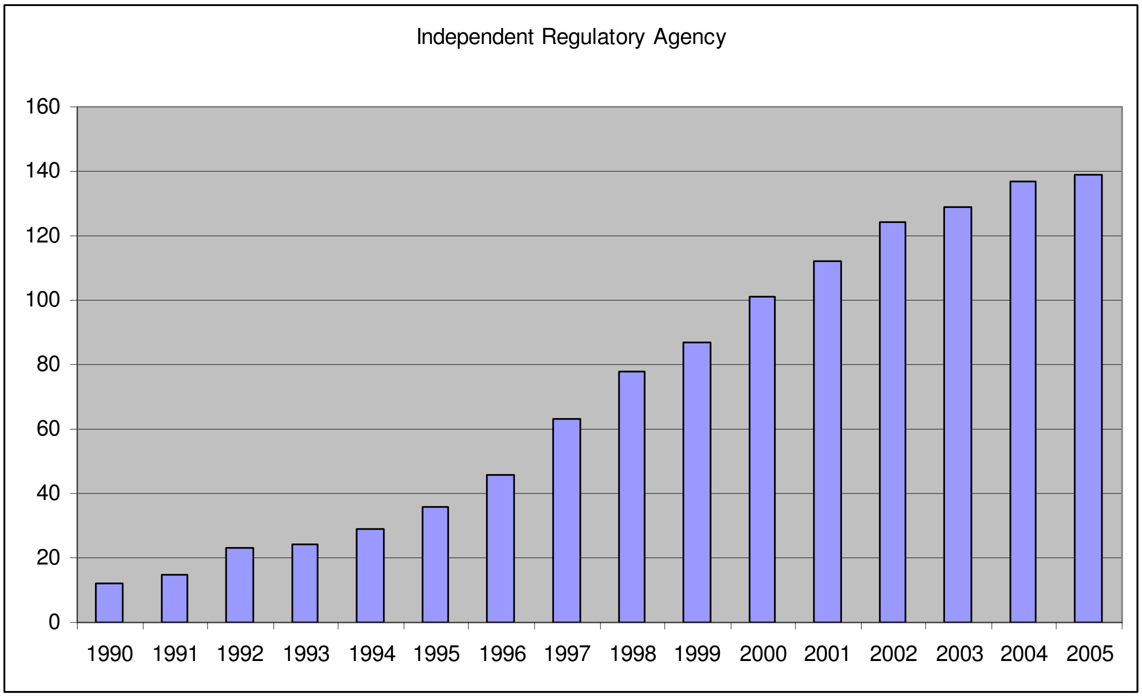
Two independent variables are included to capture within the model the institutional and political development of individual countries. These indicators include both ICT-specific policy solutions, such as the creation of an independent regulatory agency, and high-level political development variables, such as government spending as a percentage of GDP.

Regulatory Agencies

Regulatory structure in a country should include explicit, unified regulations on both governance and incentives to avoid developing an inadequate governing structure. Regulatory governance includes the mechanisms designed to restrain arbitrary regulations. Incentives can include price supports, cross- and direct subsidies to operators, market entry support, and assistance for carrier interconnection (Cook, 2004). ICT regulation is integral to understanding global technology trends and is a key determinant in inducing private investment in the ICT sector. To be successful, a developing country's regulatory structure must be strong enough to withstand corruption and arbitrary governmental actions.

Although most countries have shifted from state-run monopolies toward regulated competition (see Exhibit 3.5), many developing countries still have state-run monopoly telecom operators that are also their own regulators. The creation of an independent body that helps to enforce a competitive market has a major impact on the ICT adoption rate (Baudrier, 2001). Countries with independent regulatory agencies also typically have strong government involvement within the ICT sector – adding support to the hypothesis that adoption may be closely tied to governance issues, rather than simply economic growth. Developing countries with good governance should be able to pull ahead of other countries with the same income levels.

Exhibit 3.5: Expansion of Regulatory Agencies within ITU Member States



Source: International Telecommunication Union, 2006.

Although this model cannot account for all of the various regulations listed above, the creation of an independent regulatory agency should have a positive effect on the rate of ICT growth within the country. An independent body that is dedicated to designing and enforcing a competitive market structure will have a major impact on the adoption rate within a country (Ure, 2003). The creation of an independent regulatory agency is included as a dummy variable, with those years after development of the agency marked with a 1. Similar to the privatization variable, a lagged agency variable was also considered and ultimately unused. Again, this was due to the long time frames for designing and creating an independent regulatory agency, giving the market ample time to prepare and respond.

Government Expenditures

Government expenditures include all public sector spending as a percentage of GDP. This variable is a proxy for political development within a country. Countries with high levels of government spending will be well developed politically, such as Western Europe; while nations with little government spending are less likely to support ICT market development or adoption, such as several markets across Africa (Dreher, 2006). Political freedom indicators, such as the one tracked by the Freedom House, were also considered but dropped due to a lack of annual data available for all the countries covered by the study (Freedom House, 2007).

Government expenditure as a percentage of GDP is expected to have a positive correlation with ICT penetration. As a country's political infrastructure develops, a government is more likely to be able to support a strong business environment, regulate a competitive telecom market, and effectively manage a universal service mandate (Garcia-Murillo, 2005). This relationship between government expenditures and ICT market development also holds for higher country income levels. For example, several high-income countries in Europe with some of the highest levels of governmental spending outstrip the United States in spending while also having a higher ICT penetration rate.

Data Sources, Types, and Forms

Data for all dependent and independent variables has been gathered from secondary sources. The combined fixed and mobile indicators used as the dependent variable have been compiled using data from the World Development Indicators, which are collected annually by the World Bank. In addition, indicators have been gathered from the International Telecommunication Union, which has collected data on ICT and other factors from all of its 189 member countries. Data for the other independent variables has been collected from the ITU and WDI as well as the United Nations Industrial Development Organization (UNIDO), which was used as a source for development and economic indicators. The dummy variables for policy and institutional shifts came from sources at the ITU, which tracks telecommunications policy from its members. Data also includes the quadratic forms for trade, FDI, and GDP per capita. All three of these indicators have a non-linear relationship with the dependent variable.

Selection of Data Sources

Considering the range of independent and dependent variables, and with some of the study countries missing data for one or more of the variables, the model still has 154 countries. The ITU gathered data for 178 countries and the World Bank has information for 226 countries. However, of those 226, only approximately 180 have a significant amount of available data.

There is a pattern to a number of countries that were not included in the data collected by either the ITU or the World Bank. Many of those countries are currently experiencing armed conflict, such as Iraq, or are dependent areas, such as Greenland, with no separate data collection. Unfortunately, indicators for these countries were not available through any other source. There should be no pattern for the additional countries that have been removed from the model due to missing data for a few indicators.

Data Collection and Timing

Data used in this pooled time-series cross-sectional analysis includes observations from 1990 to 2005. This data allows for analysis of variance across time and across countries, which is essential to understanding the impact of institutional factors on ICT adoption rates. Data for 2006 was not readily available for all of the independent variables, but the existing study period should capture the recent growth of ICT utilization in developing countries along with increases in ICT institutional reforms. By including 15 years of data, the study captures the technological and policy changes that began to emerge in the early 1990s in a handful of countries and expanded during the late 1990s across a large subset of the study countries. Exhibit 3.6 contains descriptive statistics for the dependent and independent variables.

Exhibit 3.6: Descriptive Statistics

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
Fixed and mobile subscribers	2791	271.95	358.98	0.32	1998.12
Lagged GDP per capita	2523	8456.939	8850.785	466.1686	64298.52
Lagged GDP per capita squared	2523	1.50e+08	2.94e+08	217313.2	4.13e+09
Gross FDI (% GDP)	2076	7.071171	37.25057	0	1121.338
Gross FDI squared	2076	1436.938	31087.68	0	1257400
Trade (% of GDP)	2590	83.79	46.01	1.53	376.22
Trade squared	2590	9136.01	11346.39	2.34	141543.2
Privatization	2996	0.30	0.46	0	1
Population density	2849	152.99	444.11	-1951.97	6328.81
Services (% of GDP)	2578	52.70	14.20	4.14	88.48
Government expenditures (% of GDP)	2470	16.52	7.27	2.9	76.22
Regulatory agency	2635	0.42	0.49	0	1
Privatization * agency	2618	0.2247549	.41739	0	1
FDI * GDP per capita	1898	186929.2	2131387	0	6.38e+07

Methods

The data described above is used to estimate the effects of institutional factors on telecom adoption while controlling for economic and social factors. The model below was used to estimate the influence of privatization on the state-owned telecommunications monopoly, and the influence of the creation of an independent regulatory agency on the adoption of fixed and mobile services, while controlling both market liberalization and economic development across the study countries. This research attempts to control for time-variant omitted variables with pooled time-series cross-sectional regression and used a number of models, starting with pooled OLS, which is described below.

$$y = \alpha + \beta_1(\text{GDP per capita})_{it-1} + \beta_1^2(\text{GDP per capita}^2)_{it-1} + \beta_2(\text{foreign direct investment})_{it} + \beta_2^2(\text{foreign direct investment}^2)_{it} + \beta_3(\text{trade})_{it} + \beta_3^2(\text{trade}^2)_{it} + \beta_4(\text{privatization})_{it} + \beta_5(\text{population density})_{it} + \beta_6(\text{services})_{it} + \beta_7(\text{government expenditures})_{it} + \beta_8(\text{regulatory})_{it} + \beta_{48}(\text{privatization * regulatory})_{it} + \beta_{12}(\text{GDP per capita * foreign direct investment})_{it} + \varepsilon$$

However, this model is inefficient compared with a random effects (RE) model and is likely to have an omitted variable bias that can skew variable coefficients. These omitted variables can be time-variant such as a telecom subsidy, which is likely to rise and fall over time and be correlated with privatization. Once a country privatizes its monopoly, it can no longer maintain a cross-subsidization across the various sectors of the market, causing many countries to shift to subsidies aimed at indirectly supporting competitive operators or directly subsidizing subscribers. Other omitted variables are time-invariant, such as country-specific cultural issues, which may delay adoption and integration of new technologies into the society. These cultural issues are likely to also affect the society's openness to international trade and investment, controlled for within the model by trade and FDI as a share of GDP, and are unlikely to change during the 15-year time frame of this study.

To address time-variant omitted variables, an RE model was tested. This model allows cluster correlations and is also efficient compared with both pooled OLS and fixed effects (FE).

$$y_{it} = \alpha + \beta_1(\text{GDP per capita})_{it-1} + \beta_1^2(\text{GDP per capita}^2)_{it-1} + \beta_2(\text{foreign direct investment})_{it} + \beta_2^2(\text{foreign direct investment}^2)_{it} + \beta_3(\text{trade})_{it} + \beta_3^2(\text{trade}^2)_{it} + \beta_4(\text{privatization})_{it} + \beta_5(\text{population density})_{it} + \beta_6(\text{services})_{it} + \beta_7(\text{government expenditures})_{it} + \beta_8(\text{regulatory})_{it} + \beta_{48}(\text{privatization * regulatory})_{it} + \beta_{12}(\text{GDP per capita * foreign direct investment})_{it} + u_{it} + v_{it}$$

However, if these omitted variables happen to be correlated to the model's explanatory variables, a random effects model would not be appropriate, giving us inconsistent estimators. Based on the existing literature, this could include educational expenditures and literacy, which are correlated to GDP per capita. Development metrics, such as infant mortality, are correlated with government expenditures and GDP per capita. Also not included are R&D expenditures, which are correlated with services as a percentage of GDP.

In addition to these variables that do not have enough observations to be included in the model, there are metrics that are not currently tracked but may be country-specific and correlated with this model's variables. These could include national or regional cultural variations that slow technology adoption. There are also ICT policy and larger governance issues that are correlated with privatization and regulation that are country-specific, but cannot be tracked by international databases. This can include the ability of governments to execute and enforce ICT regulations, fund and implement ICT support policies, and support technology innovation efforts to tailor ICTs for the national market. A fixed effects approach controls for these unobserved country-specific factors, such as the subsidies and cultural issues discussed above, and allows for more accurate determination of the effect of privatization and regulation on the dependent variable.

The fixed effects model below was used to estimate the influence income, liberalization, and development have on telecom levels across countries. Fixed effects models may exacerbate measure error and are less efficient due to a loss in degrees of freedom. However, with 2,124 observations, this should not be a major concern. In addition, while this FE model may still bias the estimator, it does allow for time-variant omitted variables within the model that are correlated with explanatory variables.

$y_{it} = \alpha + \beta_1(\text{GDP per capita})_{it-1} + \beta_1^2(\text{GDP per capita}^2)_{it-1} + \beta_2(\text{foreign direct investment})_{it} + \beta_2^2(\text{foreign direct investment}^2)_{it} + \beta_3(\text{trade})_{it} + \beta_3^2(\text{trade}^2)_{it} + \beta_4(\text{privatization})_{it} + \beta_5(\text{population density})_{it} + \beta_6(\text{services})_{it} + \beta_7(\text{government expenditures})_{it} + \beta_8(\text{regulatory})_{it} + \beta_{48}(\text{privatization * regulatory})_{it} + \beta_{12}(\text{GDP per capita * foreign direct investment})_{it} + \varepsilon_{it}$

Fixed effects are the most common models used with pooled time-series cross-sectional data sets, where a vast majority of the study population is observed, which is the case with my cross-national data. Because this is a cross-national study, multicollinearity could be a problem and several checks were completed after removing FDI, trade, and GDP per capita squared. A pairwise correlation of the data was completed as well as a pairwise correlation of the coefficients. In addition, the variance inflation factors (VIFs) for each variable and the model average were checked.

To compare the constant coefficients (CC) model with the random effects models, a Breusch and Pagan (B-P) test was used. This test determines if the error terms are independent with the country unit, with a null hypothesis that random effects are not needed. If the null is rejected, this does not guarantee that RE should be used – just that CC may not be the most appropriate.

The Hausman test was used to compare the random effects and fixed effects models. This test determines whether there is a significant difference between the two models, with a null hypothesis that there is no difference between the RE and FE models.

If we fail to reject the null, then the RE is preferred given its greater efficiency versus the FE model. In addition, an F-test was done comparing the pooled OLS model to the FE model.

Heteroskedasticity was also checked using a version of the White Test to determine whether there is a correlation between any of the independent variables and the variance in the error term. The null hypothesis is that the independent variables will be significantly correlated with the residuals, resulting in a high r-squared and a significant F-test.

Results

Exhibit 3.7 contains the results for the regressions using telecom adoption as the dependent variable. It's important to note that the R-squared for economic development indicators are typically very high, due to the aggregate data being used. The model was tested for multicollinearity by checking the correlation of the variables, the correlation of the coefficients, and the variance inflation factors. For all of these tests, the GDP per capita squared, FDI squared, and trade squared variables were all omitted. Both the variable check and the coefficient check had only two results higher than 0.6. The VIFs ranged between 1 and 2, with the average for the model at 1.46. This is relatively low, suggesting that despite using national economic indicators, the model does not have a significant problem with multicollinearity. All of the variables were kept in the model for the additional tests discussed below.

Both the B-P and Hausman tests rejected their null hypotheses at the 1 percent level, suggesting that the FE model is most appropriate—as we would expect due to the country-specific variables that are correlated with the DV and explanatory variables. The B-P test shows that there is clustering, and therefore the RE model is preferred over CC. The Hausman test demonstrates that there is a significant difference between the RE and FE models, and that the FE is preferred. In addition, the F-test for the significance of the fixed effects intercepts indicates that FE is preferred over pooled OLS.

Exhibit 3.7: CC, RE, and FE Results

	Constant Coefficients	Random Effects	Fixed Effects
Lagged GDP per capita	0.030	0.008	0.097
	(0.002)**	(0.004)*	(0.006)**
Lagged GDP per capita squared	0.000	0.000	0.000
	(0.000)	(0.000)**	(0.000)
FDI (% GDP)	-0.876	1.970	2.650
	(0.806)	(0.753)**	(0.701)**
FDI squared	0.002	0.003	0.001
	(0.000)**	(0.000)**	(0.001)*
Trade (% of GDP)	1.174	2.235	2.445
	(0.329)**	(0.500)**	(0.568)**
Trade squared	-0.001	-0.004	-0.005
	(0.001)	(0.002)*	(0.002)
Privatization	78.847	66.297	19.770
	(15.923)**	(17.137)**	(15.803)
Population density	0.026	0.019	0.167
	(0.010)*	(0.020)	(0.092)
Services (% of GDP)	0.924	2.921	6.427
	(0.506)	(0.717)**	(0.791)**
Government expenditures (% of GDP)	3.649	2.626	3.633
	(0.899)**	(1.243)*	(1.340)**
Regulatory agency	80.131	73.041	31.049
	(11.911)**	(11.516)**	(10.467)**
Privatization * agency	54.735	125.382	106.885
	(20.555)**	(20.044)**	(17.897)**
FDI * GDP per capita	-0.00002	-0.0001	-0.00008
	(0.000)	(0.000)**	(0.000)**
Constant	-226.313	-348.828	-1,196.472
	(27.614)**	(42.593)**	(62.439)**
Observations	1727	1727	1727
R-squared	0.79		0.71
Number of id		154	154

Number of countries: 154. Standard errors in parentheses.
* Significant at 5%. ** Significant at 1%.

In addition, the model was also tested for heteroskedasticity using the White test. Running the regression with the square of the residuals, the resulting R-squared was 0.996, demonstrating that the independent variables did explain much of the residuals. The F-test for the model was also significant at the 1 percent level along with many of the

T-tests for the variables. This may be due to issues inherent in economic indicators, such as autocorrelation, which may be influencing these tests. However, given that the FE model is still the most appropriate, and that it allows for omitted variables to be correlated to explanatory variables, the results for the White test do not suggest that the model estimates are unusable.

The major independent variables in the model were privatization and regulation. A completed T-test of the variables showed that the agency and interaction terms were both positive and significant at the 1 percent level, while privatization was not significant in the fixed effects model. The coefficients for agency and interaction terms on the dependent variables of 31 and 106.9, respectively, on average hold the other factors constant. Therefore, countries with a regulatory agency on average will have an additional 31 fixed and mobile subscribers per 1,000 inhabitants than countries that do not, holding all other variables constant. In addition, those that have privatized and created an agency have 106.9 additional fixed and mobile subscribers per 1,000 inhabitants on average than countries with neither, holding all other variables constant. With a mean of 272 for the dependent variable, these increases of 31 and 106.9 suggest that the benefits of undergoing the privatization and regulatory reform processes are valuable to countries seeking to accelerate ICT adoption.

In a similar fixed effects model that left out the interaction term for agency and privatization, the coefficient for privatization was significant and positive at the 1 percent level. The coefficient for privatization was 93 while the coefficient for agency was 56.3. This suggests that the interaction term and the privatization variable are explaining the same variation in the dependent variable. In contrast, agency is still positive and significant. This suggests that there are few countries with an agency but that have not privatized, yet there are countries that have privatized but not created an agency. The results from these two fixed effects models – one with and one without the interaction term – suggest that there is a common sequence of events in which countries privatize their monopoly and then create their agency.

Lagged GDP per capita is significant at the 1 percent level, influencing the DV 0.097 on average for every 1 unit increase in lagged GDP per capita, holding everything else constant. In comparison, this model with non-lagged GDP per capita and GDP per capita squared results in the same coefficient to the fourth decimal place, 0.0969, and was still significant at the 1 percent level. This suggests that although the Granger test rejected the null hypothesis of non-causality, the causal relationship between ICT adoption and GDP per capita was not significantly biasing the coefficient.

For the coefficients of the other independent variables, each maintained its significance and direction with the introduction of lagged GDP per capita. However, most of these coefficients were slightly higher with the lagged variable than with the non-lagged variable. This included trade as a percentage of GDP, which had a coefficient of 1.97 with the non-lagged variable and 2.65 with the lagged variable within the fixed effects model. Another example was services as a percentage of GDP, where the coefficient increased from 5.65 with the non-lagged GDP per capita variable to 6.43 with the lagged variable. The significant exception to this shift was the interaction term for privatization and agency, where the coefficient decreased from 120.13 with the non-lagged variable to 106.88 with lagged GDP per capita. Conversely, the coefficient for privatization increased from 8.93 to 19.77 with the lagged variable while agency increased from 23.61 to 31.05. The interaction term and the agency variable were both significant at the 1 percent level and privatization was not significant. Although the coefficients for the individual institutional variables increased with the introduction of the lagged variable, the overall relationship between these two variables, their interaction term, and the dependent is of a similar magnitude, direction, and significance with both the lagged and the non-lagged GDP per capita variable included.

Gross FDI was positive and significant at the 1 percent level while FDI squared was significant at the 5 percent level, with coefficients of 2.65 and 0.001, respectively. The interaction term for FDI and lagged GDP per capita is also significant at the 1 percent level with a negative coefficient of -0.00008. This low coefficient is due to the high maximum for the variable, where a one-unit increase for FDI * GDP per capita would only decrease the DV by 0.00008. More importantly, the negative coefficient suggests the two variables are not complementary and therefore a shift in FDI within a low GDP per capita country will have a larger effect on the DV than a shift in a high GDP per capita country, holding all else constant. This is supported in the literature, where these increases in FDI can lead to technology transfer, having a large effect on the ICT market of a developing country while countries operating at the technology frontier are likely to see fewer direct benefits to their ICT adoption rates.

Trade was significant at the 1 percent level but had a positive coefficient of 2.45, and trade squared is negative and significant at the 10 percent level. This suggests that for countries with low levels of trade, the variable has a positive relationship with the DV; and at higher levels of trade, the relationship becomes negative, as was hypothesized. In addition, the services and government expenditure variables were both positive and significant at the 1 percent level, while population density was positive and significant only at the 10 percent level.

As shown in Exhibit 3.5, a majority of countries are now choosing to liberalize their market through independent regulatory agencies along with privatizing their state-owned operators. Several exogenous factors are driving these countries to undergo this transition, including international regimes such as the World Trade Organization (WTO), regional organizations such as the Association of South East Asian Nations (ASEAN) or the EU, foreign competition from global carriers, and international investment (Henisz et al., 2005). However, these factors may be pushing these countries to transition without the necessary policy or institutional reforms necessary to sustain them (Baudrier, 2001). The larger context for this transition within ICT sectors is good governance, which is difficult to implement and maintain, particularly within developing countries (Bortolotti, 2007). This has resulted in nations, such as Thailand, that have not been able to maintain their higher rates of adoption after privatization and reforming regulations due to poor governance structure (Jirachaipravit, 2007).

