I, Kenneth Koech Cheruiyot Ph.D., hereby submit this original work as part of the requirements for the degree of Doctor of Philosophy in Regional Development Planning.

It is entitled: The Geography of the Intra-National Digital Divide in a Developing Country: A Spatial Analysis of the Regional-Level Data from Kenya

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The Geography of the Intra-National Digital Divide in a Developing Country: A Spatial Analysis of Regional-Level Data in Kenya

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of the University of Cincinnati

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By

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ABSTRACT

It is widely agreed that different technologies (e.g., the steam engine, electricity, and the telephone) have revolutionized the world in various ways. As such, both old and new information and communication technologies (ICTs) are instrumental in the way they act as prerequisites for development. However, the existence of the digital divide, defined as unequal access to and use of ICTs among individuals, households, and businesses within and among regions, and countries, threatens equal world, national, and regional development.

Given confirmed evidence that past unequal access to ICTs have accentuated national and regional income differences, the fear of further divergence is real in developing countries now that we live in a world characterized by economic globalization and accelerated international competition (i.e., New Economy). In Africa and Kenya, for instance, the presence of wide digital divides – regionally, between rural and urban areas, and within the urban areas – means that their threat is real.

This research, which employed spatial analysis and used the district as a geographical unit of analysis, carried out a detailed study of ICTs’ development potential and challenges in Kenya. It addressed the following questions: (1) What is the extent of the intra-national digital divide in Kenya? (2) What are the factors that determine Kenya’s intra-national digital divide? and (3) How can the intra-national digital divide be substantiated using regional-level data? The research obtained socio-economic, infrastructural, and geographical data.

Using descriptive, concentration, and spatial modeling techniques, the results indicate the presence of marked spatial digital divides as measured by the number of telephone connections and the number of Internet cafés in Kenya. These measures correspond with “old” and “new” digital divides, respectively. Spatial regression results showed lack of significant spatial
dependence in the “old” digital divide and presence of significant spatial dependence in the
“new” digital divide. Interpretation of regression results discusses the significant determinants of
Kenya’s intra-national digital divide. These determinants include broadly socio-economic,
infrastructural, and geographical variables. Further evidence identified roughly that telephone
and Internet clustering in the country mirror the existing pattern of economic development. This
means that the role of deliberate government policies in guiding ICT-related development
towards convergence is paramount.
DEDICATION

For my wife, Roselyne, my daughters Chebet and Cheptoo, for their untiring sacrifice during the long duration of my doctoral studies, and my parents.

I will always love you all.
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However, all errors and omissions are mine alone.
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<tr>
<td>ARCC</td>
<td>African Regional Computing Center</td>
</tr>
<tr>
<td>BPOs</td>
<td>Business Processing Outsourcings</td>
</tr>
<tr>
<td>CAD/CAM</td>
<td>Computer-Aided Designs/Computer-Aided Machines</td>
</tr>
<tr>
<td>CCK</td>
<td>Communication Commission of Kenya</td>
</tr>
<tr>
<td>CIDCM</td>
<td>Center for International Development and Conflict Management, University of Maryland, College Park, Maryland</td>
</tr>
<tr>
<td>FDI</td>
<td>Foreign Direct Investment</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
</tr>
<tr>
<td>ICT4D</td>
<td>ICT-for-Development</td>
</tr>
<tr>
<td>ICTs</td>
<td>Information and Communications Technologies</td>
</tr>
<tr>
<td>ISP</td>
<td>Internet Service Provider</td>
</tr>
<tr>
<td>ITP</td>
<td>Index of Technological Progress</td>
</tr>
<tr>
<td>ITU</td>
<td>International Telecommunications Union</td>
</tr>
<tr>
<td>Kbps</td>
<td>Kilobytes per second</td>
</tr>
<tr>
<td>KIPO</td>
<td>Kenya Industrial Property Office</td>
</tr>
<tr>
<td>KP&amp;TC</td>
<td>Kenya Posts &amp; Telecommunications Corporation</td>
</tr>
<tr>
<td>KES</td>
<td>Kenya shillings</td>
</tr>
<tr>
<td>LDCs</td>
<td>Least Developed Countries</td>
</tr>
<tr>
<td>LLOs</td>
<td>Local Loop Operators</td>
</tr>
<tr>
<td>MCTs</td>
<td>Multipurpose Community Telecenters</td>
</tr>
<tr>
<td>MIPS</td>
<td>Millions of Instructions per Second</td>
</tr>
<tr>
<td>NTIA</td>
<td>U.S. Government National Telecommunications and Information Administration</td>
</tr>
<tr>
<td>NICs</td>
<td>Newly Industrialized Countries</td>
</tr>
<tr>
<td>OECD</td>
<td>Organization for Economic Co-operation and Development</td>
</tr>
<tr>
<td>PDNOs</td>
<td>Public Data Network Operators</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>Research and Development</td>
</tr>
<tr>
<td>SMS</td>
<td>Short Text Message</td>
</tr>
<tr>
<td>SSA</td>
<td>Sub-Saharan Africa</td>
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<tr>
<td>TFP</td>
<td>Total Factor Productivity</td>
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<tr>
<td>TNCs</td>
<td>Transnational Corporations</td>
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<tr>
<td>UNCRD</td>
<td>United Nations Center for Regional Development</td>
</tr>
<tr>
<td>UNDP</td>
<td>United Nations Development Program</td>
</tr>
<tr>
<td>VoIP</td>
<td>Voice over Internet Protocol</td>
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<tr>
<td>VSAT</td>
<td>Very Small Aperture Terminal</td>
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<tr>
<td>WAP</td>
<td>Wireless Application Protocol</td>
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CHAPTER I: INTRODUCTION