Exhibit 3.8 shows four versions of the constant coefficients: one CC model without variables for privatization or regulatory agency, two CC models with only one of these two variables, and then a CC model with both of them. These different versions of the CC model were run to determine the relationship between the two key explanatory variables – privatization and regulatory agency – with the other independent variables. FDI has a much stronger relationship with the creation of an independent regulatory agency than privatization because the coefficients for FDI in the CC models with agency are higher. This may be due to the higher level of good governance that is needed for both increasing FDI and successfully completing regulatory restructuring. This supports Globerman and Shapiro's study, which suggested that governance infrastructure is a key determinant of FDI (Globerman and Shapiro, 2002). In contrast, the relationship between government expenditures and privatization is stronger than with the creation of an agency. This relationship may be stronger because the ICT privatization of a developing country will coincide with a larger privatization effort as the national government shifts from a primary to a supporting role within the economy, as suggested by Bortolotti (2007).

Exhibit 3.8 also shows that the coefficient for privatization, at 148.3 in the second column, is higher than the coefficient for agency, at 134.8 in the third column. This supports Wallsten's study, which suggested that countries move through this transition sequentially, first with the privatization and then with the regulatory agency (Wallsten, 2002). The higher coefficient suggests that more of these developing countries have undergone privatization and have yet to create their independent regulatory agency. This also is supported by the interaction term between these two variables and included in the fixed effects model discussed above.

Exhibit 3.8: Constant Coefficients Regression Results for Dependent Variable – Fixed and Mobile Telephone Penetration

	No Privatization, No Agency	Privatization, No Agency	Agency, No Privatization	Agency and Privatization
Lagged GDP per capita	0.033	0.029	0.033	0.030
	(0.002)**	(0.002)**	(0.002)**	(0.002)**
Lagged GDP per capita squared	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Foreign direct investment	-1.574	-1.586	-1.841	-1.790
	(0.412)**	(0.392)**	(0.406)**	(0.393)**
FDI squared	0.001	0.001	0.001	0.001
	(0.000)**	(0.000)**	(0.000)**	(0.000)**
Trade	1.795	1.417	1.399	1.192
	(0.354)**	(0.336)**	(0.338)**	(0.328)**
Trade squared	-0.005	-0.003	-0.002	-0.001
	(0.001)**	(0.001)*	(0.001)	(0.001)
Population density	0.034	0.032	0.030	0.030
	(0.011)**	(0.011)**	(0.011)**	(0.010)**
Services	2.692	1.529	1.479	0.942
	(0.525)**	(0.504)**	(0.516)**	(0.502)
Government expenditure	1.217	3.001	2.807	3.726
	(0.952)	(0.909)**	(0.925)**	(0.900)**
Privatization		148.319		111.704
		(10.113)**		(10.484)**
Regulatory agency			134.806	98.243
			(9.538)**	(9.856)**
Constant	-242.513	-224.977	-251.217	-234.930
	(29.515)**	(28.042)**	(28.265)**	(27.424)**
Observations	1762	1755	1727	1727
R-squared	0.75	0.77	0.78	0.79

Standard errors in parentheses.
* Significant at 5%. ** Significant at 1%.

Threats to Validity

Below is a brief discussion of the various threats to validity of the model, including misspecification, data availability, and multicollinearity.

Multicollinearity

There is a wide enough difference between the types of measures included in the dependent variable, which includes two ICT indicators, and the independent variables, which are social, economic, and institutional indicators, that multicollinearity should not be a problem with the model. It is more of a possibility that some of the independent variables are explaining the same variation in the dependent variable. This could include GDP per capita and several of the economic development variables, such as services. But most of the dependent variables are measuring such different factors that the potential threat should be small.

Several tests were already performed for the fixed effects model. The model was tested for multicollinearity by checking the correlation of the variables, the correlation of the coefficients, and the variance inflation factors. None of these checks had high enough results to suggest concern for multicollinearity.

Heteroskedasticity

The model also tested for heteroskedasticity using the White test, running a regression with the square of the residuals to see if the independent variables explain much of the residuals. This test was performed to determine whether independent variables are explaining the dependent variable’s error term, particularly focusing on the relationship between the dependent and the independent variables, GDP per capita, FDI, and trade. The non-linear relationship between the dependent variable and these three variables begins to break down as a country's level of GDP per capita, FDI, or trade decreases. Countries tend to bunch together with a weaker correlation between these variables and adoption. This becomes less of a problem for the high-income countries, with the variance declining.

Autocorrelation

Autocorrelation has the potential to be a serious problem. There is little likelihood that a country's level of adoption for a given year will vary widely from the next year's level. A country's adoption level will build on the previous year's level – also meaning that it will rarely decline from one year to the next. Autocorrelation can cause problems with the standard errors and could inflate the significance of the independent variables.

Causality

This study attempts to control for the problem of causality with pooled time-series cross-sectional regression, but the policy treatments could simply be codifying what is already happening within the country. Trends over time are hard to separate from the true effect – many of the variables are increasing each year, making it difficult to determine the effect across those variables. These national statistics may not be measuring the necessary trends within the market that result in the privatization process and a regulatory agency. Similarly, these two explanatory variables could be an outgrowth of market conditions, presented during the rapid ICT adoption but not the cause of the growth.

Simultaneity Bias

This model attempted to control for the causal relationship between ICT adoption and GDP per capita with a lagged explanatory variable. This concern was based on the results of a Granger causality test that rejected the non-hypothesis of non-causality. However, the coefficients of GDP per capita and lagged GDP per capita were both 0.097, suggesting there was little coefficient bias as a result of the Granger causality.

Model Misspecification Due to Omitted Variable

Due to data availability, there may be variables that are not included in the model. As an example, R&D expenditures, education expenditures, and urbanization are correlated with ICT adoption. However, it is difficult to obtain these variables for low-income countries – potentially producing a bias within the model. To mitigate this misspecification, several variables were included as proxies for these variables, such as services and population density, that manage to capture the relative sophistication of a country's economy.

Data Availability

There are several additional limitations to the model's data, the first being the issues surrounding the dependent variable. There are many critical drawbacks to available measures of ICT metrics. Without reliable regional or sub-national information, international databases from the World Bank and ITU are forced to rely on national statistics, which hide regional discrepancies within countries. Many developing countries have very high levels of ICT inequality and the national statistics conceal the lack of infrastructure and investment in their rural or low-income areas. This inequality could certainly lead to bias within the model over time. Countries with similar levels of ICT adoption, but widely varying degrees of inequality, could have very different outcomes in their efforts to accelerate ICT penetration.

Independent Variable Formatting

There may also be misspecification with the way the data is represented in the model. For example, total FDI as a percentage of GDP is only one way out of more than six that this information can be represented. Choosing the wrong format could easily create a problem with the coefficients or standard errors. This variable formatting may also influence the other independent variables in the model, impacting each other in unpredictable ways. Because the r-squared is so high with economic development models, one solution would be to add variables to the model through trial and error once additional variables are collected and reformatted.

Discussion

The results from the model were largely consistent with my expectations and the existing literature. A country's GDP per capita explains a large share of the dependent variable's variation, but it can also overstate the connection between high income and high levels of telecom adoption. By including privatization and regulatory variables, in addition to economic development metrics, the model was able to account for much more of the variation across countries. Because countries with independent regulatory agencies typically have strong government involvement, this suggests that adoption may be closely tied to governance issues rather than simply economic growth. Although a low-income country cannot leapfrog past high-income countries in terms of telecom adoption, developing countries with good governance should be able to pull ahead of other countries with the same level of GDP per capita.

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Section 4: Pitfalls of the National ICT Policy Implementation Process – A Comparative Study of Malaysia and Thailand

Introduction

Thailand and Malaysia have both undergone a rapid transformation of their ICT sectors, including their networks, national policies, institutions, and regulatory regimes. It is my contention that the privatization of the monopoly operator and the creation of a regulatory agency are the foundation for all other governmental ICT initiatives designed to accelerate telecommunications adoption. This is a difficult process to successfully implement, with many countries unable to sufficiently reduce the authority of the PTT to develop an agency that is politically independent. Despite these difficulties, this process is vital to the success of a national ICT market. The creation of a competitive market and a government regulator is the basis on which all other regulatory reforms, institutional reforms, and national ICT policies must rest. If a country cannot achieve a politically sustainable balance of power between the government, the former monopoly, and the competitive players, then that country cannot sustain rapid ICT adoption.

As countries privatize their monopolies, governments must work to open their telecom market to new entrants while supporting new infrastructure deployments – in short, helping to drive demand while supporting the development of the ICT sector (Gasmi, 2000). However, the policy initiatives underpinning these regulation and utilization efforts must be precisely sequenced to support a thriving ICT sector within a developing country (Wallsten, 2002). Successful governments have closely coordinated their ICT market policies with the private sector to achieve regulated and sustainable competition.

Within this institutional and market context, I examine the ICT adoption paths of Malaysia and Thailand. Both of these countries are at similar levels of economic and political development, although Malaysia has had a more stable macroeconomic and political environment since the Asian Crisis of 1997. Each country has modeled its ICT institutional structure and policies on the successful example of Singapore, along with South Korea and Japan, for their national broadband and infrastructure initiatives. Despite these similarities, political considerations in Thailand have influenced the privatization of the monopoly operator and the creation of the regulatory agency according to government officials interviewed for this case study. These considerations have led to a less competitive environment for the ICT market and the country has not been able to sustain its pace of ICT adoption, resulting in a plateau in Thailand's progress.

This case study section discusses and compares the ICT market, regulation, and policies of Thailand and Malaysia. The section is divided into six parts. The first includes the case study methodology while the second provides an overview of the economic conditions within Malaysia and Thailand, with a specific look at international firms and investment. The third part provides a detailed discussion of the current conditions of the ICT sectors in Thailand and Malaysia, including an examination of adoption levels and market competitiveness along with a comparison to other middle-income countries. The fourth part studies the regulatory regime of both of these middle-income countries while the last part offers my conclusions about Thailand's and Malaysia's ICT sectors based on this case study analysis.

Case Study Methodology

The case study will outline and compare the policy and implementation trajectories of these two middle-income countries as well as the hurdles that impeded government implementation. Data sources for this country study include international indices, secondary surveys, governmental reports, and third-party research on ICT industries, government regulations, and ICT policies. The research also includes fieldwork in Thailand and Malaysia, completing 24 interviews with key officials responsible for design and implementation of the national ICT strategies.

Interviews were completed with stakeholders in the public and private sector. These government interviewees include officials at ministries of communication, science, and technology agencies; ministries of finance; and national telecom regulators. In addition, several outside experts located at think tanks or other organizations were contacted and interviewed. All of these interviewees were contacted and interviewed in confidence; therefore, no names will be referenced in this study. However, the ministry or organization where interviewees were employed will be cited where appropriate. These interviews helped to clearly define the policy evolution that has taken place as well as highlight successes and failures within the implementation process. From the private sector, these interviews focused on local telecommunications firms to understand their plans for ICT investment and their support for the national strategy. In addition, interviews were completed with outside experts and additional officials, including those in the Ministry of Finance. A list of the ministry or organization for interviewee is included in Appendix A along with the interview protocol in Appendix B.

Using the results of these interviews, I examined the commonalities between Thailand and Malaysia in their ICT strategies, implementations, and hurdles. I also analyzed how Singapore's and South Korea's ICT reform processes have influenced Thailand's and Malaysia's policy designs. Using this comparative information from these two middle-income countries, I made national strategy and policy implementation conclusions based on gaps in their current ICT outcomes. These two case study countries will be used to examine the following research questions:

- Are public sector policies and programs necessary for initiating and sustaining ICT growth?

- How does the governmental role successfully transition from monopoly operator to a supporting player in the ICT sector?

- Have weaknesses in Thailand's institutional structure and regulatory regime led to a growing gap in penetration rates between Thailand and Malaysia?

I would argue that there is strong internal validity to the case study due to the political, economic, and ICT sector similarities discussed in detail below. Both Thailand and Malaysia are middle-income countries with similar GDP per capita growth patterns and are at similar levels of political development. However, Thailand has suffered a recent setback due to its democratization as a result of a coup in 2006. Malaysia and Thailand have implemented national ICT strategies and institutional reforms based on the

Singaporean model. Despite these similarities, the two countries have experienced a large and widening gap in ICT adoption outcomes – making them excellent target countries for this case study research.

There are external validity limitations with two case study countries that are both middle-income, Asian exporting economies. There are limits to the generalizability of these conclusions to countries in other regions or other income categories. This is particularly true of low-income countries, which face far different demand and infrastructure challenges than Malaysia or Thailand due to their macro-economic status. However, these cases do offer clear lessons to other middle-income countries that are undergoing their own national ICT policy and institutional reform process.

Economic Conditions

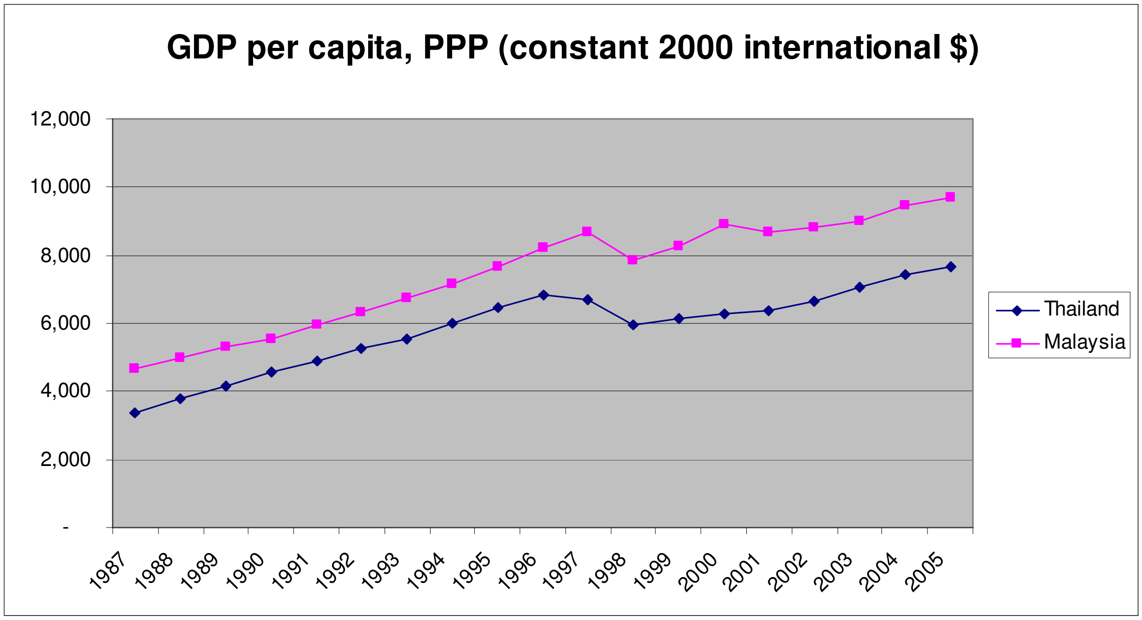
Other East Asian countries used a combination of direct industry supports and protections to drive high-tech exports and, in turn, accelerate economic development. Two of the most notable are South Korea and Singapore, where local industry was protected from foreign competition but the government was willing to use its political capital to cut support to failing businesses while rewarding successful firms with new opportunities (Amsden, 1989). The danger politically for any developing country is that a government will not be independent enough to stand up to special interests and political favorites that do not meet the standards for protection, but have enough political power to ensure government support anyway (Levy, 1994). Korea and Singapore are examples of the few countries that have been able to do this successfully. In contrast, Thailand and – to a lesser extent – Malaysia have not been able to successfully enforce these development policies (Jomo, 2003; Ritchie, 2005). By placing political considerations as a primary factor for determining which sectors to protect and promote, these two national governments have limited the technological development and innovation capacity of local industries – which, in turn, has had a detrimental effect on economic development.

This third part of the case study section includes a discussion of the economic conditions within Thailand and Malaysia, examining the continued influence of the Asian Financial Crisis of 1997 on the growth trajectories of the two countries.

Thailand

Thailand's economy was the first to be struck by the 1997 Asian financial contagion and was one of the countries most affected by the crisis. Thailand took several years longer than other Southeast Asian countries to restart its growth due to a combination of poor regulatory oversight, political influence, and over-leveraged capital (see Exhibit 4.1). In interviews with Thai government officials and ICT policy experts, several interviewees argued that the Thai government has yet to implement the necessary government and financial reforms to avoid a similar crisis. The GDP per capita of Thailand has long grown at rates similar to Malaysia's, although it trailed by approximately $1,000 per capita during the early and mid-1990s. After the crisis, Thailand was approximately $2,000 below Malaysia due to its longer turnaround period and slower growth into the early 2000s.

Exhibit 4.1: Comparison in GDP per Capita Indicators from 1987 to 2005 for Thailand and Malaysia



Source: World Development Indicators, World Bank, 2006.

The economy has also been hampered by the political instability caused by the standoff between the parliament and the prime minister, who was forced out by the military in a quiet coup d'etat in 2006. This instability has had a large dampening effect on capital investment and FDI according to government officials at the finance ministry along with private consumption within the country. This is especially damaging to the Thai economy, which only recently had seen its inflows of FDI as a percentage of GDP rebound in 2005, increasing to 2.6 percent after experiencing inflows that averaged only 1.1 percent from 2002 to 2004 (World Bank, 2006). The coup has also delayed the approval of 10 infrastructure "mega-projects" that had been proposed by the previous government for improving transportation, irrigation, and ICT networks, among others. Although these projects had been delayed by the impasse between the parliament and the prime minister, it is unlikely that they will be implemented by the government installed by the military with the same large budgets originally envisioned – potentially slowing the expansion of ICT access within Thailand. The current Thai government is constrained by a number of factors, including the lack of an electoral mandate, an aversion to continuing the policies and initiatives of the ousted prime minister, and concerns about unsustainable spending on infrastructure projects.

The Thai economy is diverse and includes strong agricultural, manufacturing, and service sectors, with a strong focus on exports – which remain the key driver of economic expansion. The agricultural sector has long been a central industry in Thailand, helping to drive exports, but Thai agriculture is facing strong international competition (Abonyi, 2005). This has pushed Thailand's share of the global market lower in recent years. Although the value-added sectors within processing and distribution have expanded, success in global markets generally has been limited to relatively few companies. Thailand has also been successful at developing an automotive sector focused on production of light trucks. This success has led to export of vehicles and auto parts regionally and internationally. The industry, which was once closely protected by the government to foster its growth, must now contend with the reduction of these protections – and they will be reduced further if a free trade agreement is reached with the US. Once the economy is more open to international firms, this sector also will face the difficult challenge of significantly improving productivity to compete effectively. The software industry has been a key component of the government's long-term strategy to bolster the development of local ICT industries. Supported by a range of direct and indirect government support, the industry is still in its infancy, lacking international presence. Domestic demand for ICTs far outstrips domestic capability, creating a sector that is dominated by imports of hardware, software, and professional services. Taken together, these three sectors represent key areas of growth opportunity for Thailand and industries that could benefit from higher ICT utilization to improve productivity.

Malaysia

Malaysia is striving to reinvent itself from a manufacturing exporter to an advanced services and technology innovator (Shari, 2003). The country's manufacturing facilities, even within the electronics industry, had been low on the global product supply chain and handled mostly assembly and other finishing processes. The country is currently at a crossroads in its development, where it can no longer rely on its manufacturing base alone to spur economic growth and development. Its technology policies have yet to place Malaysia among the global innovators. Recently, Malaysia had been an example of a country that has focused almost singularly on technology development through foreign investment and technology transfer. However, the national government is now attempting to move its economy away from a dependency on MNC product exports and toward technology design or innovation (Lall, 1999). The national technology policy is at the center of the government's attempt to create an opportunity to achieve the status of an advanced industrialized nation.

Most noticeable about the Malaysian economy is the central position of the electronics exports sector within economy policy. In the 1970s, the Malaysian government decided to focus on these exports and has strived to diversify the economy ever since (Rasiah, 2003). The sector chosen by the national government was to be the electronics industry since it had already been expanding rapidly and was set to take off. As the semiconductor market was taking off, fierce competition between Japanese and American firms continually pushed prices lower and companies were searching for ways to decrease costs. Japanese and American firms began locating their facilities in Malaysia in the 1970s to tap into the country's low-wage workers, economic stability, and financial incentives, such as its 10-year pioneer status (Hobday, 1999). The Malaysian states also began setting up free trade zones (FTZ), starting with Penang, which quickly grew into one of the global centers of the semiconductor supply chain (Wah, 1999). This helped usher Malaysia out of the agriculture phase and into the manufacturing phase of development. This growth pole strategy worked wonders for economic growth, but ignoring other sectors only reinforced the county's reliance on a single sector within manufacturing for its economic survival.

The spillover from the industry has been slow coming; and when it has come, it has had a relatively limited benefit because the electronics manufactured in Malaysia are almost strictly for export and there is little local content (Bunnell, 2002). As a result, there were few growth opportunities for indigenous firms indirectly linked to the sector, save for a few suppliers (Lall, 1999). Within much of the Malaysian electronics manufacturing industry there is an over-reliance on MNCs for capital, technology, and management. This reliance has created few linkages between local suppliers and global firms (Hobday, 1999). These linkages have begun to some degree, but these local suppliers' level of technical complexity for the ICT industry remains below the government's goals. This sector has moved beyond simple assembly work that was prominent in the 1970s, but not enough indigenous capability has developed to grow local businesses (Kam, 1999).

ICT Adoption within Malaysia and Thailand

Several developing countries including Malaysia and Thailand have announced their national policies within the last 10 years (Ramasamy, 2004). Because both were modeled after Singapore's national ICT policies and institutions, the national plans and ICT institutions of the two countries are very similar (Lallana, 2004). However, the implementation and successes of the two countries have differed considerably. I completed a series of interviews with government, private sector, and university stakeholders in Thailand and Malaysia in 2006 to help determine the cause behind these two differing experiences. This research found that key factors for both countries included transparent telecom privatization and regulation, strong political institutions and leadership, and sustained public-private coordination.

This fourth part of the case study section is broken into three components. The first provides an overview of the technological conditions in Thailand and Malaysia. The second discusses ICT penetration rates within the two countries, including the challenges and successes across the different ICT services, such as mobile phones and broadband. The third component examines the competitive environment in Thailand and Malaysia and discusses the wide disparity in competitiveness across the various ICT services in both countries.

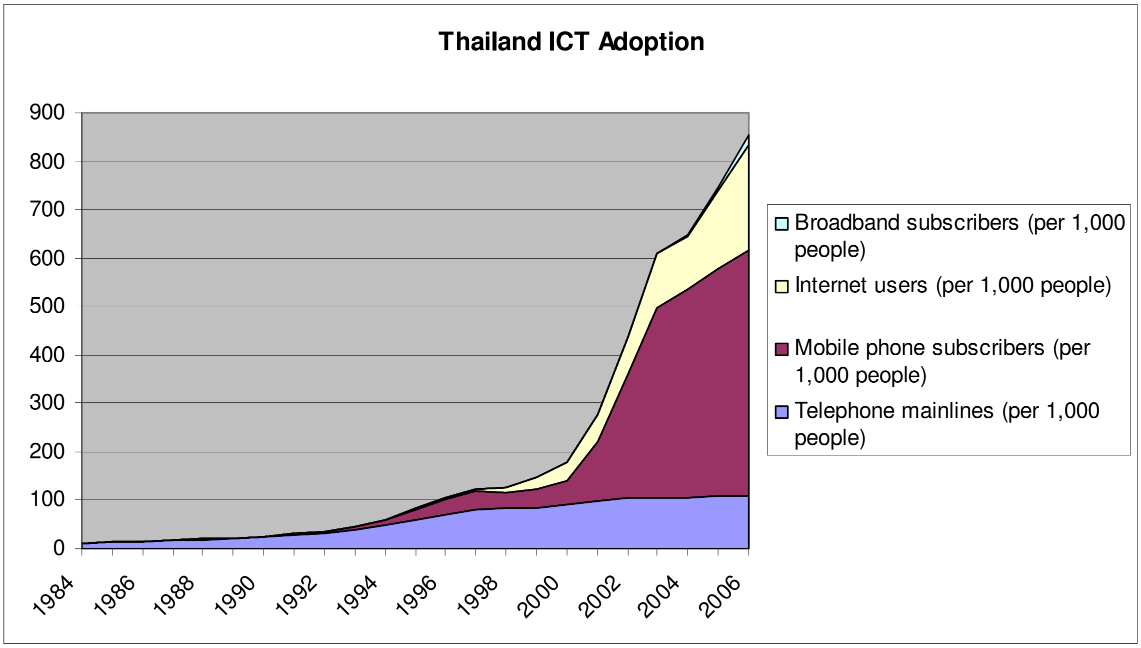
Fixed line telephony and broadband penetration is below average for Thailand, given its level of economic and technological development. This situation was much worse in 2000, when the government began working to catch up through its ICT Master Plan. Although broadband rates are improving, this is not due to the government intervention but higher demand by more affluent customers.

Level of ICT Penetration

Thailand

The fixed and mobile market within Thailand had followed a trajectory similar to that of many other developing countries, including Malaysia, according to data collected by the World Bank (2006). The wireless market had increased dramatically since 2000 (see Exhibit 4.2). However, it has stagnated since 2003 while the wireline market has remained flat, leaving a four-to-one disparity between the two markets. Starting in 2003, Thailand saw a rapid rise in Internet usage within the country – although this may be hampered if the government cannot support mobile broadband services. A notable difference between Thailand and Malaysia is the wireless adoption rate, which flattened out in 2004 (World Bank, 2006). According to interviews with operators in Thailand, this flattening of the adoption continued through 2006 and was caused by the regulatory and legal issues surrounding the market. These regulatory challenges have resulted in limited investment in the sector and dampened competition. This has left Thailand lagging far behind its neighbors in total adoption as well as market growth rates since 2003.

Exhibit 4.2: ICT Adoption Rates in Thailand



Source: World Bank, 2006.

There is a lack of high-quality fixed line infrastructure in Thailand that can support DSL services, limiting the adoption rates. According to officials at the Ministry of ICT, this has left Thailand with a total of 500,000 broadband subscribers, held mostly by competitive players such as True Corporation, a competitive fixed and mobile provider. Company officials argue that True has a last mile advantage over all the other service providers with its 3 million high-quality access lines that are DSL-ready. Because the incumbent's lines are not adequate to support next-generation services, True's position in Bangkok and the suburbs has pushed the company to the top of the market. True does offer wholesale leases on its access lines. However, its high prices leave no room for margins and make the leased line business model financially unsustainable.

This competitive landscape has left little broadband price competition in Bangkok and little incentive for True or other providers to deploy in provincial areas. The Ministry of ICT has set a target of 1 million subscribers by year-end 2007. However, there is no strategy in place to implement this policy. In addition, service providers will be pushing to negotiate with the government that any expansion of their networks into rural areas should count toward their universal service obligation, which is set at 4 percent.

Another key factor limiting the deployment of broadband services in Thailand is the regulatory structure supporting the adoption of third generation (3G) wireless technologies. 3G mobile services can support mobile data connections at broadband speeds. Officials with the national regulator have suggested that Thailand has fallen behind its neighbors in this sector. No mobile carriers are even applying for an import license of 3G platforms as of late 2006. The regulatory structure for 3G wireless is split between the National Telecommunications Commission (NTC) and an as yet unformed National Broadcasting Commission (NBC). All seven commissioners for the NBC have been rejected by a federal court and no further action has been taken since the parliament was dissolved by the prime minister. Without the NBC, there can be no new entrants into the market and no additional spectrum can be allocated to existing wireless providers.

The Thai market has become increasingly risky for service providers. For example, two major competitors in the mobile market, AIS and DTAC, have been bought by Temasek Holdings of Singapore and Telenor of Norway, respectively. With the regulatory uncertainty and rapid technology change, company spokespersons at the competitive operators have argued that they require deep pockets and expertise to survive the telecom market reforms while making the leap to next-generation networks. This leap in technology is particularly risky for countries such as Thailand that are not designing or manufacturing these new platforms. This forces service providers to invest in foreign technology and vendors that will not tailor their solutions for the specific requirements of the market. That leaves local service providers with the risky bet of trying to forecast future directions of the global infrastructure market. A wrong forecast can leave providers with a network technology that global vendors do not support and without the necessary capital to migrate their networks.

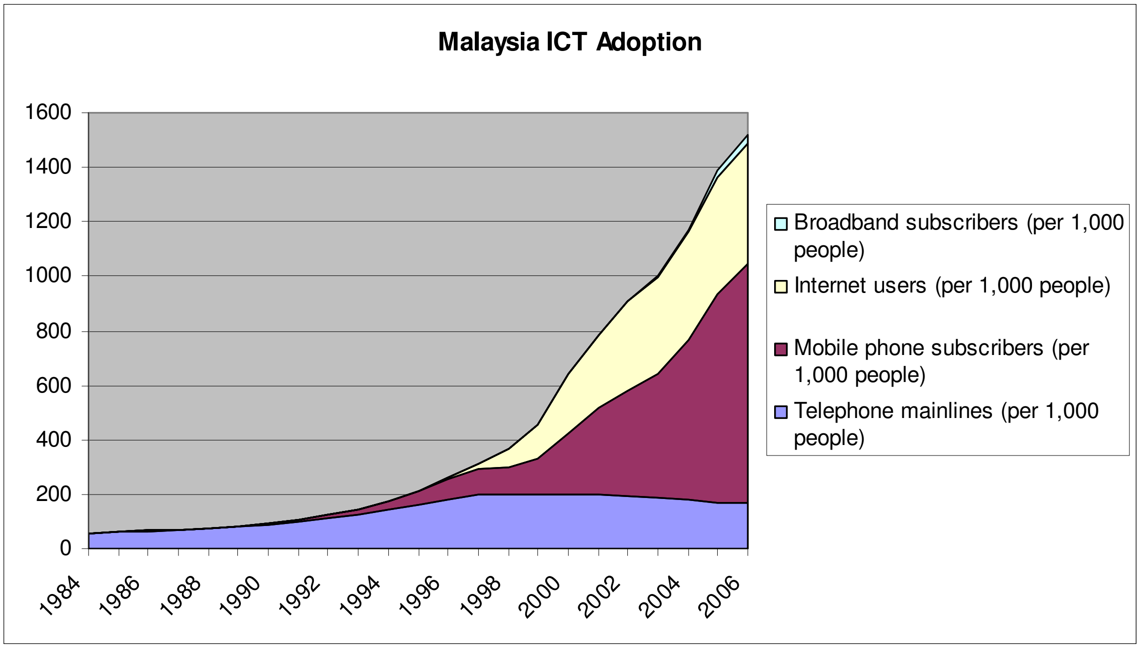
This situation within the telecommunications market will continue to limit the economic development prospects and technology innovation capabilities of the country. The regulatory, financial, and infrastructure hurdles facing telecom competitors are distorting the Thai market. The market power of a handful of players has left the country with few options for service, limited deployment, and relatively high prices. In addition, delays by the NTC and the central government in clarifying the regulatory structure are only leading to worsening conditions as the country falls farther behind its neighbors.

Malaysia

Malaysia has moved quickly to push out telecommunications infrastructure within the country (see Exhibit 4.3). Until the mid-1990s, the teledensity of the country languished at fewer than 100 lines for every 1,000 people (World Bank, 2006). Many developing countries have shifted their focus from deploying more mainline connections, which are landlines to homes and businesses, to wireless penetration. Malaysia's wireline penetration rate peaked in 2000 before starting to decline due to the explosion of wireless users. Internet usage managed to take off a decade ago and reached almost 40 percent of the population as of 2004. This lack of wireline penetration could hinder Internet access if Malaysia cannot continue to support the rollout of mobile broadband services and telecenters (Firth, 2001). Total broadband usage reached 1 percent as of 2004.

Wireless access grew rapidly after 1999, managing to outnumber landlines almost four-to-one in fewer than six years (World Bank, 2006). The disparity between wireline and wireless users in Malaysia is common across many developing countries (Gray, 2004). There are many reasons for this market situation, the most notable of which is geography. Countries with mountainous areas or islands have difficulty cost-effectively connecting users with landlines. Installing a cell tower to serve an area within a developing country is easier and less costly than stringing copper wires, allowing wireless service to be expanded quickly.

Exhibit 4.3: ICT Adoption Rates in Malaysia

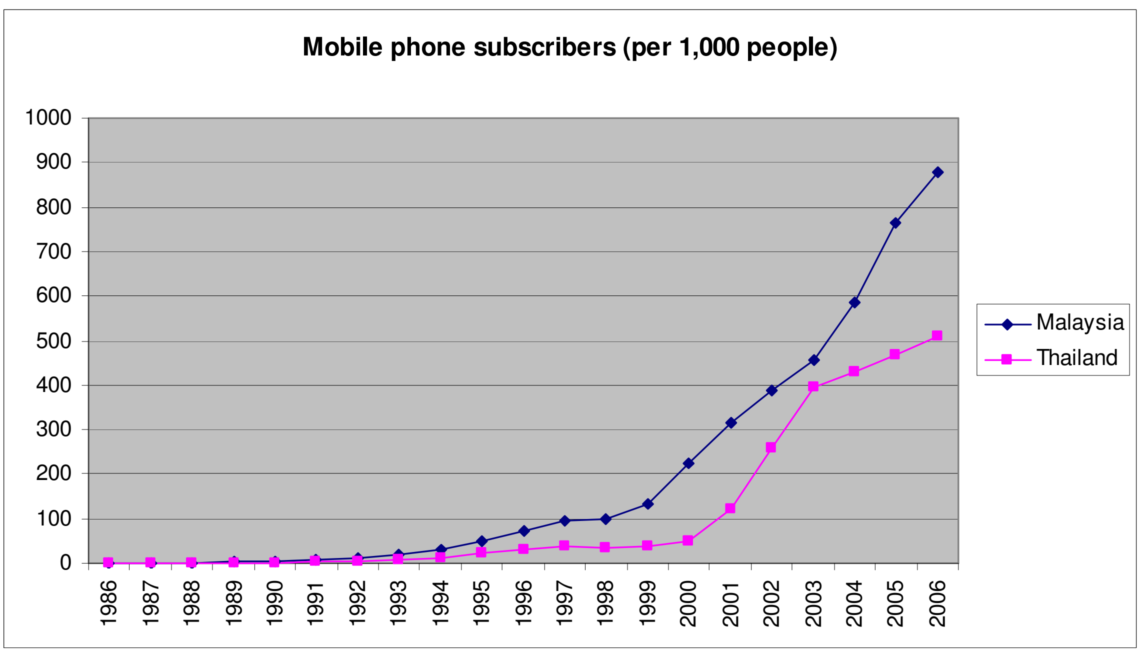


Source: World Bank, 2006.

Wireless technology also lets competitive players into the markets more easily because they do not have to go through the cost and expense of laying landlines. Telecommunications competition is the best way to ensure that prices decline, service improves, and coverage expands (Lee, 2002b). Because landline services are typically still in the hands of a government-owned or -controlled monopoly in developing countries, little is done in terms of services price, quality, and footprint. This has allowed wireless services to leapfrog over landlines, bringing telecommunications access to a majority of people. Although Malaysia has successfully rolled out telecommunications infrastructure, there are still gaps in its access. Several areas within the country, particularly rural areas, have not experienced a rapid increase in teledensity. This regional lack of telecommunications infrastructure has led the government to refocus national policies on expanding the infrastructure in areas outside of the capital (James, 2003).

Exhibit 4.4 depicts a comparison of mobile adoption rates in Thailand and Malaysia based on data from the World Bank (2006). This exhibit demonstrates that Thailand was able to effectively liberalize its market and almost match the rate of mobile penetration with Malaysia in 2003 before hitting a plateau the following year. According to interviewed government officials and think tank telecommunications experts, this is a direct result of the lack of clear regulatory, policy, and institutional structure in Thailand hampering private sector investment in the telecommunications industry, as discussed below.

Exhibit 4.4: Mobile Phone Adoption Rates in Thailand and Malaysia



Source: World Bank, 2006.

ICT Challenges Facing Developing and Rural Countries

Although the institutional, economic, and technological environments of Thailand and Malaysia are similar, there are two key differences between the countries that impact their ability to adopt ICTs: a disparity in GDP per capita that has grown in recent years, and an increasing gap in rural population as a share of the total population. As mentioned above, Thailand's GDP per capita is nearly $2,000 lower than Malaysia's while its rural population is almost 68 percent of the total (World Development Indicators, 2006). This is over twice as high as Malaysia's rural population, which was at 33 percent in 2005 after declining from 50 percent in 1990 (World Development Indicators, 2006).

The regression model discussed in Section 3 demonstrates the positive correlation between the ICT penetration rate and GDP per capita, with the national penetration rate measured as the number of fixed and mobile subscribers per 1,000 inhabitants. A country's GDP per capita has a strong and positive relationship with ICT adoption, as demonstrated in Section 3's model. Increases in GDP per capita can lead to higher disposable incomes, which can be spent on new ICT services (Bassanini, 2002). In addition, as a country improves its GDP per capita, it is likely to shift from an agrarian economy to one that focuses on manufacturing and service sectors (Wong, 2002). These sectors, particularly in advanced services, have higher levels of ICT adoption, which assists in accelerating national penetration. However, GDP per capita increases do not account for the wide variation in ICT adoption across countries – resulting in many example countries with lower incomes but higher ICT penetration rates than Thailand.

The model in Section 3 also demonstrated the positive relationship between ICT penetration and population density, included as a proxy for urbanization. This is due to a number of factors that increase the costs of serving rural areas and potentially limit penetration rates. Network infrastructure deployment costs will be higher in comparison to urban areas due to lower density in rural areas; this increases the length of last mile access networks (Galperin, 2005). This lower density also increases the operational costs of carriers, requiring them to cover a larger area with a scarce number of technicians. In addition, the income disparity between rural and urban areas also presents a significant challenge, with carriers experiencing lower revenues per person in rural areas (Li, 2005). None of this suggests that carriers cannot find a financially sustainable business model serving rural subscribers; but it does suggest that there are additional hurdles to increasing penetration rates within these areas.

It is important to note that these rural population and GDP per capita metrics do not account for all of the variance in ICT penetration rates. In fact, several example countries have low levels of urbanization similar to Thailand's or a similar GDP per capita, but have managed to successfully accelerate their ICT penetration rates (World Development Indicators, 2006).

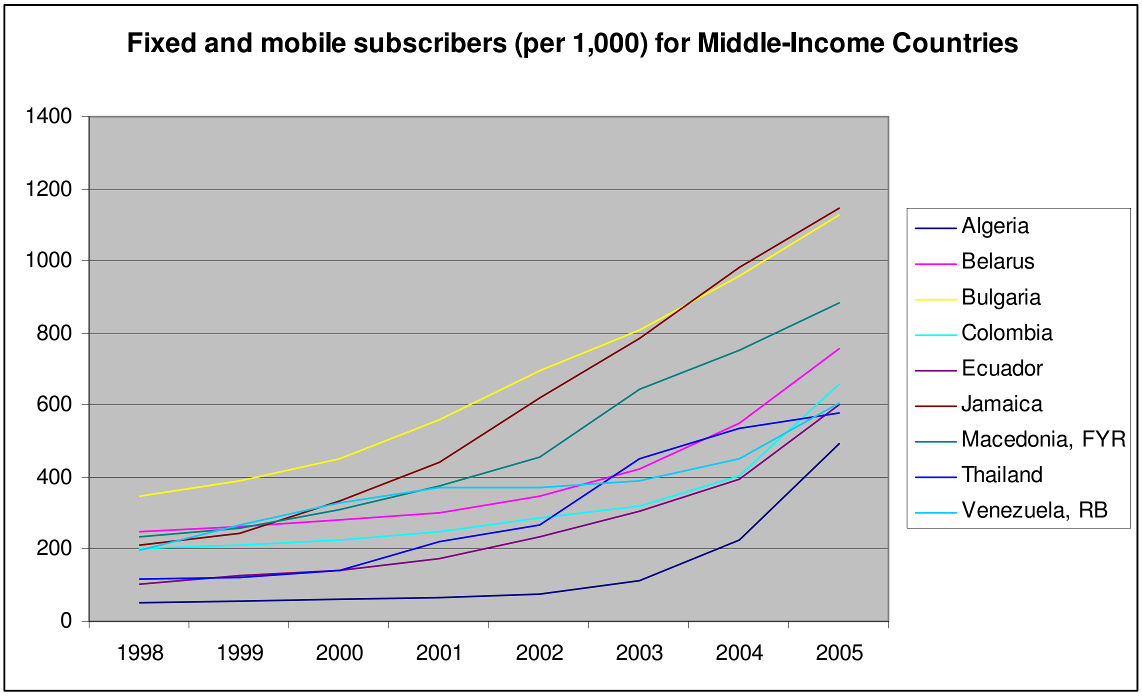
Rural and Middle-Income Case Countries

The model in Section 3 suggests that population density and GDP per capita have a positive and significant relationship with ICT adoption within developing countries. However, several countries that have levels of rural population and GDP per capita similar to Thailand's have successfully initiated and sustained rapid ICT adoption. In addition, several countries that did not surpass Thailand in 2005 are now estimated to have overtaken that country's penetration rate for fixed and mobile subscribers. The charts in Exhibits 4.5 and 4.6 depict the ICT adoption rates in countries selected for their appropriate levels of GDP per capita and rural populations.

Thailand vs. Countries with Similar GDP per Capita

Each of the countries included in Exhibit 4.5 has levels of GDP per capita that are similar to or lower than Thailand's. For example, in 2005, Thailand's GDP per capita was $7,740, while Algeria's was $6,283, Ecuador's was $3,863, and Jamaica's was $3,819 (World Development Indicators, 2006). Despite being low- or middle-income countries, several have been able to maintain rapid growth rates within their ICT sectors. Thailand's ICT adoption rate has been surpassed recently by Belarus, Colombia, Ecuador, and Venezuela. Algeria is also on pace to overtake Thailand's penetration rate in 2007, while additional countries, such as Jamaica and Macedonia, have lower GDP per capita but have maintained a higher rate of adoption for the past 10 years. The chart in Exhibit 4.5 depicts the trends for fixed and mobile subscribers per 1,000 people for the countries discussed above.

Exhibit 4.5: Mobile Phone Adoption Rates in Middle-Income Countries



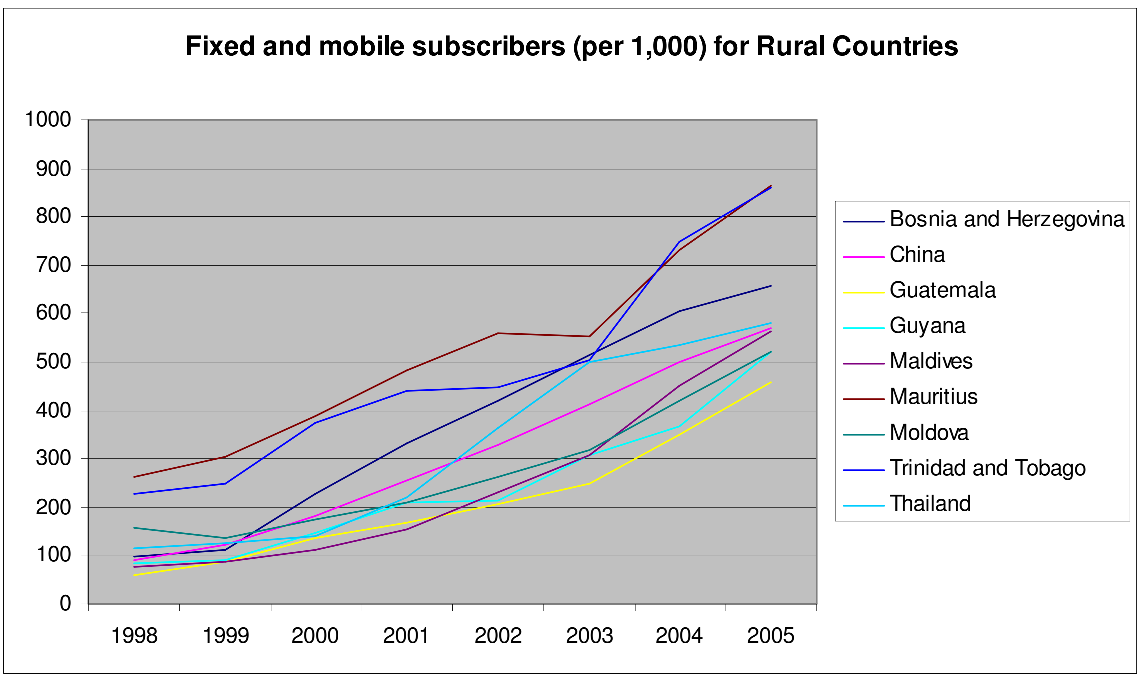
Source: World Development Indicators, 2006.

Thailand vs. Countries with Similar Rural Populations

With 68 percent of its population living within a rural area, Thailand has one of the lower levels of urbanization for a middle-income country. However, several countries that have similar-sized rural populations have managed to successfully accelerate their ICT adoption rates (see Exhibit 4.6). With more than 50 percent of their populations in rural areas, all of the countries included in the chart below have rural populations of a similar size to Thailand. For example, in 2005, China's rural population was 60 percent of the total, Bosnia's was 54 percent, Guatemala's was 53 percent, Guyana's was 72 percent, and Moldova's was 53 percent (World Development Indicators, 2006). Each of these countries has managed to accelerate and maintain its accelerated ICT adoption rates, with several countries on track to overtake Thailand by 2007.

The most notable is China, which has a similar-sized rural population and a lower level of GDP per capita, at $6,011 in 2005 (World Development Indicators, 2006). The country has been able to foster accelerated growth in its ICT sector, with its fixed and mobile subscribers estimated to reach 626 per 1,000 inhabitants in 2006 (Yankee Group, 2007). In contrast, Thailand's ICT adoption rate is estimated to be 618 in 2006 (Yankee Group, 2007). The chart below presents the ICT adoption trends of countries with similar levels of rural population.

Exhibit 4.6: Fixed and Mobile Phone Adoption Rates in Rural Countries



Source: World Development Indicators, 2006.

Competition in the Telecommunications Market

Thailand

The Thai ICT market has been hindered by the lack of competitive delivery of services, limiting adoption and driving up prices (Jirachaipravit, 2007). Until recently, the state-owned enterprise TOT had a legal monopoly over domestic communications in Thailand; and until the creation of the independent commission, the state-owned enterprise (SOE) was also its own regulator. With this firm acting as its own regulator, the organization was given the ability to offer concessions to other players to raise revenues for themselves and the government. In the early 1990s, TOT began offering concessions to two competitors, AIS and True, to deliver mobile services. When I interviewed competitive carriers, they argued that rather than seeking to bolster competition, these concessions were designed to raise funds for TOT and the government. This trend continued when two additional concessions were born out of the 1997 economic crisis. This focus on short-term revenues rather than creating a long-term plan for fostering ICT market liberalization has left the country without a sustainable competitive landscape.

More recently, after the creation of an independent regulatory commission, two additional mobile licenses were granted to TOT and another former state-owned monopoly, which are both deploying wireless services. Under this regulatory structure, two former monopoly state enterprises are now competing with their own concessionaires according to an official interviewed at the Ministry of Finance. Unfortunately, this is not uncommon in Thailand, where two ministries use their overlapping authority to create state-owned entities that compete for market share. Another example includes the Ministry of Commerce and the Ministry of Industry, which both created monopoly textile firms, leading to intense competition between the two. In many cases, this is how competition is introduced into a given economic sector.

Officials at the national regulator stated that with the ICT market operating under a monopoly until recently, adoption rates were hindered by slow responses to customer requirements and inefficient service delivery. The former fixed line monopoly, TOT, was slow to offer widespread broadband services due to this slow response to customer demand along with its highly bureaucratic procurement system, which stretched out the process for purchasing broadband platforms by several years. A competitor, True Communications, was able to take advantage of TOT's slow deployment and has expanded its broadband market without any significant competition. A former official with the Ministry of ICT suggests that this lack of competition within the market has led to expensive and low-capacity broadband services from a private company that are limited only to the capital.

The demand for ICT services already exists in Thailand, but high prices and poor customer service are preventing adoption rates for broadband and other services from taking off (Jirachaipravit, 2007). Fixed line telephony and broadband penetration is below average for Thailand's level of economic and technological development in comparison to its economic peers. However, the country was further behind in 2000, prompting the government to begin working on efforts to catch up to its neighboring countries through an ICT policy and institutional reform process. Although broadband adoption rates are improving, this higher demand is driven largely by affluent customers in the capital rather than specific government intervention. This has led to adoption within some segments of the population, particularly within planned communities, that can now access broadband service. In response, service providers have begun developing plans for deploying voice and data services to compete. However, this has yet to substantially increase services within the market.

Another former state-owned company, CAT, had a monopoly on international internet gateways until it was opened up recently by the national regulator, with licenses pending for several service providers. CAT was also its own regulator, like TOT, and was also able to offer concessions to operators within the market, creating both market competition and regulatory confusion under the previous structure. Several interviewees within the government and at competing carriers argued that under the CAT monopoly, the cost of international bandwidth was prohibitively expensive, increasing the costs of hosting and international data transport. These high costs have limited the country's opportunities within the business process outsourcing market, which has grown rapidly as offshore back-office centers have begun opening in Thailand's Southeast Asian neighbors (Ismail, 2003). Specifically, the higher traffic costs offset Malaysia's and Singapore's higher labor costs, reducing Thailand's competitive advantages in the market. In another recent example, a government agency was forced to host an international website because the cost of supporting international traffic to the site would be four times the cost in Thailand. Mobile operator AIS was the first company aside from the former state-run monopoly to receive a license from the national regulator to lease international internet gateway facilities and offer services. Previously the company had leased an international trunk from CAT for international calling, which left AIS with only a 22 percent share of international revenues according to company officials. AIS was the first to apply for the license and others, including fixed line operator TT&T, have applied and expect to receive theirs soon as well. Although this market is opening up with new international gateway licensees, so far these new providers have been slow to reduce international connectivity costs within the market.

TT&T, the former monopoly provider, had a concession under the old regulatory structure to offer services to rural provincial customers. Unfortunately, the concession fee for TT&T, which was set through auction at 42 percent of gross revenue, is a symptom of the government's focus on government income rather than services to the population. With this high burden of the concession fee, TT&T's spokespersons suggested that the company's business model quickly became unsustainable. TT&T was able to win the concession auction through its high bid; but because it was not based on a sound business model, the company has consistently lost money as a result. With their rural business losing money and little competition within the broadband market, the owners of TT&T started a new venture called TTT to deliver broadband services. Because the previous concession did not allow for broadband services, the company has been forced to secure a new broadband license from the national regulator, which is much less costly than the concession from TOT. Although this will help bring competition to Thailand's broadband market, the convoluted licensing and corporate structure created by the regulatory scheme has resulted in significant barriers to market entry that will be difficult for additional providers to overcome (Gray, 2004).

The brightest spot within the Thai competitive landscape is the mobile wireless market. In addition to CAT, TOT, and True mentioned above, there are three other mobile service providers: DTAC, AIS, and Thai Mobile. The largest providers, AIS and DTAC, have an intense competition within the Thai mobile market, driving both companies to respond with reduced pricing structures. These low mobile prices have driven the market to several times the size of the fixed line market. However, there are risks within the market. According to domestic carriers and officials with the national regulator, foreign competitors have not been able to sustain their presence within the market. Hutchison, a large multinational provider, attempted to enter the market by subsidizing handset costs for subscribers, but was only able to secure 2 percent of the market. At the same time, the high market risks have pushed AIS, DTAC, and Thai Mobile to sell to foreign owners to secure access to the financial resources required to deploy mobile broadband technology. Although several providers have received a 3G license from the regulator, or are working to request one, not one provider has deployed any mobile broadband network infrastructure due to the high costs and regulatory risks. Without a clear and stable regulatory environment, no providers will move quickly to enter the mobile broadband market, even with the deep pockets of foreign investors to support them (Levy, 1994). This leaves Thailand falling behind its neighbors in terms of both adoption levels and the technological evolution of the mobile market.

Malaysia

Telekom Malaysia Berhad (TMB), which was incorporated in 1984 and privatized in 1990, is the former Malaysian monopoly operator. Company spokespersons report that the company is still partially owned by the government, with a 45 percent stake, but this has been reduced from 70 percent in 2000 and may be reduced even further as the government's investment agency considers divesting from the company. Although the fixed line market has been open to competition for almost 10 years, TMB has continued to dominate the market – operating over 95 percent of the fixed lines within the country. However, the company has been forced to undergo a transformation as its traditional fixed line business erodes – declining annually since 2001 as end users switch to mobile phone service due to the high prices and poor performance of the monopoly, according to company financial reporting. Unlike the fixed line market, the mobile sector has robust competition and has been growing rapidly for the past 10 years. The competitive services offered by new entrants have stagnated TMB's own mobile offering, from the wholly owned subsidiary Celcom. Celcom has a significant share of the mobile market, but that share has also declined over the past year. This has driven the company to seek revenue growth and margins in nearby markets, such as Indonesia, India, and Sri Lanka, representing a majority of the company's total subscribers. This regional expansion by TMB follows the example of Singapore's SingTel, which has also moved quickly into neighboring markets due to market saturation and declining margins in its home market.

The continued decline in the fixed line market and the market saturation of the mobile sector have pushed TMB to refocus its domestic efforts on the broadband sector. The government, with its National Broadband Plan, has also sought to accelerate private sector investments by expanding the national network infrastructure to increase the country's ability to support broadband services (Malaysian Communications and Multimedia Commission, 2006). TMB will utilize its extensive fixed line network to quickly deliver broadband services, tapping into the pent up consumer and business demand for high-speed connections. However, this increase in broadband, through voice over Internet Protocol services will also create an additional conduit for end users to switch from their traditional telephony services, further eroding the monopoly's market share in favor of competitive providers.

The significance of TMB's mobile market position is that no single carrier has the market power to limit competition; and through low prices, mobile services have acted as a substitute to the fixed line market (Gasmi, 2000). Although the internet access markets still require additional competition, this mobile market circumstance is testimony to the benefits of proper privatization and regulation of the market, ensuring that the barriers of entry are reduced, that market power is limited to ensure price competition, and that the market is stable enough to support investment.

A competitive operator, Maxis, is the largest mobile service provider and is currently moving to capitalize on the opening of wireless broadband licenses by the national regulator. In addition to the wireless offering, the company is also deploying fixed line network infrastructure that will compete with TMB's broadband offerings. Like TMB, this operator is also partially owned by the government; but at 20 percent, its share of government ownership is significantly lower than that of the former monopoly. Due to low margins and mobile market saturation, Maxis has also expanded into Indonesia, India, and other Asian countries to ensure revenue growth, competing directly with TMB for regional market position.

The third major mobile operator is DiGi Telecommunications, which is 61 percent owned by a foreign operator, Telenor of Norway. This arrangement runs against the national policy on foreign ownership, which limits foreign control to 49 percent. However, in interviews, non-governmental telecommunications experts suggested that the government wants to avoid punishing Telenor and driving it out of the market. As a result, the government has been flexible in allowing the company to divest to 49 percent with a five-year waiver. The company has been able to expand its revenues by offering new mobile data services. However, there will be limitations on those offerings. According to press releases from the national regulator, DiGi lost its bid to win a license for third generation (3G) mobile broadband services due to the regulator's preference for domestic providers and now faces a stiff competitive challenge from these other providers. At the same time, the company is reliant on the domestic wireless market at a time when the market is saturated and the other two major operators are expanding regionally. Although the provider's foreign ownership helps ensure its financial sustainability, its relatively weak market power both domestically and regionally suggests that the Malaysian mobile sector's competitive landscape may not be stable over the long term.

The Malaysian regulator's approach to DiGi demonstrates the careful balance that developing countries must have when dealing with foreign owned operators. The country would like to limit FDI within telecommunications companies to 49 percent, but it has given Telenor a five-year waiver and has even given the company a one-year extension. At the same time, the regulator has offered new 3G licenses to four domestically owned operators, giving them an opportunity to compete in the single growth area of the saturated Malaysian market, but leaving out DiGi due to its large foreign ownership stake. The national regulator suggested that it must give local firms priority when licensing a scarce national resource such as 3G spectrum licenses. Simultaneously, the regulator has encouraged DiGi to seek out a partnership with one of the local firms that have won a license, potentially solving the issues of 3G licensing as well as the foreign ownership requirements. In this case, it does not seem that the regulator's goal is to block foreign participation in mobile broadband services, but to ensure the continued market power of the local firms.

Two new competitors in the market, MiTV Corporation and TT dotCom, are using new licenses offered by the regulator to enter the 3G mobile broadband market in 2007. These companies, in addition to Maxis and Celcom, beat out DiGi to offer these new mobile data services. The MiTV network will be deployed through a combination of domestic and international funding as well as a public offering. TT dotCom is also using this new wireless license, like MiTV, but is focusing on offering residential broadband services to fixed locations – competing directly with the DSL services of TMB. The market entrance of these two new providers will expand competition within the mobile market, pushing prices lower and driving the existing operators to expand their current mobile data network and service deployments.

It is not easy to determine the correct level of openness within a developing country's telecommunications market (Lall, 1999). Malaysia has attempted to strike the right balance by inviting domestic and foreign operators into the market, but limiting the market power of foreign operators through licensing and FDI limits. These two factors influencing the market also interact with one another, making it difficult to gauge how the market will react and increasing the likelihood of unintended consequences. This also shows how quickly a developing country – whether it is Malaysia, Thailand, or another country – can shift the competitive landscape too heavily in favor of foreign or domestic operators. Developing countries may go through similar stages of ICT adoption and market development. However, the policies, regulations, and market supports must be carefully tailored and continually readjusted to avoid market failures.

Telecommunications Regulatory Structure

The creation of an independent commission to design and enforce telecommunication regulations is a key component to ensuring a competitive market and accelerating ICT adoption (Nambiar, 2006). Both Thailand and Malaysia have undergone this process, creating a regulatory agency, reforming the laws, and privatizing the telecom sector's monopoly. However, the two countries have had very different outcomes, with Thailand facing significant political influence in each of these processes.

This part of the case study is divided into three components. The first explores the regulatory agencies of both countries. The second component discusses the privatization process of the state-owned telecommunications monopoly, paying particular attention to the political issues surrounding privatization in Thailand and the limits this flawed process have placed on ICT adoption within the country. Last, this part examines the universal service obligations placed by the national regulators on the incumbent and competitive operators in Thailand and Malaysia. These obligations can raise the necessary funds for rapidly expanding access within a developing country, if the mechanisms for raising and disbursing the monies are carefully designed and implemented.

Independent Regulatory Agency

Thailand

Recently, Thailand's government created an independent telecommunications regulator, the National Telecommunications Commission (NTC), which is working to rebalance the overall competitive environment of the telecommunications market. In interviews with national regulator officials, they suggested that this was a departure from the previous government's focus on simply balancing carrier competition through regulating state-owned service provider structure. The official went on to suggest that the goal of the NTC is to empower stakeholders to manage their own competitive position with legitimate means. Under the 2006 fair trade practices legislation, these regulatory reforms include capping tariffs, requiring carriers to unbundle their network elements, and develop contracting standards for arrangements between carriers as well as with their customers. This is an "ex post" regulatory action, where the NTC is defining anti-competitive behavior of existing operators and has been given power by the parliament to investigate and fine those in violation of these regulations. A common example includes major carriers utilizing their market power to price squeeze competitors. The Commision hopes that these new regulations will help balance the competitive landscape and open up the market to additional investment from both foreign and domestic operators that may have been waiting for the reforms before investing.

This process has been hampered by both institutional and political hurdles (Jirachaipravit, 2007). After the telecommunications law creating the NTC had been enacted, but prior to the selection of the commissioners, the NTC's responsibilities were housed in the Post and Telegraph Department (PTD) and run by its staff. The staff of this parastatal transferred to the NTC once the commissioners were selected, leaving the new commission with an encumbering bureaucracy. Political hurdles have included the major carriers sending their proxies to serve on the board of the NTC. This opened the door to criticisms from market watchers claiming that customer-friendly reforms, such as number portability, have been slowed down out of deference to the operators.

For the Thai carriers, it is currently unclear what the regulations will be on licensees for broadband, mobile, and other services. The NTC has reserved the right to revisit the issue and set regulations on pricing and universal service, but there is no indication of what form that will take or the time frame for this action. In addition, although the NTC is working to set up new regulations in 2007 for interconnection and other issues, it is unclear whether these regulations will cover concessionaires such as True Corporation in addition to licensees such as TTT.

The current regulatory structure for the mobile telephone sector is the result of difficult political negotiations between the government, the former state-owned incumbents, and the mobile wireless carriers. According to government officials interviewed for this research, the country must undergo a lengthy political process to unwind the industry from this arrangement to shift to a license-based framework. Thus far, the process of converting the existing concessions into licenses has taken 10 years and the NTC expects this process to continue with legal actions taken by carriers to change or influence the reforms through the court system.

The original concessionaires, the telco providers TOT and CAT, along with the private sector licensees all want to reduce their revenue sharing responsibility under the new licensing framework created by the NTC. However, Ministry of Finance officials state that these carriers also argue for continuation of the government guarantees that existed under the concessionary system. In essence, this amounts to requesting a greatly reduced cost structure while providing monopoly guarantees – a system that would simply not be sustainable or competitive. Similar problems exist across a range of issues that are also connected to the competitive footing across providers, such as spectrum allocation, tax requirements, and tariff structures. Each of these issues will need to be resolved in concert with the shift to the new licensing structure. As a result, the process has become politicized and publicized as carriers seek out support from various interest groups and the public for their demands within the negotiation. This has slowed down an already difficult and lengthy process and was made worse in 2006 due to larger economic and political instability.

Another important reform includes the regulations on the charges carriers apply to another carrier for transporting a competitor's voice or data traffic, known as interconnection charges (Jensen, 2005). This new regulation will allow for private arrangements between carriers for transporting competitor traffic through a cost-based interconnection system. This will not include a price ceiling, but these interconnection arrangements will be made public and carriers will have to allow other providers the same deal. This will reduce the costs for competitive players to enter the market while reducing the likelihood for collusion through private deals. However, in my interviews competitive carriers suggested that these new regulations will certainly give additional market power to the two largest mobile providers, AIS and DTAC. These providers will be able to demand higher prices from the smaller mobile competitors, which are not able to buy discounted capacity in bulk, but that do need to access to their competitors' networks to complete a high percentage of their calls. This may place these smaller competitors at a significant disadvantage to the market leaders, potentially limiting long-term prospects for adoption rates.

Malaysia

The telecommunications market had been a monopoly controlled by the precursor to TMB, known as Syarikat Telekom Malaysia Berhad (STM), which was run by the Ministry of Energy, Telecommunications, and Post. This ministry was also the telecommunications regulator, creating a government-owned and -controlled monopoly within the sector. In 1994, the Ministry instituted a new National Telecommunications Policy that began the slow process of liberalizing the sector, according to interviewed ministry officials. This new policy allows new entrants into the market. However, the government reserved the right to limit the total number of competitors to ensure the economic viability of the sector.

In the late 1990s, Malaysia underwent a transformation of its regulatory structure and laws (Lee, 2002a). Malaysia underwent an institutional reform process, renaming the Ministry of Telecommunications, Energy, and Post as the Ministry of Energy, Communications and Multimedia (MECM) (Painter, 2004). The change was part of a larger effort to adapt government agencies to the technology and convergence that were under way within the market between communications, media, and the Internet.

Malaysia's original vision for its transformation into a knowledge society under the evolving Vision 2020 plan included developing a content creation and distribution sector (Wee, 2003). By expanding the purview of the Ministry, the government hoped to provide additional government support to these efforts.

At the same time, two national acts were approved in 1998: the Communications and Multimedia Act (CMA) and the Communications and Multimedia Commission Act. These acts defined the new regulatory and market structure for telecommunications and in 1999 created the Malaysian Communications and Multimedia Commission (MCMC), which consolidated telecommunications oversight within the country under one entity. The MCMC consolidates the regulatory functions that had been housed within the Ministry of Energy, Communications and Multimedia, the STM, and the Ministry of Information.

Under the previous structure, the STM was both the operator and directly under the Ministry, which limited its ability to act as an impartial monitor of the competitive landscape within the market. Under the new Commission, the regulator now has its own budget and staff as well as additional legislative authority to pursue its regulatory functions, according to interviews with Commission officials. These functions include the enforcement of regulations, review, and recommendations on licensing applications; liaison with industry trade groups; and draft regulations and policy recommendations to the MECM. Although the MCMC provides these policy and licensing recommendations to the MECM and is a separate government entity, the Ministry still makes the final decision and implements ICT policies.

The second act, the Communications and Multimedia Act of 1998, outlined four key areas of regulation that were to be the focus of the Ministry and the Commission to support the sector's transition into a competitive market. These four areas included economic regulations that focused on incentives for operators to balance the competitive landscape and to expand ICT access through universal service obligations. Under the previous regulatory structure of the SMT, there were no specific regulations that allowed for the enforcement of penalties against anti-competitive behavior. This is vital if the government is to intervene on behalf of telecommunications competitors to prevent the abuse of market power by the dominant players.

This key provision within the act aims to provide the government with the legal authority to enforce regulations against anti-competitive behavior by operators. Abuse of this market power can limit the financial viability of competitive operators, reducing their share of the market and limiting service access, affordability, and reliability (Levy, 1994). Yet, the provisions of the CMA allow for these anti-competitive actions to be ignored if they are within the national interest. In addition, only the Ministry may deem actions to be anti-competitive, rather than the MCMC, which further expands the opportunities for regulatory capture.

The act also included technical regulations such as security and service specifications for telecom operators as well as interoperability requirements between the operators. These interoperability requirements are important to prevent larger operators from using their market power to undermine new entrants into the sector. The third and fourth areas of the act were consumer and social regulations, which ensured service reliability and affordability along with incentives to local content developers and distributors to promote Malaysian culture.

The creation of the MCMC and the CMA policy structure allowed the market to begin the process of rebalancing the competitive landscape, giving new entrants the opportunity to compete cost-effectively against the former monopoly. However, there have been several criticisms of the current regulatory system (Nambiar, 2006). For the MCMC to meet international regulatory best practices, the body would need to operate with more transparency, offering a public view into its deliberations and recommendations. Not all of the policy and regulatory recommendations offered by the MCMC to the MECM are made publicly available, limiting the overall transparency of the Commission.

More importantly, the government is currently represented in the MCMC by one of the five commissioners – and all five commissioners are chosen by directly the Ministry. This suggests that the Commission is not as independent as it needs to be – a circumstance that is complicated further by the predominance of the Ministry over regulatory and policy decisions. There is also little the Commission can do to act as an impartial third party in disputes between operators or act as an appeals body for operators that wish to contest a decision handed down by the Ministry.

Telecommunications Privatization Process

Thailand

Due to the ad hoc nature of the privatization process within Thailand, several operators have their own sector within the market where they are an incumbent carrier (Hossain, 2003). The privatization process and the introduction of competition began as a result of membership into the WTO. The overall market has improved greatly over the past five years. However, regulatory reform efforts have ebbed and flowed. This has forced the NTC to play catch-up now as the country has seen its competitors accelerate their reforms and ICT adoption rates even faster in the same time period.

Under a recent Corporatization Act, the government developed a structured process for privatizing state-owned enterprises. This act required the SOE to create a committee of government, union, and industry officials dedicated to the privatization process and outlines the requirements for the oversight tasks that must be completed over the course of privatization. Experts in law, telecommunications, and finance from the academic community are also included along with officials from other SOEs. Ministry of Finance officials stated in interviews that members of the committee are required to be free of any conflicts of interest and cannot be associated with the privatizing SOE. The committee approval carries a great deal of weight; the cabinet only has review authority and cannot veto the approval. Unfortunately, the process for committee review has not been transparent because the proceedings and positions are not made public. Because the process itself is not transparent and the committee has so much independent power, all of the checks and balances are over committee member selection. As a result, there is little effort to improve the transparency and operations of these committees.

During the same period, the parliament moved the regulatory oversight of SOEs from the Ministry of Finance to Thailand's Securities and Exchange Commission. The goal was to transfer the investment burden back onto the state enterprise rather than the central government. To help achieve this goal, the government guarantee was withdrawn from many SOEs. To create a migration path for these companies, the government developed a sliding scale, where if the corporatized SOE is still more than 75 percent owned by the government, the guarantee is still in place. If the ownership is over 50 percent, then the SOE can request the guarantee. The government hoped that by moving away from government guarantees, which act as incentives against efficient operation, they would be able to help shift the focus of the SOEs from simply expanding infrastructure to market-optimized service delivery.

In the telecommunications markets of most countries, carriers build, own, and operate (BOO) the network infrastructure (Smith, 1995). In Thailand, the concessionaire carriers were operating under build, transfer, operate (BTO) regulations, meaning that the state-owned enterprises TOT and CAT legally own the networks that are built by their concessionaires in addition to the large fees collected based on revenues. To transition the market and increase incentives for private investment, committees were set up to direct this concession conversion process. This process required the industry to move from BTO to BOO and provide carrier licenses to each of the market's competitors.

According to an official with the Ministry of Finance, this process was created based on input from international experts and best practices from other developing countries. The regulatory instability of the telecommunications market undermined the process almost from the beginning. The act changed the SOE's corporate practices, allowing for more flexible hiring, labor standards, procurement, budgeting, and accounting that were not possible as a public-sector company. However, it did not require a change in the SOE's structure or give the Ministry of Finance the necessary powers to evaluate whether restructuring was necessary under the privatization process. The Ministry could not break up an SOE into component pieces or structure several overlapping subsidiaries under a holding company. The end result was that the Ministry could not ensure the newly privatized SOE would not be able to abuse its market power to limit the competitive market environment.

The first two state-owned enterprises to undergo this new process were TOT and CAT. The process lasted over two years for each of them and required lengthy discussions around the membership of new boards of directors and the corporate structure of the newly privatized companies. Although both fought and stalled the process, due to concerns about leaving the comfort zone of government support, the TOT privatization was relatively easy because the company was remaining under the same corporate structure. TOT was simply transferring ownership from public to private hands and the company had anticipated the transition. An official at the national regulator stated that TOT had even set up a privatization office eight years earlier.

The Ministry of Finance official stated that the process for CAT was more difficult than TOT because CAT was being split into two companies: a telecom provider and the post office. Although TOT was viewed as financially sustainable, there was concern that CAT's telecom business would not be able to survive as a stand-alone company without the post office. There were discussions around merging CAT and TOT, but this was tabled due to the different corporate cultures and political concerns over the market power of the new entity. These concerns about CAT's sustainability turned out to be well founded. Although the post office became an example of a profitable and successful SOE transition, the telecom operator is quickly losing its financial viability.

After this lengthy process and only limited success in telecommunications market, the Thai government limited the oversight tasks and sped up the process for the other SOEs undergoing privatization, according to both governmental officials and outside experts. A state-run fuel company, PTT, was privatized in only five meetings – pushed through by support from its previous benefactor, the Ministry of Industry. The capital airport was also privatized just as quickly, leaving little time for forging a liberalized and competitive market within these sectors. In addition, both of these entities had police powers and were able to keep these powers once they were privatized. In a telling example, the Ministry did not have the political capital to remove these powers during the corporatization process, resulting in private entities having police powers. It is this lack of transparency, political considerations, and rushed process that has left these privatized sectors without clear regulatory structures or competitive environments. This short-sightedness has severely limited the growth potential of these sectors, including telecommunications, limiting the supply, quality, and price reductions one could expect from the corporatization of a state-owned industry.

Malaysia

The privatization process in Malaysia started in the 1980s and was prompted by rising government deficits – leading the government to seek out quick revenue sources such as privatizing the telecommunications monopoly. This process was also sparked by the government's conclusion that the private sector was in the best position to expand the market, allowing the government to reduce its administrative burden of deploying and maintaining the national network (Lee, 2002b). This is a central position that the government continues to demonstrate through its ICT policies, creating a supportive role for the government within the sector rather than that of a lead financier and arbiter of market developments (Ritchie, 2005).

The monopoly provider Telekom Malaysia Berhad, renamed from Syarikat Telekom Malaysia Berhad in the mid-1980s, was taken public in 1990. Originally, only a quarter of the company was owned by the private sector, growing slowly to 30 percent by 2000. Over the past several years, this transition has accelerated, giving the private sector a 65 percent stake with the possibility of increasing in the near term. The government continues to hold a golden share, allowing it to veto company decisions that are deemed to be adverse to the national interest. A similar arrangement has been made in other privatized monopolies, both in Malaysia and in Thailand, as well as within developed countries that have undergone the privatization process.

Although the national regulator has offered licenses for the fixed line and mobile sectors, Malaysia has not been successful at opening its fixed line market. As mentioned above, this market continues to be dominated by TMB, which has not seen its market share or power decline since liberalization. These offerings were not able to gain market share, despite the national regulator offering five fixed line licenses. This is due to the high capital costs of entering the fixed line market, which has kept out competitive offerings according to competitive carriers in Malaysia. This limited competitive situation has been true within both developed and developing countries. Even in the US market, there is little fixed line competition to the former monopolies with the exception of the cable companies – operators that spent decades building out their own parallel fixed line networks.

In contrast, as noted above, the liberalization of the mobile market has been much more successful. With significantly lower capital costs, several mobile providers have been able to compete cost-effectively against the former monopoly (Proenza, 2006). In addition to Celcom, TMB's subsidiary in the mobile market, three other licenses were granted to operators. These three competitive companies began operations in the mid-1990s and have since merged into two players, with Maxis leading the market. The mobile sector, in contrast to the fixed line sector, is marked by price competition, service expansion, and market saturation.

The third major market to undergo liberalization is the Internet access sector, which had previously been served by monopoly provider JARING since the 1980s. This Internet service provider is a subsidiary of the MIMOS research and development group, a government-owned entity. In 1996, the market was opened to TMB to begin offering dial-up services. At this time, the government still had a controlling stake in TMB, making the only two licensed ISPs both government controlled. In 1998, the market was further liberalized and opened to five new licensees to deliver Internet services, of which only three deployed services. There has been some competition within the dial-up market, with TMB's market power declining but still representing over 50 percent of market share as of 2005. Meanwhile, company reports state that TMB still represents over 90 percent of the broadband market.

The other licensees, such as Maxis, have focused their competitive deployments within the more lucrative business market. This has left the larger consumer market without significant broadband competition, allowing TMB to avoid price competition while minimizing the costs of expanding its network. This is not surprising because TMB has over 95 percent of the fixed line market. Fixed copper line infrastructure is required for DSL deployment; and without cost-effective access to these lines, no competitor will be able to capture a significant share of the fixed line broadband market (Proenza, 2006). Malaysia has not been able to utilize the national regulator to set requirements on TMB, such as forcing the incumbent to allow competitors access to wholesale broadband services that they can sell as retail services. The US has faced a similar market failure. It has not been able to mitigate the market power of the former incumbents to allow new entrants to overcome this barrier to entry.

This may change in Malaysia with the deployment of broadband mobile solutions, which could open the market up to a new wave of competition. However, it is unclear whether these services will be successful in Malaysia, as they have been in Japan and Korea, where uptake has been high. Many other developed countries, most notably in Western Europe, have few subscribers despite spending vast sums on infrastructure and spectrum. If the market can reach a critical mass in Malaysia, it may become a technological work-around for competitive carriers, like Maxis, to offer a full range of telecommunications services over their wireless networks – avoiding the time and resources necessary to deploy a parallel fixed line network.

Universal Service

Thailand

A key component to Thailand's reforms is the launch and management of the universal service fund. According to officials with the national regulator, the obligation is set at four percent; but it is unclear how growing broadband revenues will be dealt with or if the universal service fund will be used to deploy broadband infrastructure in addition to traditional fixed line infrastructure. The universal service obligation for carriers was a requirement under the telecom legislation. However, there is little guidance to the NTC on implementation.

Several open questions remain, including whether all carriers should pay into the fund; and of those that are included, whether the treatment of wholesale carriers should differ from retail providers. Another key question is the implementation of the tax on a sliding scale that depends on the current levels of infrastructure deployment within rural areas, which allows providers to reduce their USO from the full 4 percent. Most important, the regulator still needs to define the policy mechanism for injecting the universal service funds into the market, whether that is through direct subsidy to customers or to the providers for their deployments to under-served areas (Gasmi, 2000).

Malaysia

For the Malaysian USF, broadband is also part of the universal service obligation; added to the USO by the cabinet in 2005, targeting areas with lower than average penetration rates. The USF is managed by the Malaysian Communications and Multimedia Commission, the governmental entity that is responsible for determining the level of USF support by region and collects the six percent fees from telecom operators. MCMC officials stated in my interviews that 89 areas within Malaysia are receiving funds, and telecom operators bid in a tender process to win the opportunity to build infrastructure within these areas, with a single winner of the tender per region. The universal service fund also continues to support deployment of the PSTN to households and payphones in low-income and rural areas.

The government has set the national goal of 25 percent broadband penetration for households based on wireline deployment of ADSL infrastructure (Malaysian Communications and Multimedia Commission, 2006). In 2005, the MCMC stated in its report that the country had 1.3 million subscribers or 23 percent of households connected with broadband. The key component of this deployment initiative uses government intervention to spur private sector investment in areas that have little or no infrastructure. This intervention continues until the area reaches five percent penetration, which the government has determined through demand modeling as the level required to develop a critical mass of private sector support. After this five percent threshold, the government begins to throttle back its broadband support and encourages private service providers to enter the region.

Conclusions

These two cases demonstrate the limitations of using regression modeling to analyze ICT adoption across developing countries. The indicators that can be quantified within a regression model would not adequately explain the differences in Malaysia's and Thailand's adoption rates. Both countries were able to claim that they had privatized their monopolies, created regulatory agencies, and developed competitive mobile markets. Until the context and details of those accomplishments are analyzed, only then do the wide differences in the two countries' approaches become apparent. By examining these cases, we can begin to understand the underlying causes, such as poor policy implementation, of the widely different outcomes in ICT adoption for the two countries (Krongkaewa, 2003). These underlying causes are also vital to other middle-income countries when formulating the proper policies and approach to implementation.

Malaysia is only a few years ahead of Thailand in terms of GDP per capita. However, the country's ability to adopt and utilize ICTs has far surpassed that of Thailand. Malaysia was able to accomplish this rapid adoption rate by ensuring that the political challenges did not override the economic and technological decision-making process of the government – avoiding the costs of poor technology choices that can lock in future decisions and hamper development. Malaysia was also more successful at modeling itself after the institutional and regulatory structures of Asia's top-performing economies along with their national ICT policies. Although Malaysia has supported only limited fixed line and broadband development, the country has followed the example of South Korea, as written by Amsden, cutting off underperforming political favorites.

Rapid acceleration of ICTs can be launched through the reforms completed in Thailand, which opened the mobile market to competition. However, the country was not able to sustain this growth for long without the institutional reforms necessary to maintain the competitive balance within the market. Thailand was almost able to match Malaysia's level of mobile adoption in 2003, when both investment and ICT adoption flattened. This was caused by unnecessarily high risks in the market brought on by poor regulation within the market. Thailand had very similar plans and institutions as Malaysia, but it did not give them the political capital, budget, or authority to properly implement these plans. Without the ability to fight the market power and political clout of the large operators, the ICT agencies were unable to prevent the warping of the ICT policy implementation.

To successfully implement a national ICT strategy and in turn accelerate adoption rates, a national government must quickly evolve its role within the market in reaction to the changes across technology, end-user demand, and global competition. It is not enough for a government to transition from the monopoly operator to a privatized provider; the state must shift from direct to indirect supporter across a range of policies and markets – each market evolving at its own pace and requiring its own level of state involvement. This effort is complicated by the rapid changes in technology, end-user demand, and global competition – exogenous factors that are well beyond the control of the government but have a profound impact on the success of policy implementation.

If the privatization and regulation processes are flawed by political considerations, severe limits will be placed on the government's ability to implement ICT policies no matter how they are formulated. The privatization process diffuses the market power from the PTT to other operators, allowing for a more balanced competitive landscape. The creation of an independent regulatory agency concentrates the necessary authority to sustain the competitiveness of the market while allowing other ICT agencies to execute their strategies without political interference. Without this diffusion of market power and the concentrated political control of the regulator, the dominant ICT operators will use their political leverage to prevent the evolution of the ICT market, rendering any national ICT strategies ineffective.

The trajectories of economic development and technological innovation do not follow one another exactly, but each one influences and overlaps with the other. A middle-income country cannot focus on technological development while ignoring economic development without significant development consequences, limiting a country's ability to transition to an advanced services economy. The recent political events in Thailand are limiting both economic and technological development, while Malaysia has been better able to manage the transition. Thailand will be able to regain its lost technological footing, but only after it can get its political system in order. Malaysia may not be a candidate for developed country status in 2020, as its prime minister had originally envisioned, but it has effectively leveraged its competitive advantages within the global economy by bolstering its technology expertise and innovation to expand the country's technology niches. Malaysia has more work to do to expand its innovative capacity. However, the country will be able to continue on its path of increased ICT adoption and economic development for the foreseeable future.

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Section 5: Institutional Structure and Fostering ICT Utilization in Malaysia and Thailand

Introduction

One of the key components of East Asia's success has been the creation of national institutions, which have successfully supported technology adoption within these countries. By advancing national technology capacity, a country's technology institutions are an important contributor to economic development (Feinson, 2003). Despite the increased international competition for high-skilled workers and investment, Malaysia and Thailand have managed to build economies with increasing levels of technology adoption and utilization. These advancements have come through a combination of indigenous capacity building and international investment from multinational corporations (MNCs), both of which were closely directed by the national technology institutions (Hsiao, 2003).

This aspect of government involvement in the ICT sector includes supporting the increased utilization of communications technologies across a broad range of sectors within the economy. This would include increasing availability of ICT applications to individuals and organizations within the public, business, and educational sectors in the economy as well as among consumers. Penetration rates for telephones and the Internet can increase steadily within a country, but utilization rates for these technologies may not expand without government initiatives, particularly within poor and rural areas. Middle-income countries may not experience the productivity and developmental benefits of ICTs, which have been measured within OECD countries, without public sector support to ensure that these benefits are diffused across the country (Schreyer, 2002).

By focusing on ICT utilization in addition to access, government efforts can support productivity gains across economic sectors within middle-income countries. This institutional support for increased utilization can take many forms, including government-supported technology training; aggregating demand and serving as an anchor tenant; fostering e-government, e-health, and other services; universal service funds; and governmental safeguards for services such as e-commerce (Frieden, 2005). The communications services will need to be adapted to the needs of the local economic, political, and cultural environment, particularly if these services are originally introduced by an international entity. To meet local requirements, these national efforts require public-private-university coordination to successfully adapt ICT services imported internationally and to enhance services created indigenously (Balaji and Keniston, 2005).

For these policies, it is important to distinguish between countries operating on the technology frontier and those that are transferring and adapting technologies from other countries (Steinmueller, 2001). The major issue with developing countries attempting to catch up technologically is when the skill sets of the workforce developing under one economic stage are not adequate to adapt to the new stage (Steinmueller, 2001). ICTs can assist in the knowledge transfer and the lowering of required skill sets for employees. However, this still requires a baseline level of capability (David, 1997). In addition to a lack of local expertise, progress in technology adoption can also be slowed by market structures that limit innovation and competition, reliance on poor local infrastructure that hampers technology adoption (such as relying on low-quality phone lines for Internet access), and distribution problems due to geographic and market constraints.

Supporting ICT utilization requires government intervention to ignite and support the innovation process within the country. In addition to public-private cooperation, this effort requires governmental intervention to ensure spillovers between MNC branch sites, free trade zones, and entrepreneurial incubators and the rest of the economy (Storm, 2005). This process is easily susceptible to concentrating investment as well as societal benefits and positive externalities. Within a developing country, lack of transparency can lead to a single city becoming the sole beneficiary of the ICT investment and policies (Porter, 1998). The government needs to focus on accelerating innovation, increasing utilization, and diffusing benefits simultaneously to receive the full economic benefit that ICTs can have on a country. So far, few developing country governments have demonstrated that they are capable of launching an effort like this, let alone making it politically and economically sustainable for the long term.

Research Questions

This case study approach will outline the economic, political, and technological environments of Thailand and Malaysia, highlighting the key policy and institutional choices that have resulted in their respective technological utilization rates. This case study analysis will focus on the growing gap between the two countries, where Thailand has not been able to keep pace with Malaysia, which has accelerated its ICT utilization rate. Malaysia has achieved this by successfully completing a series of ICT institutional and policy reforms that have created a competitive ICT market while directly supporting the local ICT industry. This case study section relies on the same secondary and primary sources detailed in Section 4 to examine the commonalities and differences in ICT institutions and policies between the two countries. This ICT utilization study is driven by the following research questions:

- Is development of a domestic ICT sector a key component of larger ICT adoption efforts?
- Are institutional reforms necessary to sustain the growth in the local ICT sector?
- What lessons can be drawn from the examples of Malaysia and Thailand for other middle-income developing countries?

This section is divided into four parts. The first outlines the economic and technological context for Malaysia and Thailand with a detailed focus on international investment and technology transfer. The second part offers a detailed look at the ICT institutions, including the ministries of ICT and science. This part includes a discussion of the evolution of these institutions, the cross-border influence between the two countries, and the organizational challenges facing these agencies. The third part provides an overview of the design and implementation process for the national ICT policies as well as the key challenges facing the national institutions in implementing these policies. The final part includes a discussion of the conclusions drawn from these two cases on the government's role in improving ICT utilization.

Economic and Technological Environments in Thailand and Malaysia

Both countries are at a crossroads in their development; neither can safely rely on manufacturing alone to spur economic growth. Exhibit 5.1 summarizes key national indicators for the two countries plus Singapore's indicators for comparison. The national ICT policies are at the center of the government's attempt to create new economic opportunities while improving its ability to compete globally.

Exhibit 5.1: National Economic and ICT Indicators for Thailand, Malaysia, and Singapore

Economic Indicators, 2005	Thailand	Malaysia	Singapore
GDP per capita, PPP (constant 2000 international $)	7,720	9,681	26,390
Services, value added (% of GDP)	46	40	66
Foreign direct investment, net outflows (% of GDP)	2.6	3.0	17.2
Urban population (% of total)	32	67	100
Technology Indicators, 2005			
Telephone mainlines (per 1,000 people)	110	172	425
Mobile phone subscribers (per 1,000 people)	469	771	1010
Internet users (per 1,000 people)	159	435	571
Broadband subscribers (per 1,000 people)	9	19	153
ICT expenditure (% of GDP)	4.1	7.0	9.4
High-technology exports (% of manufactured exports)	27	55	57

Source: World Development Indicators, World Bank, 2005.

Malaysia is a great example of a developing country that has focused almost singularly on technology development through foreign investment. While attracting a great deal of foreign direct investment, the country's economy has grown dependent on exporting MNC goods to foreign markets (Blomstrom, 1998). The industry is moving slowly toward designing and innovating its own products. However, currently many of Malaysia's manufacturing facilities are low on the global supply chain.

Many developing countries have shifted their focus from deploying fixed lines to wireless penetration. Malaysia has managed to push both wireline and wireless infrastructure, with average penetration for wireline doubling since the 1990s despite a slowdown in growth during the Asian crisis. Wireless access grew even faster, managing to slightly outnumber landlines in less than a decade. A number of areas within the country, particularly outside the Malay Peninsula, have been neglected during the rapid increase in teledensity. This lack of telecommunications infrastructure in these areas also highlights a larger problem of concentrated investment and governmental support to the detriment of the rest of the economy (James, 2003).

Thailand closely studies its neighbors to benchmark its own ICT policies and institutional structure. When Thailand was implementing structural reform in 2002, Malaysia was undergoing a similar effort and Thailand ended up mirroring Malaysia's ICT institutional restructuring. Now that Thailand is working on a second round of ICT reforms, it has looked to Malaysia again to see how its ICT structures have evolved. Despite being very concerned about losing international investment to Malaysia, Thailand does not have the high levels of governmental coordination and marketing that other Southeast Asian economies do. Thailand is currently competing with countries that have low-cost labor, such as China, as well as countries with high levels of skilled labor, like Singapore.

International Investment and Technology Transfer

The section below discusses FDI, MNCs, and the role of technology transfer because these issues are vitally important to the creation and expansion of a developing county's ICT sector.

Thailand

An important component to the development of local industries and the acceleration of technology adoption is the foreign investment and technology transfer from global corporations located in Thailand (Jansen, 1995). Like other developing countries, Thailand's high-tech industries in particular must rely on international investment and technology transfers (Kohpaiboon, 2006). Through technology and knowledge transfer from these MNCs to local branches and suppliers, a developing country can rapidly expand the capabilities of local industry to adopt and utilize technologies. Thailand has attracted significant amounts of FDI into its economy, reaching over 6 percent of GDP before the financial crisis in 1997. However, the country has not been able to expand this investment since the technology collapse in 2001 (World Bank, 2006). In addition, successful diffusion requires government intervention as well as coordination with the private sector to ensure that these technologies diffuse throughout the economy rather than concentrate within a single industry or region. Thailand has not been able to address this issue. In addition, the government has failed to directly link its approach to foreign direct investment with its efforts to enhance local technological capabilities. This is in contrast with Malaysia and Singapore, which were able to utilize FDI to expand local technology capabilities and accelerate adoption (Wong, 1999).

According to interviews that I completed with the Ministries of ICT, Finance, and others, there are increasing concerns within Thailand about losing MNC investment to neighboring countries. Although FDI incentive efforts are run by the Office of the Board of Investment, Thailand does not have the high levels of governmental coordination incentives, or marketing that other Southeast Asian economies use to increase their foreign investment. Several government officials each commented that Thailand is currently competing with low-cost countries, such as China and Vietnam, with which it cannot compete on price, and countries such as Malaysia and Singapore that have a much higher level of available talent for ICT and S&T. This situation makes it particularly difficult for Thailand to attract investment in technology sectors, which are deemed strategically important to the long-term growth of the economy.

As mentioned above, one key issue facing Thailand is the fact that it does not offer tailored packages for industry sectors, even those targeted by the S&T Master Plan, such as biotechnology. The government offers one incentive package that has lower hurdles for importing capital and employees as well as preferable terms for taxes, leases, and other benefits. However, unlike neighboring Malaysia and Singapore, these packages are not tailored to fit the needs of particular industries, which may be capital-, resource-, or labor-intensive, reducing the effectiveness of the government's effort. In response to this need, officials at Thailand's science ministry stated that they are currently working with the Board of Investment to put together a tailored package for the hard disk drive industry to attract companies such as Seagate and Fujitsu.

The Thai government began work on a bi-lateral Free Trade Agreement with the US that will increase US investment while opening the market to additional US-based MNCs. The officials at the ministries of science and finance stated that the agreement would also begin to lower the protections around the Thai technology sectors, affecting the status of fledgling industries, such as the local software sector, and making them vulnerable to international competition. In turn, Thai government officials argued that this agreement would put pressure on the science ministry and other agencies to support these ICT and S&T industries against increased competition from US firms moving into the market. The negotiations have stalled in 2007 due to political instability in Thailand along with internal Thai governmental divisions on the benefit of the agreement.

A major component to enhancing local ICT industry development is the creation of a venture capital industry that invests in startups that are either commercializing local research or adapting international technology to the local market (Ramasamy, 2004). The local Thai venture capital (VC) community organized itself into the Thai Venture Capital Association in 1994, with members from the financial, accounting, legal, and advisory services industries. The VC community focuses its investments on firms that have reached their expansion stage. As a result, Thailand faces significant hurdles supporting early round startups with adequate financial backing due to the high levels of risk – a common problem for many developing countries. The Thai government has supported the expansion of the small venture capital community through tax incentives and a number of government-backed funds (Intarakumnerd, 2004). These VC funds target both small business development and areas affected by the financial crisis, seeking to fill in gaps left by the private sector.

In addition to the private sector, Thai enterprises also tap international lender sources such as the Asian Development Bank (ADB) and particularly firms that were state-owned enterprises, according to officials at the Ministry of Finance. A majority of this international funding comes through bi-lateral sources, such as the Japan Bank for International Cooperation (JBIC). The last ADB loan – which was part of the emergency loans of the International Monetary Fund bailout package after the financial crises of 1997 – was paid off in 2003. Thailand used JBIC funding to support new power plants and the new international airport in Bangkok. These sources of funding are important to Thai SOEs because many of them operate at a significant loss but remain vital to the deployment of national infrastructure (Ali, 2003).

Malaysia

Malaysia has been very successful at attracting FDI and MNCs in the manufacturing and IT sectors, reaching a level few developing countries can match (Jomo, 1997). Hundreds of MNCs and billions of dollars in FDI have flowed into the country, particularly into the free trade zones (FTZ) and technology parks set up near the regional manufacturing and technology centers. This includes over 1,700 technology companies – both domestic and international – in Malaysia's Multimedia Super Corridor as of 2007, according to the MSC's online reporting. Government officials interviewed for this research suggest that there is close coordination across government ministries as well as between the private and public sectors to promote targeted ICT sectors. The public and private sectors also develop FDI incentive programs, creating packages tailored to specific firms and sectors. Fueled by these foreign corporations, Malaysia has become a top exporter globally, boosting economic growth and local incomes. Of particular importance is the IT sector, which has grown rapidly through the involvement of foreign capital and MNCs. The government has been able to attract a wide range of software and IT MNCs, and meet its internal targets for relocating firms within the technology parks, even after the global technology downturn in the early part of the decade. This resilience despite downturns at home and abroad is a testament to the coordinated efforts of the public and private sectors to attract technology transfer, investment, and employment opportunities.

Few ASEAN countries approach the high rate of FDI that Malaysia has maintained during the past 10 years, reaching 9 percent of GDP. However, Singapore is the other notable exception. The country was able to maintain investment through the financial crisis and saw a brief decline in 2001 due to the global technology slowdown. In 2004, its FDI rate was 4 percent of GDP and increasing year-over-year. Both Korea and Japan averaged around 2 percent of FDI during their development phases, preferring instead to use licensing agreements with MNCs to foster technology transfer rather than direct investments (Ismail, 2003). This policy choice within Korea and Japan proved to be very beneficial in developing indigenous innovation capacity, where Malaysian policy is now focused. Jomo (1997) argues that one of the main political reasons for allowing such a high influx of FDI into the country was to balance the economic power between the ethnic Malays and the minority ethnic Chinese, which have a disproportionate influence within the economy. The FDI was encouraged by the Malaysian government as a way to lower the Chinese minority's economic influence while supporting the growth of Malay-owned firms (Jomo, 2003). This has allowed the country to rapidly expand its global presence within the ICT sectors. However, it has also increased the country's dependency on MNCs and FDI. In addition, several sectors such as the electronics industry have not significantly expanded their roles and are limited to providing low-skill assembling within the global supply chain.

This predominance of foreign investment has created a gap in funding available to start-up technology firms in Malaysia and has led the government to develop entrepreneurial financing options for local firms. This has prompted the Malaysian Industry-Government Group for High Technology (MIGHT) to support the development of a financing corporation that coordinates with private sector financial institutions to lower the barriers for investment, according to officials within the organization. The finance corporation's activities include completing due diligence on prospective firms for investment while helping to foster relationships between start-up firms and private sector investment houses. These activities are vital to jump-starting local technology start-ups since the venture capital industry in the country is very small and relatively new. This government entity also identifies global technology niches – such as biotechnology, photonics, and advanced manufacturing – where Malaysian firms will have a competitive advantage due to the large base of local technology expertise.

Another important focus area has been fostering skills training from MNCs, particularly from US firms. While Japanese and European firms send a larger percentage of their employees to off-site training, a much larger percentage of US firms have Malaysian employees in middle- and top-management positions including managing director (Wah, 1999). This translates into allowing a full range of technologies, from simple to complex, to be implemented in Malaysian facilities under Malaysian managers. The end result of these managerial positions for Malaysians within US firms is on-site skills development that potentially could create a class of experienced entrepreneurs that can help Malaysia achieve its goals for building local innovation capabilities.

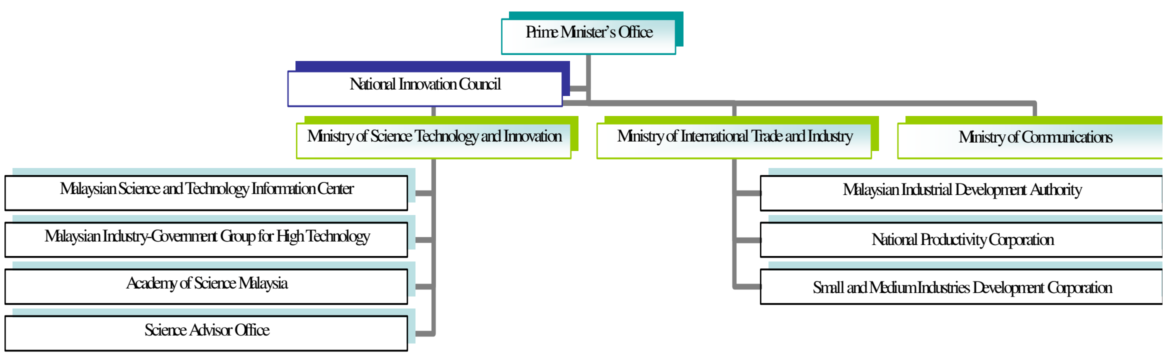
ICT Institutions

Until 10 years ago, a vast majority of countries opted for public provisioning of telecommunications services. Today, virtually every government in the world has – to greater or lesser degrees – begun to shift toward more private, more international, more competitive, and more distributed and de-centralized management of their ICT industries (Wilson, 2003). Wilson states that developing country governments are not moving at the same pace as developed countries, nor are they using the same agencies or getting the same results. Wilson also suggests further that regulatory and institutional issues are the critical success factors for the growth in ICT penetration rates within Malaysia and Thailand.

This part of the case study section is divided into four parts, with this introduction providing the background on the ICT and technology institutions of Thailand and Malaysia. The second component examines the institutional development of the Ministry of ICT in both countries, studying in particular the evolution of the ministries in the past 10 years. The third component provides a similar study of the ministries of science and technology, while the fourth examines in detail the influence of Singaporean institutional reforms on both countries. Last, this section offers a discussion of the hurdles both countries must overcome to improve the design of their ICT institutions.

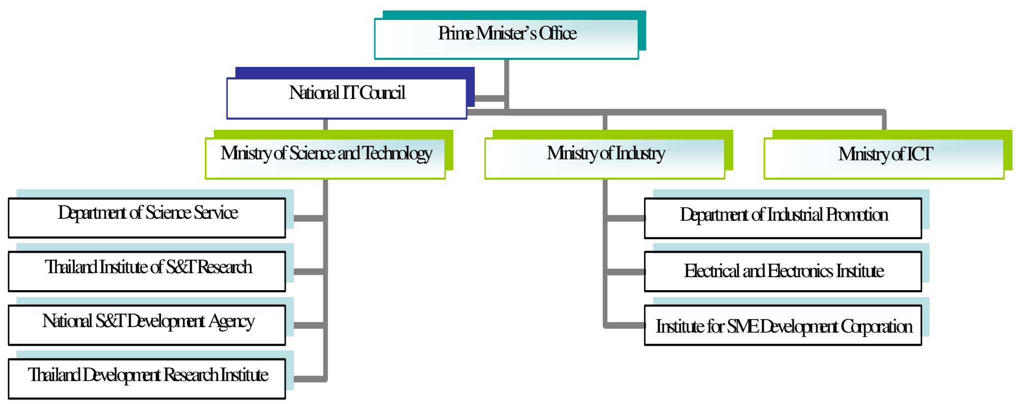
A key component to the success of ICT strategies has been the creation of national technology institutions, which have successfully supported technology adoption within these countries (Zysman, 1983). These institutions exist in both Thailand and Malaysia. However, Malaysia has been more successful in coordinating these entities to support its national ICT policy implementation. These structures consist of both governmental and non-governmental organizations that direct, support, and fund national technology initiatives. These structures include advisory boards, business development and training agencies, R&D institutes, and commercialization programs. Malaysia's technology institutions, by advancing national technology capacity, are an important contributor to economic development (Feinson, 2003). Exhibit 5.2 presents the organizational chart of Malaysia's ICT institutional structure.

Exhibit 5.2: Malaysia's ICT Institutional Structure



Although Thailand has an institutional structure similar to Malaysia's, the country's agencies do not have the budget, authority, or monitoring capabilities to implement its ICT policies transparently. In addition, the country has volatile regulatory conditions, leaving ICT operators without a credible commitment by the government to enforce and maintain the regulatory regime. This commitment is essential to the long-term investment environment, which is key for the capital-intensive telecommunications and IT industries (Weingast, 1995). In contrast, an independent regulator in the sector, which is only now being formed, increases market certainty and long-term stability. The ICT sector will invest heavily in their infrastructure only if the necessary regulatory and institutional structures exist (Levy, 1994). Exhibit 5.3 presents the organizational chart of Thailand's ICT institutional structure.

Exhibit 5.3: Thailand's ICT Institutional Structure



These countries have both developed ICT strategies containing three key strategy areas, focusing on ICT infrastructure deployment, ICT training, and ICT industry development. Malaysia and Thailand have taken these basic ICT initiatives and adapted them to the needs of their local economic, political, and cultural environment.

The network infrastructure deployment plans have been based on South Korea's very successful government initiatives to support ICT network expansion (Frieden, 2005). These plans focus on increasing access, deploying fiber networks, and expanding universal service obligations. Some of these efforts have been successful, depending on the demand for ICT services that already exists within each country.

The second key area includes workforce skill development to assist in ICT knowledge transfers from MNCs while increasing local technology innovation capabilities. Thailand has moved to support training and skills development through its Ministry of Education and Ministry of Industry. However, Malaysia has made it a primary focus for its national development strategy.

The third area, IT industry development, was the primary area of focus for the private sector and the two national ICT strategies. In 2003, Thailand created Software Park and the Software Industry Promotion Agency to bolster its fledgling industry. In Malaysia, the IT sector has grown rapidly through the involvement of foreign capital and MNCs, both of which are coordinated through the Multimedia Super Corridor. Through the MSC, the government was able to attract a range of software and IT MNCs. The country is now focused on increasing the technology transfer and training from these global IT firms into its local ICT industries.

According to interviewed officials from MIGHT, the organization has identified several high-tech sectors that offer Malaysia a niche to compete in the global market. These sectors will benefit from a cooperative public-private effort to coordinate training and R&D efforts to bolster local capacity in these areas. Although this policy was only recently announced, it is a vital step in Malaysia's national strategy to utilize ICTs and develop a knowledge-based economy.

Institutional Development for Ministries of ICT

Thailand

In 2006, Thailand began working on its second round of institutional reform – before the coup that created an unstable political situation that has slowed this reform effort to a halt. The first round was completed in 2002, which resulted in the creation of several new ministries including the MICT. Interviewed ministry officials stated that one current proposal for this second round of reform is to combine the Ministry of Science and Technology and the Ministry of ICT. The goal is to combine the expertise and funding of the two ministries to elevate and accelerate the efforts for developing an ICT industry and increasing access and utilization of ICTs across the population. Ministry officials stated in interviews that the MICT was created from parts of several other ministries:

- Ministry of Transport and Communications: Coordinating the infrastructure-intensive ministries of transportation and communications was more appropriate in the past, when the focus of the telecommunications industry was extending fixed line assets. With the advent of new services and technologies, including mobile wireless, this ministry was broken up into two pieces – with the Communications division going to the newly formed MICT.

- Ministry of Science, Technology, and Energy: Until the reform process, the science ministry had IT policy and regulatory structure in its purview. The National Electronics and Computer Technology Center (NECTEC) argued that IT and communications technologies were converging, and that it no longer made sense to have separate ministries in charge of these two technology sectors. Therefore, the IT component of the Ministry of Science and Technology went to the MICT.

- National Statistical Office (NSO): This office was previously in the Office of the Prime Minister before being moved to MICT. The NSO provides statistics on ICT adoption as well as other government and private sector indicators.

It was debated whether to move NECTEC, the national innovation agency discussed more fully below, under the MICT because it had previously been responsible for developing ICT policy for the country. For ministries or departments that are purely governmental, moving across the government's organization structure is not a difficult move. However, NECTEC is an independent agency with its own law establishing its purview and regulations; to house the independent agency within the MICT would require a new law, which would take several years to pass. Officials at NECTEC stated in their interviews that they were also unwilling to give up its status because it would no longer be able to compete for technical personnel with the higher salaries of the private ICT sector. As a result, NECTEC was not moved under the MICT in the first round of reform. Unfortunately, this divided effort has created coordination and resource allocation problems. Neither the new ministry nor NECTEC has the critical mass of expertise to support ICT adoption and utilization policies on its own, which has resulted in the proposal for a second reorganization.

Malaysia

The Malaysian government has undergone two institutional restructurings of the agencies that support the development of the Malaysian ICT sector. Prior to 2004, the Ministry of Communications and the Ministry of ICT were together in a single ministry that focused on infrastructure and services and represented Malaysia at international regulatory and trade bodies. These two ministries were put together in 1998 through the Communications and Multimedia Act, which deregulated the telecommunications industry and created the Malaysian Communications and Multimedia Commission.

Although the MICT had only been active for a few years, the agencies within the Ministry were split again into two components. The MICT's responsibility over ICT infrastructure has been transferred to the Ministry of Energy, Water, and Communications (KTAK), which also became the primary agency for international bodies, such as ASEAN, the ITU, and APEC. The Ministry of Science, Technology, and Innovation (MOSTI) continued to focus on R&D and S&T development while supporting a joint effort with KTAK to implement Malaysia's ICT policies. After working together in the MICT, KTAK and MOSTI personnel still coordinate closely on their overlapping policy portfolios. They are also working out a more balanced approach to representing the Malaysian government at international organizations, such as the ITU, by sending representatives from both agencies.

Evolution of Ministry of Science and Technology

The administrative organization charged with coordinating the design and implementation of Thailand's national ICT policies and initiatives is the National IT Committee (NITC). When the Committee was created in the early 1990s, NECTEC acted as the secretariat, developing ICT policy and frameworks for the country. The Committee is officially headed by the prime minister and includes members of IT, telecommunications, banking, and other industry trade groups. A former official with the NITC stated that a deputy PM is typically assigned to run the Committee, in addition to other duties and obligations. As a result, the Committee's ability to develop and implement ICT policies would vary widely depending on the personal interests of the deputy assigned. Those with a strong interest would inject their vision into the Committee, where it would cascade through the other ministries, accelerating efforts and improving initiative outcomes. In contrast, ICT policy design and implementation would suffer a significant slowdown under deputies who were not as interested in this NITC leadership position.

Thailand – National Electronics and Computer Technology Center

The national innovation agency, NECTEC, was created through the National Science and Technology Development Act by Parliament as an independent agency – also called "semi-governmental" – to focus on R&D efforts within the electronics, information technology, and communications technology industries (Intarakumnerd, 2004). This classification requires a specific act of Parliament to create the agency and puts its employees outside the traditional civil service requirements. Most notable are the employment contracts that replace the employment-for-life arrangements typical in other agencies. Although it is a riskier job situation, these employees draw a higher salary and have much more flexibility regarding work procedures and regulations for the agency. Rather than the civil service regulations, NECTEC's are set by its own board, which is headed by the Minister of Science and Technology. This flexibility allows NECTEC the ability to hire and retain the necessary technical personnel to carry out its mission to bolster R&D activities within Thailand.

NECTEC was placed under National Science and Technology Development Agency (NSTDA), which is part of the Ministry of Science and Technology and was created as part of the same act. Officials interviewed for this research stated that NSTDA is focused on developing and supporting S&T policy within the Thai industry through four key divisions: nanotechnology, biotechnology, material sciences, and NECTEC. The development agency works with major universities to develop and commercialize technology innovations and has recently set up a Technology Licensing Office to work with universities to license and commercialize their research. The Ministry of Science and Technology completed its own master plan for science and technology policy. This plan identified several industrial sectors to target for support by NSTDA and the other agencies within the ministry, including food processing, automotive, garment, and others. According to NSTDA officials, prior to this plan, university and government researchers had applied for funding based on their own disparate interests, which left R&D efforts uncoordinated within these sectors. To receive funding under the science master plan, researchers and ministries must demonstrate how their funding and policy support the government's S&T goals.

Once the Ministry of Information and Communication Technology was created in 2002, NECTEC was no longer the policy-making arm of the National IT Committee and the agency no longer had monitoring and evaluation responsibilities for the ICT sector. Although it had written the IT policy framework, IT2010, and its telecommunications sector companion, Master Plan 2002-2006 (NECTEC, 2006), the agency was not able to design or write the follow-up plan in 2007 – even though this new plan would still draw on the IT2010 framework created by NECTEC.

Before developing the IT2010 policy framework, NECTEC evaluated its previous framework, IT2000, for the successes and challenges of implementation. The program evaluation was conducted by outside consultants from the ICT industry and university departments. Once completed, it was used as a guideline for designing the new policy framework, the IT2010.

With a critical shortage of expert manpower at the MICT, the ministry has outsourced some design components to NECTEC to complete, according to interviews with NECTEC officials. However, there is no ongoing evaluation due to manpower and funding shortages; and it is unclear whether the MICT, which is responsible for writing the Master Plan in 2007, will evaluate the implementation of the previous ICT plan. This policy and oversight confusion has led to a significant disconnect between the original goals and intent of the ICT policy framework and the initiatives implemented by the MICT and the other ministries. The split in bureaucratic responsibilities has also limited the Thai government's ability to adequately track and benchmark ICT policies against its stated goals.

Officials at NECTEC stated that the agency focuses much of its work on applied R&D efforts, commercialization efforts, and technology transfer. Its agenda is tailored to ensure that there is commercial demand for the R&D activities currently being funded by public and private sources. In addition, the agency runs its own labs, staffed by researchers that complete university training through NECTEC scholarships both in

Thailand and abroad. These researchers are contracted to the government for twice the length of their schooling. However, NECTEC loses many non-scholarship researchers to the private sector due to uncompetitive compensation packages. Similar to the National Science Foundation in the US, NECTEC provides grant funding to university researchers in addition to its own labs, particularly in areas where the agency is lacking in expert personnel.

The national innovation policies aimed at developing the ICT sector are designed by NECTEC and the MICT for implementation across the other ministries. Interviews with officials at NECTEC and the MICT confirmed that once NECTEC develops the policy, the Ministry of Science and Technology presents it to the cabinet for approval. If the policy is approved, it is set as a national policy for all of the ministries and departments to follow. Although NECTEC and MICT are responsible for the ICT policies within the country, both of these government organizations are short on funding and manpower. This is due to the lack of large-scale projects, which tend to receive the most funding and political attention. NECTEC, the MICT, and the Ministry of Science and Technology have very limited authority, political influence, and budget while the Ministries of Finance, Commerce, and Transport all have high levels of political power due to their budgeting authority for large infrastructure projects.

Thailand – Software Industry Promotion Agency

The Thai government has set a target of creating an indigenous IT sector, but the private sector has made little headway. The government has been working on a series of IT bills to support the sector, but in the last nine years has only passed two. As a result, there is no master plan or policy strategy for developing this IT sector – although it is outlined in IT2010. There have been some successes by the Software Industry Promotion Agency and within the Software Park, a national technology park devoted to the industry. However, the Software Park has done little outside of training individuals and SMEs (Gray, 2004).

Formerly a part of the MICT, the Software Industry Promotion Agency is a public organization similar to NECTEC, with flexible regulations and employment contracts. According to discussions with an executive at SIPA, the agency has focused on deploying several pilot programs aimed at improving government services. One pilot was completed using local software developers to build an online interface for the immigration service. Another example included the development of an online portal to promote Thai regions for business investment and job creation. This is similar to the efforts of local US chambers of commerce, aggregating key economic, demographic, and quality of life indicators for prospective investors and businesses. Although this is an easy step for a US region, in Thailand the data is spread across many disparate agencies and databases, making integration difficult. SIPA also tracks and provides information on available ICT experts and upcoming graduates to attract investment in the software sector.

In addition, a Software Park was developed by the NSTDA as part of an industry support policy designed for the National IT Committee. The Software Park has the same independent agency status as NECTEC and offers office space and shared computer facilities to small software entrepreneurs. The park also offers a firm matching program, linking small software companies to larger Thai and international partners. Both SIPA and the Software Park have similar goals and there is overlap between the two efforts due to a lack of institutional coordination.

Implementation problems related to supporting the development of a local software industry include the challenges of utilizing the government as an anchor tenant for the software produced by these firms. Thailand cannot simply buy foreign software off-the-shelf; the country needs tailored solutions that take into account the cultural, political, and economic environment of the country (Gray, 2004). However, the local Thai software firms tend to use open source software (OSS) as the kernel for the development of their products. Government procurement of this software would lower the IT costs versus Western products, such as those from Microsoft. Currently, few government users have OSS-based Thai software installed due to regulations instituted by the government auditor, which requires ministries to compile and justify each of their IT purchases.

The auditor has become the de facto standard setter within the government bureaucracy. In order to make a purchase, ministries must demonstrate how this alternative IT resource will outperform the standard option in all circumstances and provide details for the hardware or software, such as the specific Linux kernel that the OSS is based on. In contrast, the forms and review process for a Microsoft purchase are relatively easy, funneling government users toward this de facto standard. According to government officials and industry observers, one hope to reverse this trend is for MNCs that are partners with local firms to advocate for government reforms that would open the market. Like systems integrators and hardware manufacturers, MNCs have been much more vocal in supporting the Thai government than their local counterparts. A wider opening of the government market will help bolster this nascent ICT sector.

Malaysia – Ministry of Science, Technology and Innovation

Malaysia's Ministry of Science, Technology and Innovation identifies target sectors for national technology policies for the next 10 years, focusing on areas where the Malaysian government can support private sector competitive advantages. Its activities include risk assurance for private sector development, and monitoring and evaluation of policy implementation. MOSTI was previously the permanent secretary for the NITC, which is similar to Thailand's NITC; is also chaired by the prime minister; and is coordinated across the private sector and several ministries for ICT policy implementation in Malaysia, including education and energy, water, and communications.

In interviews, ministry officials described additional initiatives including technology development and innovation, as well as best practice development for R&D within the local S&T industries including the ICT sectors. MOSTI also supports improved coordination across private and public research centers through strong leadership directed by the prime minister's office. MOSTI views its role as an ICT enabler through increased investment, expanded R&D activities, and enhanced innovation capacity. MOSTI also is responsible for regulating and enforcing the Communications and Multimedia Act. This regulation is in coordination with the national regulatory commission.

Through the NITC, MOSTI conducted an assessment of national ICT needs in 2006 to revise the national ICT policies and initiatives. The Malaysian government is currently in the middle of its 2006-2010 economic plan and ministerial budgets have already been set. But MOSTI will utilize the 2007 budget to launch its initiatives and then move to revise the 2008 budgets during the mid-plan review. This flexibility of funding is key to Malaysia's ability to respond to the rapidly changing landscape within the ICT sectors. From the NITC planned report on ICT needs, focus areas on the ICT road map include:

- Industry Building – Identification of key companies to attract in each focus area, the pull factors, the strategies to build local companies, etc.

- Capability Development – Identification of the current capability level, the gaps that need to be addressed, and long- and short-term strategies needed to develop the capabilities.

- Infrastructure Development – Identification of infrastructure needed to support the growth of ICT focus areas, including investments.

- R&D and Technology Development – Identification of R&D and technology needed to support each focus area and types of institutes necessary; collaboration between research institutions and industry.

- Community Development – Identification of target groups, social development projects, and key public services necessary for community development.

- Special Project Development – Identification of special projects required to drive ICT adoption in non-ICT areas.

A steering committee, which includes ministry stakeholders as well as business leaders there as observers, was formed to administer this effort and handle project approval. Once the steering committee approves a project, it is passed on to the full NITC for approval and then presented to the prime minister's cabinet. The stakeholder ministries, such as education, are involved at each of these three steps of the process to ensure buy-in and continued support across the ministries for funding and implementation.

Malaysian Industry-Government Group for High Technology

MIGHT is a non-profit quasi-governmental organization that operates under the oversight of MOSTI, Malaysia's innovation and science agency. The organization is charged with supporting and operationalizing "Malaysia Incorporated," which is modeled after Japan and Singapore's public, private, and academic coordination to innovate and compete in the global marketplace. This coordinated initiative, called the "triple helix," to build innovation capacity is driven by the stakeholders in these three sectors across the country (Kam, 1999). MIGHT is made up of 15 to 20 business, government, and academic leaders and is co-chaired by the PM's science adviser. All policy proposals, once accepted by MIGHT, flow through the science adviser to the PM's office and then to the cabinet for approval and funding. MIGHT has successfully bridged the gaps across these three sectors and coordinated with competitive firms within the private sector to support globally competitive industry development.

In the early 1990s, there was little coordination within Malaysia's private sector let alone across the public or academic sectors. In 1993, the organization was under the prime minister's office when it was moved to MOSTI. The decision was made to place the organization under the prime minister to bolster its ability to draw political support from the PM as well as the other executive agencies. Aside from these political considerations, this move was also necessary due to MIGHT's focus on specific privatized industries that cut across multiple agencies and as a result had previously not received the necessary governmental support to bolster their development. One example outside the ICT sector is the aerospace industry, which had previously fallen under the communications, transport, and finance ministries. With no single ministry leading the effort to support this industry within Malaysia, and no single ministry able to coordinate across the overlapping efforts, there was a lack of support and coordination. Under MIGHT's direction, a national aerospace blueprint was developed through 12 months of policy meetings by a technical committee that included the airlines and manufacturers, and a steering committee that was chaired by the prime minister's science adviser. Once presented to the prime minister, the government funded a multi-year effort that was coordinated by a purpose-built policy vehicle chaired by the prime minister – the Malaysian Aerospace Council – that evaluates the progress of the national aerospace blueprint every six months.

According to interviewed officials, MIGHT's process of governmental support is to use successful interventions, whether they are within the aerospace or ICT industries, as pilot programs for launching efforts across a range of technology sectors. For MIGHT to target a given sector, it must fall within the portfolio of several ministries, have already undergone the privatization process, and cannot have a private sector organization already operating to support sector development. This last requirement prevents the government from duplicating private sector efforts or reducing the incentive within the private sector to establish these coordinating bodies on their own. MIGHT also looks to see where Malaysia can find global technology niches, where it is feasible for the country's existing technical expertise to compete internationally while driving national exports and innovation. It also looks to leverage the existing industrial and technological base within the country. The other areas of focus for MIGHT include entrepreneurial development financing, pharmaceuticals, and radio frequency identification (RFID) tags.

Malaysia – National RFID Program

As mentioned above, there is a clearly defined process for evaluating the technology niches that will receive support through the ICT road map. This includes an assessment of the market demand for a given information technology, the viability of this technology, Malaysia's ability to compete in this market, and the global competition within this sector. Once this technology for global export is chosen, a road map will be created for governmental support that will include key performance indicators (KPIs) developed and monitored by MOSTI.

The goal of the national RFID program is to develop a cluster of firms capable of supporting the development, innovation, and marketing of this emerging technology. RFID tags are inexpensive chips that can be used to track inventory by a range of industries, most notably retail and logistics. The program's larger goal is to support the revival of the national semiconductor industry, which has seen its market share and margins shrink due to global competition and the global technology slowdown in the early 2000s (Rasiah, 2003). Although Malaysia is third in the world for semiconductor manufacturing, the country's design houses for hardware, software, and middleware had begun to whither and lose their attractiveness to top engineering talent during this downturn. Malaysian wafer facilities, built with government funding, were very competitive but had lost out to global companies with combined chip design and application capabilities. In response to this situation, the government decided that it could not rely on manufacturing capabilities alone and began working to support the development of chip applications along with the revival of the country's chip design houses. The government support for the revival of the national semiconductor industry included MIGHT negotiating a technology license from Japan for an RFID chip and then leasing this technology to a newly created private company, Senstech.

To build a sustainable level of supply and demand, the government has created a multistage plan for development and deployment. The first phase includes using the government as a test bed and to have the government act as a coordinator across the key private sector players to begin the transition away from bar codes. The government is offering these government agencies the right to use these RFID chips if they are suitable to the program. The government has also agreed to act as the anchor tenant for the technology once it is produced, purchasing the chips for governmental applications to jump-start the industry. These governmental purchases will be used for government programs as well as by state-owned enterprises in sectors such as cattle tagging, logging, and auto manufacturing. However, if agency or SOE testing demonstrates that these chips are not suitable, end users can transition to other available RFID sources. The second phase includes extending the program to wholesale and retail logistical support within Malaysia. To serve the needs of these sectors, the program will expand production to benefit from the economies of scale that are essential in lowering the costs of individual RFID chips. The final step will focus on the international markets and competing against global firms for exports. This phase's approach is key to developing a financially viable sector while positioning Malaysia's semiconductor at the forefront of this growing ICT sector.

Malaysia – Multimedia Super Corridor

The Multimedia Super Corridor is a large technology park devoted to ICT sector development and is the cornerstone of the government's efforts for supporting the development of ICT industries within Malaysia (Bunnell, 2002). The MSC is run by the Multimedia Development Corporation (MDeC), which has representation within Malaysia's National IT Council. Another key institution supporting the MSC is the MSC Implementation Council, which focuses on technology sector investment and development. The MSC Implementation Council is chaired by the prime minister and the MDeC acts as the permanent secretary. Other ministries provide oversight for these efforts, with MOSTI approving MDeC policies and programs, and the Ministry of Finance approving budgets and five-year development plans. MDeC's focus on the MSC is complementary to MIGHT, which has a broader portfolio of expanded technology industries nationwide.

Officials that manage MDeC claim that the organization has been designed as a one-stop shop of government services for MNCs. Previously, these international firms and investors had to work with multiple ministries individually, which slowed the approval process for importing equipment, capital, and employees. Today, MDeC will work with MNCs and the relevant ministry, such as immigration, to fast-track requests. MDeC also completes an annual firm census of the companies operating within the MSC, monitoring the utilization of the facilities and the number of investments, employees, revenues, and profits. This information is reported to MOSTI to be incorporated into the S&T policy planning process in conjunction with the Malaysia Industrial Development Authority.

The MSC effort is driven by KPIs, which are benchmarked annually with goals for exports, employment by function, and investment, among others. To help ensure these targets are met, there is regular communication between MOSTI and MDeC as well as monthly dialogue between MDeC and its MSC tenants. MDeC also reviews the operations and tax status of each business and has revoked the licenses of both MNCs and local SMEs for breach of contract. A majority of the companies with revoked licenses have been local; these SMEs have difficulty maintaining their efforts to compete within ICT sectors.

The MDeC is also working to bolster the development of these SMEs through a program that targets these firms at each stage of development. Starting with support for idea creation, seed capital, first stage, and all the way up to IPO, there is a tailored program within the MSC to support the investment, training, supplies, and industry connections of these firms (Jomo, 2003). There is also significant funding and expertise available to support R&D efforts. The MDeC is also working to improve commercialization efforts of university research by matching faculty and students with MSC companies as well as providing incubators for university-based start-ups.

The MDeC is currently implementing plans to expand the MSC to additional population centers around Malaysia (Bunnell, 2002). This effort is championed by each state within Malaysia, with the MDeC coordinating the development of the regional technology parks. To avoid duplicated efforts and state-level competition, each of the new MSCs must differentiate their economic and innovation goals to win approval to develop a park. One example is the MSC in Penang, which is focused on the electronics industry and leverages the state's robust semi-conductor industry. As of 2006, four additional MSCs had begun development with the support of government tax breaks, no labor restrictions, no hurdles for fund transfers, and government guarantees on communications services.

These regional MSCs also have the advantage of additional land that they can lease to MNCs, whereas the original MSC outside Kuala Lumpur has no additional land available for new investors. States are given permission to lease this additional land at no cost to attract global ICT companies to their MSCs. In addition, MSCs have been built out with transportation, water, power, and telecommunications networks to meet the stringent requirements of ICT sector MNCs. The government provides this support for 10 years with a mid-term review to ensure that the business activities are still meeting the requirements set by the MSC, which limit MNC investment to knowledge sectors.

Influence of Singapore and Other Countries on Institutional Structure

Thailand watches its neighbors very closely to benchmark its own ICT policies and institutional structure. Thailand was implementing its first structural reform when Malaysia was undertaking a similar effort. As a result, Thailand mirrored its restructuring after its neighbor. Now that Thailand is considering working on a second reform, it has looked to Malaysia again to see how that country has evolved its ICT structure. Both countries' science ministries were previously permanent secretary to the National IT Councils. In addition to Malaysia, Thailand's ICT agencies have looked to other countries in Asia to develop its ICT policies and institutions, including Singapore, Japan, Korea, and other ASEAN countries (Koh, 2006). Singapore has been widely viewed has having a successful ICT sector as well as an institutional and regulatory reform process (Painter, 2007).

The Malaysian government closely examines the ICT policies and institutions of other Asian countries for its own reform efforts. For broadband and other ICT infrastructure deployments, Korea's program was used as a model; while Singapore was used to reform institutional structure and policy implementation mechanism (Koh, 2006). In 2002, MOSTI completed an evaluation of its institutional and program structure to assess areas that required improved performance. After reviewing Singaporean ICT and innovation policies (Wong, 1999), this study concluded that Malaysia needed to reevaluate its process for choosing its global technology niches to compete internationally. Wong suggested that Malaysia had focused too heavily on services to the exclusion of infrastructure development. In response, KTAK was designed to support the government's ICT efforts while reducing the likelihood of duplicated efforts across the other agencies. Malaysia also examined the Indian government's effort to support software development and service industry outsourcing. These policy reviews are completed by Malaysia and its Asian neighbors through official visits, ASEAN exchanges, and informal relationships between government officials.

Another example of cross-national policy pollination of ICT policies is the Malaysian government's emulation of Thailand's SchoolNet program. After visiting Thailand, the Malaysian communications ministry lobbied within the government for funding to deploy a national school network to improve access to educational resources and distance learning. Within the year, the program had approval from the ministries of treasury, communications, and education. Using MCMC licensing fees, all Malaysian schools and universities were connected within 18 months using a range of broadband access technologies, finishing by mid-year 2005. SchoolNet has connected almost 10,000 schools at 384 Kbps, which is the standard set by the Malaysian government for broadband. Program implementation is run by the National Broadband Plan Secretariat, a small agency that monitors ICT initiatives and executes pilot programs for new initiatives before they are rolled out by the private sector. MyREN, a program similar to SchoolNet, has connected 15 university campuses with up to 8 Mbps connections. Malaysian government officials cited the Thai example as the inspiration for the policy and rollout of the program as well as providing a catalyst for rapidly approving and funding the initiative.

Another example of ICT best practices imported from other Asian countries is the Malaysian government's support for the deployment of telecenters. Officials at the science and technology ministry stated that the original program design had called for the use of post offices throughout the country to host PCs and Internet connections, but offered little training for staff or end users. This lack of training led to few users or benefits for the target regions. In response to this low usage, the Malaysian government reviewed international best practices for telecenters supported by a grant from the Japan International Cooperation Agency. These best practices suggested raising the budget of the telecenters to expand the number of PCs, to operate standalone facilities, and to ensure that staff members are properly trained through national ICT train-the-trainers programs. This program developed a cadre of skilled staff who could then direct training courses of their own for local users. Other program changes included grouping end-user training sessions by level of expertise, which dramatically increased the number of users.

The increase in the number of PCs also helped to ensure there was a critical mass of users, while the addition of expensive hardware and software programs – including those from the engineering field – gave entrepreneurial users an opportunity to cost-effectively access these tools. The central government also increased the salaries for these telecenter staff members and expanded the number of years that it covered the telecenter costs. This was done to give the centers more financial stability once they transition to covering their own equipment and labor costs after five years. At the end of the five years, an evaluation will be completed to assess whether each region has reached a high level of broadband penetration through public and private sector efforts. For those that have not, government-supported telecenters will continue; while other regions will operate their own telecenters.

Challenges Facing National ICT Institutions

Thailand

Within Thailand, leadership issues and conflicts of interest have both been major impediments to policy implementation. The country's National Information Technology Committee is officially headed by the prime minister, but this position was typically delegated to a deputy minister. As a result, the ability of the Committee to develop and implement ICT policies would vary widely depending on the personal interests of the deputy assigned. Policy implementation would suffer a slowdown under deputies who were not interested, according to participants who were later interviewed. More recently, the prime minister headed the NITC himself, but was also found to have a conflict of interest – potentially steering the Committee to benefit his personal business interests.

Another major hurdle for ICT institutions and agencies in Thailand is the lack of program evaluation. ICT programs are developed by ministerial CIOs. They are evaluated only at the project level and this limited monitoring is completed in a vacuum. The focus of the evaluation work is on gathering quantitative data on hardware deployment, not on qualitative data on ICT utilization and the economic benefit of the ICT initiative. Most important, there is no overall benchmarking or evaluation effort by the government against its own master plan – an essential component to ICT strategy success (Docktor, 2004).

Although there is no overarching benchmarking or evaluation effort by the government, one avenue for monitoring and evaluation is the submission of ministry-level ICT Master Plans to the MICT and the Budget Bureau (Banerjee, 2004). These

Master Plans are developed by ministerial CIOs and mapped back to the national ICT plan for justification. However, there is no set criteria for doing this. Plans may be rejected due to political considerations or may be rubberstamped to avoid bureaucratic confrontation. When plans are reviewed, they are only completed at the project level with little connection to the government's larger efforts.

Another key component missing from the MICT's efforts is the establishment of public-private partnerships (PPPs) aimed at harnessing the expertise of the private sector and the financial support of the government to spur ICT sector development. This has been a key focus of discussion and is recognized as crucial within the ministry – particularly because neighbors such as Malaysia have successfully implemented PPPs across several technology sectors (Shapira, 2005). However, there is little activity or implementation around fostering PPPs, particularly in ICT applications. Currently, when the government implements a PPP for its e-governance programs, there is a tendency to become overly reliant on the vendor for customization or changes downstream, according to officials. This leaves government ministries vulnerable to high additional costs for these programs as their IT requirements change over time.

Malaysia

By housing ICT infrastructure programs within KTAK, Malaysia can emphasize ICT infrastructure deployments while concentrating the necessary budget and authority on implementing those policies within a single agency. However, officials with KTAK and the ministry both reported that this new institutional structure does not have the critical mass of ICT expertise that was within the original Ministry of ICT and is now spread out among separate agencies.

Although there have been many successful efforts to launch government technology initiatives, this has not been the case across all potential sectors. Interviewed officials with MIGHT suggested that in areas falling under the purview of a traditional sector ministry, such as agriculture, there have been fewer new initiatives to support private sector development and little institutional reform to be more responsive to market changes. MOSTI works in conjunction with the Economic Planning Unit, a civil service agency, to develop institutional restructuring plans for each of the other ministries. There is a review and restructuring process for reducing agency overlap, which has restructured and dismantled several agencies, most recently in 2004, to make the government more responsive to market changes. These changes were deemed necessary and supported by the prime minister to enhance governmental efforts to bolster national competitiveness. However, there is still a significant tendency for traditional sector agencies to strongly resist any governmental restructuring and revitalization effort.

Design and Implementation of ICT National Plans

This seventh part of this case study section includes a detailed examination of the national ICT policies of Thailand and Malaysia. The national plans of both countries are remarkably similar, owing much to their design based on the successful plans of Singapore and South Korea. However, the implementation and outcomes for these plans have been starkly different, with Thailand's policies hampered by a lack of funding, staffing, and evaluation. A second component closely examines these challenges facing

Thailand, as well as Malaysia, as both national governments aim to expand ICT adoption through policy intervention.

Thailand

There are three major components to Thailand's national ICT policy documents: the IT2010 Policy framework, the Master Plan 2002-2006, and individual policies of the ministries. The IT2010 policy is a framework designed by an agency within the science ministry, the National Electronics and Computer Technology Center, for the National IT Committee that outlines the broad policy goals for the country. The framework was a broad vision for the country and does not detail specific policy initiatives or designate specific ministries.

The policy effort that started in the 1980s, and that led to the ICT Master Plan, began with the Thai IT sector (Intarakumnerd, 2004). Twenty years ago, the government effort was solely focused on telecommunications and the private sector wanted to broaden the scope to include software. At the time, the nascent Thai software and IT industry wanted a long-term view of government support for the development of the ICT industry to improve investment planning and attract FDI. According to officials who drafted the original master plans, the government carefully examined the efforts already under way in Singapore and then in Malaysia for best practices in formulating their own ICT policies and institutions.

In the 1990s, the NITC worked with NECTEC to influence government ICT policy, developing what became the IT2000 plan by the middle of the decade. The IT2000 plan was a five-year road map for government policies, specifically aimed at bolstering the local Thai software industry. In addition, it also called for better access to IT networks through strengthened investment in network infrastructure, a reduction in tariffs, and other policy changes as well as a focus on improving the human IT capacity within the country. The policy was designed to accelerate the growth of the IT industry specifically as well as to enhance business and governmental productivity more generally.

The IT2000 plan succeeded in building awareness regarding the IT needs of the government and its constituents among the various ministries. Officials, who were later interviewed, worked to develop the internal capacity of the ministry through training and HR efforts while expanding ICT utilization across the government. These ministries began to set aside parts of their budget for expanding ICT access within these regions.

Building on the IT2000 policy, NECTEC developed the IT2010 policy framework. This was a 10-year blueprint for governmental ICT goals and policies. This document did not outline specific programs, metrics, or ministries for implementation. Instead, the framework was a broad overview of Thailand's efforts to develop a knowledge-based society and economy. The ICT Master Plan, based on the IT2010 framework, was the operational blueprint for the government and was to be the benchmark for the ministries in developing and coordinating their ICT budgets and programs. The plan was shortened to five years over concerns shared by Ministry of ICT officials that the 10-year time horizon of the framework was too long to accurately forecast the national ICT needs, or to formulate evaluation metrics and mechanisms that could track over that length of time.

The MICT is shifting its focus from e-governance programs to building out infrastructure to support the interconnection of government departments and facilities. The current plan calls for the incumbent players to deploy and support the network through a long-term contract. The government hopes to reduce the annual costs of network capacity through the deployment of fiber-based platforms nationally. In addition to cost savings, the government hopes this new network will boost inter-departmental communication, enhance the e-governance solutions already in place, and help drive ministries toward a common back-office IT solution over the long term.

Malaysia

The explicit goal for Malaysia's economic policy has been to develop a knowledge-based economy capable of supporting globally competitive technology sectors (Shari, 2003). Originally articulated by the prime minister in 1996, and called Vision 2020, the plan sought to implement nationwide efforts to bolster the indigenous technology innovation and capacity (Wee, 2001). This goal would be achieved through close relationships with MNCs, particularly those working in the information, communications, media, and software sectors (Shapira, 2005). This plan focused on transferring technology and expertise rather than relying on becoming a piece of the global manufacturing supply chain. In the past, Malaysia held a relatively low position within the supply chain that had left the country with little value to add within the chain or prospects for productivity gains (Lall, 1999). The Vision 2020 plan also emphasizes increasing local skills through training, expanding local suppliers through deeper linkages, and greatly enlarging the national technology infrastructure. It was hoped that outside capital and technology, along with internal adaptation and innovation, would allow Malaysia to become a developed country within two decades (Kam, 1999).

The Malaysian broadband infrastructure goals were developed in 2004 and have now become a component of a larger ICT infrastructure policy, the Malaysian Information, Communications and Multimedia Services 886 strategy (also known as MyICMS 886). This five-year strategy is named after the eight ICT services, eight infrastructure areas, and six growth areas – such as content development – that the effort will focus on. Prior to the design of this policy, the Malaysian minister of communications traveled to Korea to understand the policies and implementations of the national Korean IT839 infrastructure policies. The Korean program is focused on a similar set of services, infrastructure, and growth areas with the goal of developing ubiquitous connectivity to accelerate Korean innovation and productivity. This strategy includes both wireline and wireless infrastructure and is viewed as the key infrastructure area for driving services and growth areas.

All of the component programs of the MyICMS 886 are funded through the USF or directly by the private sector, with the exception of the government network along with the secondary and tertiary education networks, MySchoolNet and MyREN. These programs are run through a large directorate within the MCMC along with a Coordination Committee. The MCMC monitors and evaluates these private sector programs and licenses them for continued USF budgetary support.

Challenges for ICT Policy Implementation

Thailand

The policy implementation hurdles faced by Thailand have included a lack of government coordination and leadership, conflicts of interest among key officials, no program monitoring, and limited policy enforcement (Krongkaewa, 2003). From the beginning, Thailand's ICT strategy was very top-down, with programs and policies driven by government ministers rather than by the needs of the private sector. The goals set within the plan were also ambitious, particularly with a five-year time frame, and would have required careful coordination within the government to follow the national ICT plan. Instead, the various ministries used the ICT Master Plan for initial budgeting only, failing to use the plan for program design or evaluation – resulting in overlapping and siloed efforts across the ministries.

The goals set in the ICT Master Plan created by NECTEC were very optimistic about what could be accomplished under the plan over the 5 years, with programs and policies driven by the government rather than the needs of the private sector. There were also severe coordination issues between NECTEC, which was setting these difficult goals, and the recently formed MICT, which was charged with implementation. When the ICT Master Plan was designed, NECTEC had believed that it would be a major component of the new MICT – constituting the core of the MICT staff – and coordination issues were not considered a significant threat. However, when this did not occur the MICT was forced to contract the policy design work to NECTEC – leaving the government without a single organization to design, implement, and evaluate the master plan. With most ministries working on their own ICT efforts independently, this resulted in significant policy and program overlap as well as bureaucratic in-fighting against what they saw as interference from the MICT.

During the implementation of the master plan, there was a wide range of success across the ministries in deploying technologies for internal use as well as in managing ICT programs. The difference often is due to the leadership within the ministry, with success tending to rely on the personal interest of the permanent secretary and minister. Other primary hurdles include a lack of operational funding, not enough technical expertise to maintain the project, and not enough capable managers. In addition, there is no formal office staffed to implement these policies or innovative programs. According to officials at the Ministry of ICT and the Ministry of Finance, the Thai government does have a KPI system in place for government activities. However, it does not include ICT KPIs at this point. The MICT did not have the evaluation expertise or resources to fulfill this role, so there was no enforcement or monitoring system in place. These KPIs need to be added to improve the government's monitoring capabilities for ICT efforts.

With the end of the first Master ICT Plan, there is no evaluation planned by the MICT prior to developing the next iteration. Due to political and cultural considerations, evaluations are conducted strictly at the individual program level and tend to minimize failures according to government officials. With most projects deemed a success, little or no organizational learning can occur. Although detailed performance metrics for an evaluation process were laid out in the Master Plan, these are broadly defined for national progress. They do not mesh with the specific policy and program goals set within the plan.

One example from the master plan included the goal of introducing computers into each village. Evaluation and monitoring of the program was left to the MICT to clearly define PC usage at the village level. This has not been completed. There is also plenty of room to skew the results of these programs, particularly for those focused on applications and utilization. For example, although the MICT tracks the number of PCs across the various ministries, it does not study how PCs are being used or affecting productivity. More generally, the ministries will use the ICT Master Plan for initial budgeting purposes only. After this initial stage, ministries do not return to the master plan to assist with program design or benchmarking. This results in overlapping and siloed efforts across the ministries, which is exactly what the master plan seeks to avoid.

Finance and ICT ministry officials have stated in interviews that the Budget Bureau does perform some ongoing evaluation, but not at the level of detail that had been previously completed for the ICT policy frameworks by NECTEC. For ministries and their departments to receive ICT funding from the central budget, each must have its own CIO and must submit its own master plan for ministerial ICT programs and policies. The individual ministries then use this plan to design and implement their annual initiatives. Each ministry and department must submit its own plan annually to be benchmarked against the national master plan before the Budget Bureau will disperse the ministry's ICT funding from the central budget.

Under the current system, many of the goals set by the previous master plan have not been met. This suggests that the new plan will have to rely on the original plan for policies and goals, with a reprioritization based on the evolving technologies and market environment. To keep momentum from failing each time there is a shift in ministry heads, the effort should be decentralized for execution at the department level, rather than the ministerial level, but with stricter enforcement guidelines.

Malaysia

To develop KPIs for Malaysia, MOSTI followed the example of the OECD to include R&D benchmarks based on input indicators such as publications, patents, and technology balance of payments. Of the output KPIs tracked for Malaysia's programs, publications have increased significantly while patents have stagnated according to an official with MOSTI. This lack of patent applications is not necessarily due to reduced R&D investment, but rather inadequate funds set aside for patenting within the local private sector and the lengthy patent process required. Currently, the process requires three to four years for a patent, which could be reduced through increased training of patent office staff. This process could also be improved through increased support for intellectual property rights and legal support to ICT sector firms. This would require coordination across the government and local legal firms. MOSTI, in conjunction with MDeC, needs to use its KPIs and other information to educate the country on the direct benefits of the ICT strategies to sustain financial and political support.

In Malaysia, the ICT policies focus on infrastructure, industry support, and human capacity development. The Malaysian government needs to focus on accelerating innovation, increasing utilization, and diffusing benefits simultaneously to receive the full economic benefit that ICTs can have on a country (Jomo, 2003). Malaysia has taken the policy step of focusing on government interventions to ignite and support the innovation process within the country. This means working with universities, the private sector, MNCs, and non-profit organizations to bolster technology transfer, FDI, and technology training.

Conclusions

The transition from low-cost labor source within the global supply chain to international competitor is a difficult one. Thailand is currently experiencing the difficulties of making this transition and is caught between the low-cost labor of China and Vietnam, and the higher levels of expertise within Malaysia and Singapore. Many middle-income countries get trapped in between as they transition because they do not have the critical mass of technology and expertise to create centers of excellence around their ICT industries. Instead, they lose their international investment and employment opportunities to countries with cheaper labor or to those with more expertise.

ICTs can help accelerate the transition process by reducing transaction costs, increasing transparency, and enhancing links across sectors and with neighboring countries. These national efforts then bolster research and knowledge transfer, which accelerates productivity growth and helps to diffuse economic benefits. To capture these benefits of ICT adoption, a middle-income country needs a strong state intervention that supports and regulates the private sector in delivering affordable access across the country. In addition, the national government must also focus on spreading the economic benefits beyond capital while ensuring that technology and expertise from MNCs are transferred to local firms across the economy – as Malaysia is currently striving to achieve. The government has carefully crafted incentives for local and international businesses to invest in Malaysian ICT industries while demonstrating its willingness to withdraw these incentives from local and international firms that no longer meet the standards for support.

An unwillingness to cut off government support can lead to huge uncertainty and risk within the ICT market, reducing investment in the sector. This limited investment slows the process of technology innovation and utilization, hampering both supply and demand within the sector. Innovation suffers as local firms avoid the high risk of adapting newer technology to a local market that is poorly supported. A lower level of supply and innovation can in turn dampen demand, limiting the reach of ICT services to select consumers and businesses able to afford them (Mephokee, 2005). To avoid this vicious cycle of reduced investment and demand, a market must address the hurdles for utilization through coordinated public-private efforts. Reaching a critical mass of users requires such initiatives as training, subsidies, and adapting the technology to the local environment.

For middle-income countries, these cases suggest that the evolving role of the state must include coordinating across public-private actors while supporting the diffusion of technology access and its economic benefits across the country. These cases also demonstrate the importance of setting aside implementation budgets, designating agency personnel, and developing an evaluation and KPI system for feedback from agencies and target populations.

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Section 6: Discussion and Further Research

Over the past two decades, telecommunications has evolved to become an essential service for the economic development of developing countries; viewed as vital for development like clean water, power generation, and new roads (James, 2003). More recently, the goal of bringing affordable telecommunications access to each household throughout entire population, particularly those in rural areas, has become a priority among national governments and within the international community as an economic development tool (Luger, 2002). Developing countries require close coordination of private and public sector resources to reach high levels of ICT adoption (Jomo, 1997). Countries with strong coordination and institutional support have been able to harness their public-private resources to produce indigenous capacity for accelerated ICT penetration, utilization, and innovation – which, in turn, directly supports the advancement of the economy.

ICT Policy Development

A number of national efforts are currently under way to develop technology sectors and increase adoption rates in developing countries, but many of these initiatives do not have a clear understanding of their potential impact and benefit on the economy – and are therefore difficult to justify politically or economically. The stated goal of this research was to provide a set of tools for local and international policy makers and technology providers to help assess the benefits of technology initiatives while tying them to the larger issue of economic development.

For local policy makers, this research could be used to assess the best practices of other developing countries along with qualifying the benefits of their policies to help justify additional governmental programs and initiatives within the ICT sector. For international policy makers at global organizations and institutions, the model and stages of ICT adoption could help identify countries behind their peers in technological development and refine the allocation of resources to enhance the impact of the aid. For local and global technology providers, such as global carriers and ICT companies, both the model and stages of adoption could be used for decision making on investments. This research could help these companies identify the trajectory of a country that is under consideration for new or additional investment.

ICT development requires acknowledgement of societal diversity across countries and within regions. Although overarching models for deployment and utilization can be developed, these models need to be flexible enough to be tailored to the national and regional requirements of the end users. This customization of ICT deployment models is based on a country's social, historical, economic, political, and cultural environment. ICT projects that are likely to succeed will build upon existing formal and informal structures in the region. Projects that are not tailored to the society may be unsuited to meet the region's needs at launch and lack the required local support to achieve sustainability.

ICT Investment – Is It Worth It?

An important question had been whether ICT investment could be linked to productivity and economic growth. This is particularly important in developing countries, which must determine whether to allocate their resources to ICTs or to another developmental initiative, such as health or education. Gordon (2000) suggests that although the computer age has indeed brought back productivity gains to developed economies after a 20-year slump (1973-1995), it does not measure up to gains made from previous innovations. He argues that this is particularly true of the modern age of 1913 to 1972, ushered in by electricity, internal combustion, and apparently indoor plumbing.

He goes on to suggest that because the productivity gains have been concentrated largely within the computer industry itself, the greatest benefits of computerization lie in the 1990s with little or no gains to be made in the future. Gordon argues that the underlying reason for this is that computers and communication technology are delivering nothing new. Two-way communication was offered by the telephone, instant news by the radio, extension of the day by electric light, and reduced transaction costs thanks to the gas motor.

At the turn of the previous century, the inventions of gas motors and electricity existed and had been used commercially for years. However, it was not until widespread adoption and innovative methods for utilization became commonplace across numerous sectors that the economy saw sustained and impressive productivity gains. Despite the belief that 2000 represented the pinnacle of five years of ICT progress, this technology has instead experienced slow and steady process across decades rather than leaps and bounds in a few, short years.

The telecommunications revolutions started in the 1970s and will take additional decades to coalesce. I would argue that we are at the very early stages of ICT integration into the wider economy and that we have not managed to take this set of technologies and diffuse them widely enough across all sectors.

Key Questions

The following section discusses the four key questions presented in the introduction of this research. The positions on these four issues are based on the research completed for the ICT stages framework, regression model, and case studies.

What is the proper role of the state in the development, deployment, and usage of ICTs?

There is no single approach that is the state's proper role in supporting ICT adoption. As discussed in my research, the role of the state is ever-changing and differs widely across countries depending on their network infrastructure, market environment, geography, and overall economy. Despite this wide variation, it is still important to note that developing countries that have had sustained success in their ICT adoption rates have also had a strong role for the government. In most cases, a developing country's ICT sector needs to be led by the private sector. However, ICT deployment cannot be done without strong government regulation and either direct or indirect financial support.

Without this level of government participation in the sector, the challenges of an unstable environment can severely limit investment and competition.

As countries shift their policies away from universal service and toward ICT innovation, the role of the state must evolve further. Public-private collaboration is key for innovating and customizing ICTs for domestic use, which is essential to increasing adoption within developing countries. Relying too heavily on international technologies, content, and applications will hamper utilization because these ICTs will not be tailored to the local environment. To create clusters of ICT firms capable of competing globally – as South Korea, Singapore, and Taiwan have accomplished – developing country governments must build strong institutions that can coordinate closely with the private sector. The process of research, development, and commercialization is difficult for any country, including developed economies. Developing country governments must take an active role to support the process while allowing the private sector enough flexibility to thrive.

How does the state's role evolve as a developing country transitions toward a more advanced ICT sector and overall economy?

The government plays a vital role in the deployment of ICT infrastructure and the development of ICT-related industries. As stated above, this role is constantly evolving to match the changing demands of the sector and shifts in technology options. The deployment of infrastructure may have a government fill several roles simultaneously, from directly running municipal networks to offering indirect subsidies to carriers for deploying national ICT infrastructure. Although these efforts require significant resources and institutional support, they still do not require the same level of effort as ICT-sector development.

As the technological capabilities of local firms and ICT providers become more advanced, governments must transition to a secondary role within the sector while simultaneously providing a more complex set of policy supports. This can include a range of public-private R&D efforts, the creation of a technology park like Malaysia's MSC, or providing venture capital to technology start-ups. All of these efforts can support the development of clusters of innovative ICT firms. However, they require significant budget and resources, and policymakers must choose from a wide array of policy options for effort.

Those initiatives listed above also necessitate strong institutional structures to implement and maintain these efforts, requiring a significantly higher level of governmental response than was seen when the government had the primary role as monopoly operator in the sector. As a result, it is a real policy challenge for both developing and developed country governments to be nimble enough in adapting to the changing domestic ICT sector and global technology market, while giving the private sector enough flexibility to pursue many different technology avenues instead of following government-led ICT decisions.

What are the determinants for the successful implementation of a national ICT policy within developing countries?

The development of a national ICT institution within a developing country assists in creating a critical mass of expertise and funding capable of implementing complex sector support policies that are necessary for accelerating adoption rates. As discussed in the case study section, there is a great deal of cross-border influence between national governments – including Malaysia, Thailand, and Singapore – in the design of these institutions. However, although creating an institution or national ICT policy based on international best practices is a necessary step, it is not sufficient to ensure successful implementation. In Thailand, the government has experienced difficulties in funding, implementing, and evaluating ICT policies due to a weakness in its institutions and instability in its political environment.

Once an ICT institution has been created, the government must set a clear national goal for ICT adoption and innovation that incorporates input from the private sector. This public-private coordination can assist in designing policy goals that are feasible (a problem in Thailand) but also target the most appropriate regions and sectors. This cooperation can also help ensure that the policy or initiative is designed to fill a gap left by the market or by other public sector efforts, avoiding policy overlap and competing initiatives. The necessary budgeting and authority must be given to the government ministry to ensure that program monitoring and evaluation are completed regularly.

Only after these national goals and policies have been set should the ICT ministry determine the most appropriate technology options to fit the needs of residents and domestic firms. These technology deployments should also offer an attractive environment to foreign companies, while avoiding the trap of placing the ICT requirements of these MNCs above the needs of domestic users. Allowing the needs of MNCs to influence national ICT goals and policies too heavily can lead to limited ICT diffusion in developing countries, particularly to rural or low-income areas.

What are the major impediments facing developing countries as they attempt to accelerate the adoption and utilization of ICTs?

One of the largest hurdles facing many developing countries, including Thailand, is the creation of a regulatory regime that is politically independent and a privatized monopoly operator that does not hamper competition. The creation of a regulatory agency and the privatization process are the foundation for all other ICT policies, including universal services programs, competitive market regulation, and ICT cluster development. If these two foundational reforms are not completed or become too heavily skewed by the political process, the resulting market conditions will hamper ICT adoption dramatically. This was the case in Thailand, which saw its ICT adoption rates stall. But similar challenges have plagued the US, which has seen its broadband market become a global laggard thanks in part to the weaknesses of the Telecommunications Act of 1996.

Another significant challenge for developing countries is their lack of ICT infrastructure, particularly in low-income countries that do not have the necessary networks to support rapid ICT adoption. This lack of a network infrastructure can become self-reinforcing, as the poor infrastructure leads to poor services, and residents postpone adoption until utilization reaches a minimum threshold due to network effects. This can further dampen demand and starve networks of needed investment for improvements and expansion. Poor infrastructure can also translate into a lack of local technological expertise, limiting the ability of operators, firms, and residents to utilize ICTs. With low levels of domestic ICT expertise, developing countries may find it difficult to support a domestic ICT industry or the creation of local content. In turn, this can hamper ICT adoption by limiting the availability of technology, content, and applications tailored to the local environment.

Further Research

Although this research covers a wide range of topics within the area of ICT diffusion, several opportunities still remain for additional study in the area of institutional development and ICT adoption in developing countries. The section below offers some initial thoughts on topics and methods that could be utilized for additional study in all three of these sections: the stages of ICT adoption, the global model, and the two national case studies.

Stages of ICT Adoption Framework

The section devoted to exploring the stages of ICT adoption attempted to span the range of key issues that determine the success or failure of ICT adoption efforts in developing countries. Although many of these issues were examined in detail, there is opportunity for further study of some of these topics within each of the stages. One of these areas includes studying the ICT policies of individual developing countries over their five stages of adoption. Tracking the policies of a single country across the stages would help clarify the evolution of the state's role in the ICT adoption process. The other area of further study includes examining the institutional structures of additional developing countries to determine the pattern of structural changes in more granular detail. This would include countries at all five stages and explore the shifting institutional structure as the developing country government shifts from centralized to decentralized participation in the ICT sector.

Regression Model

Although the fixed effect model is one of the most common approaches to estimating the correlation between economic, social, and other factors and ICT adoption, there are several other methods that can be explored in additional research. A number of telecommunications diffusion models track the penetration rates both across countries and within them, using a generalized Bass model. This model helps account for the non-linear take-up rate that exists in technology adoption, including ICTs. ICT adoption can go through several phases in these models, reaching early adopter, mass market, and then late adopter penetration – with the total penetration rate for the country shaped as an s-curve. Several previous ICT studies used modified Bass models and can be used as a foundation for further study.

Another option for this model that will be assessed is to use 2-Stage Least Squares to assess the impact of institutional and market factors on three ICT indicators: internet access, mobile subscribers, and fixed lines. This would allow for the Internet penetration equation to include ISP competition, PC penetration, and fixed line penetration in addition to the economic and social control variables. For fixed lines and mobile phones, population density and an independent regulatory agency would become key indicators.

A third option is to adopt the economic development convergence models as a foundation for understanding the ability of developing countries to quickly catch up to developed country ICT penetration rates. Based on the economic theory that countries will converge over time, this model has been used to study firm-level development within and between countries across time. Using this approach for cross-country ICT adoption, the model would use the institutional and policy factors. The intervention will begin the process of convergence and then use economic and social metrics as structural limitations that will determine a country's new converged state.

Case Studies

Although it may certainly be time consuming, additional developing country case studies would be beneficial for this research area. One approach would be to complete another round of interviews in Asian countries that have a larger variance in their ICT adoption rates, policies, and institutions. This variance in ICT adoption would offer a larger range of economic development levels among the study countries, allowing me to study in more depth the influence of economic development on evolving ICT policies and institutions. This would allow for a more detailed framework and description of the stages of adoption as well. In addition, because the study countries would still be in Asia, further research could be completed on the policy influence between countries. This would build on the research from this study, which found significant cross-pollination among Thailand, Malaysia, and Singapore in their design of ICT policies and institutions.

Finally, one of the most interesting results from some of my cross-country models was the negative correlation between ICT adoption and FDI as well as with trade. This fits with the theory that FDI and trade can begin to have a detrimental effect on the technology choices of a developing country. However, this area has not been explored thoroughly in the literature. This topic would lend itself to a case study approach, which could clarify the influence MNCs and FDI have on the choices made by government agencies, firms, and other technology buyers in developing countries. This issue also could use extensive quantitative study to determine the thresholds where additional FDI or trade have a negative relationship with ICT adoption. The interaction term between FDI and GDP per capita also suggests that there are GDP per capita thresholds where FDI becomes less of an influence on ICT adoption. Understanding the contours of these relationships between ICTs, trade, FDI, and GDP per capita would be a valuable contribution to the literature.

Section 6: References

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Appendix A: Completed Interviews

Thailand

Organization	*Topics Covered*
Competitive fixed line carrier	Broadband deployment plans, national licensing reforms, competitive landscape
Competitive mobile phone operator	Interconnection charges, regulatory structure, market structure, international mergers and acquisitions, 3G infrastructure, mobile enterprise applications
Kenan Institute Asia	Political trends, telecommunications sector structure
Ministry of Finance	Privatization process, state-owned enterprises, regulatory structure, program budgeting and evaluation
Ministry of ICT	E-governance programs, institutional reform process, agency budgeting, program monitoring
Ministry of ICT (MICT)	ICT market's competitive structure, governmental supported training programs, design of upcoming ICT master plan
National Electronics and Computer Technology Center (NECTEC)	Institutional structure, institutional reforms, international investment, ICT master plan
National Telecommunications Commission (NTC)	Regulatory structure, universal service obligation, regulatory reform process, broadcast services reform, privatization process, market competition, international best practices for regulation
Satellite operator	Rural access, broadband data services, international connectivity costs, terrestrial fiber, wireless competition
Software Industry Promotion Agency	ICT master plan design and implementation, training programs, international traffic constraints
Thailand Development Research Institute (TDRI)	Regulatory structure, privatization process, interconnection, mobile wireless sector
United States Agency for International Development (USAID)	Political structure, telecommunications training, e-governance programs

Malaysia

Organization	*Topics Covered*
Competitive mobile carrier	3G licensing and services, market competition, international and regional expansion
Fixed line operator	Broadband deployment plans, Internet access demand, competitive landscape, metro fiber deployments
Malaysian Communications and Multimedia Commission (MCMC)	Regulatory structure, reform process, universal service obligations, market competition, broadband services
Malaysian Industry-Government Group for High Technology (MIGHT)	Institutional structure, public-private partnerships, technology licensing, program budgeting, global supply chain
Ministry of Energy, Water and Communications (KTAK)	Institutional structure, reform process, Singaporean model, national broadband deployment goals
Ministry of Finance	Privatization process, program budgeting, ICT program monitoring
Ministry of Science, Technology, and Innovation (MOSTI)	Program evaluation, key performance indicators for ICT initiatives, technology policy reforms, global best practices for ICT policy design
MOSTI (second interview)	National ICT deployment plans, institutional structure, telecenter deployment and redesign, broadband infrastructure for educational facilities
Multimedia Development Corporation (MDeC)	Technology policy, institutional structure, reform process, cross-border cooperation
MDeC (second and third interviews)	Multimedia Super Corridor, state-level funding for additional technology parks, governmental interventions to bolster economic spillovers
United States Agency for International Development (USAID)	Political structure, telecom market structure, e-governance programs

Appendix B: Question Set

- What are the goals of the national ICT policies? Do they include increased adoption, innovation, training, or others?
- What regional area do the national ICT policies cover? Will this change in the foreseeable future?
- What prompted the development of national ICT policies? Who was involved?
- What types of organizations are currently supporting the ICT policies? How do you see that changing?
- What organization/institution currently leads and coordinates the national ICT strategy?
- Who are the important stakeholders that have supported national ICT policies?
- What services does the partnership offer to local residents and citizens?
- What organizational, cultural, or social barriers have been encountered with these policies?
- What have been the most important hurdles faced by the ICT strategy? How have/are they being addressed?
- What are the major economic, political, and regulatory restrictions on the activities of national ICT strategy that have been faced, if any?

- Where does the national ICT strategy receive its funding? What is the current budget? How will that change in the next one to two years?
- Have there been any issues with low demand for services? Have there been issues of support from the private sector? How does the national ICT strategy raise awareness of its activities?
- How is the lead institution working to ensure sustainability of the national ICT strategy?