It is widely agreed that rich and poor countries differ in many ways. For instance, poor countries are pitted against their rich counterparts that have the “leisure time and resources to buy new technologies and have the education and opportunity to become skilled in their use.” ¹ In the meantime, poor countries are “forced to wait until the price is reduced to make access possible” (Stanton 2004, 1). Thus, the role that the divide in adoption and/or investments with respect to various past technologies (e.g., the steam engine, electricity, and the telephone) has played in widening disparities cannot be overemphasized.

Currently, newer technologies – information and communication technologies (ICTs) – continue to revolutionize the world economy. Castells argues that ICTs are the functional equivalent of electricity in the industrial age (1998). The Internet, in particular, in its ability to distribute information throughout the realm of human activity, acts as a pre-requisite for economic and social development in our time, and is comparable to what both the electrical grid and the combustion engine provided in the industrial age. Also, as electricity, as a new technology of energy generation and distribution, made possible the factory and the large corporation during the industrial society, the Internet is the technical basis for the organizational form of the information age (Castells 1998). Meng and Li add that the Internet, a product of the convergence of information and communications technologies, and its widespread application is believed by some scholars to be the dawn of the third industrial revolution, comparable to the role played by the internal combustion engine and the railroad in the second industrial revolution (2001). Following this, Akca, Sayili, and Esengun assert that if countries ever want to benefit in

¹ The continued differences in the adoption and/or investments in ICTs mirror differences that have historically existed between socio-economic classes and their ability to access new technologies.
the emerging competition in the New Economy, then they must use information technologies in every sector of their economies (2007).²

This research investigates the geography of the digital divide in Kenya using regional-level (i.e., district) empirical data. It is guided by the argument that, since past infrastructure investments led to persisting regional and national development problems, the fact that present-day infrastructures (i.e., modern ICTs) are likely to cause more divergence, warrants research that will clarify the nature of the situation and thereby enable the formulation of appropriate interventions. This chapter will present the problem statement, rationale for the study, the research questions, organization of the various chapters in the study, and define key terms.

A. The Statement of the Problem

The presence of the digital divide, defined as an unequal access and use of digital technologies among individuals, households, and businesses within (and between) regions and countries, poses a threat to balanced world development. Digital divides exist at various geographical scales: global, intra-national, and intra-metropolitan. A global digital divide can be understood using different comparative proxies. The digital Lorenz curve plot of Internet connectivity (subscriptions per capita) versus percentage of total population connected to the Internet (Dasgupta, Lall, and Wheeler 2005), the Index of Technological Progress (ITP),³ and the World Gini Coefficient for Technical progress (Rodriguez and Wilson 2001) are key examples. Other indicators are the ratio of millions of instructions per second (MIPS) estimates as measures of ICT capacities (Roche and Blaine 1997), the ratio of regional ICT expenditures to the global

² Citing Gul, Mutlu, and Bal (2004).
³ It shows a source of variation as a composite of five indicators of technical inputs (i.e., personal computers, Internet hosts, fax machines, mobile phones, and televisions).
expenditure on informatics (Hanna 1991), and the ratio of Research and Development (R&D) expenditures to national expenditures (Pohjola 2003).

Intra-national digital divides exist in both developed and developing countries. Attempts at narrowing the gap and thereby achieving universal service (or access) provision, have been undertaken through state monopolies and subsidized revenue pools from profitable services. Nevertheless, several factors have stood in the way of realizing universal service (or access) provision. These include inadequate telecommunications infrastructure, lack of awareness of the benefits of ICT use, high prices of both initial infrastructure investments and services, a relatively less-educated community or population, the high cost of rolling out services due to a dispersed population, and the predominance of low-income households, all of which exacerbate affordability concerns (Madden and Coble-Neal 2003). In the United States, disparities are visible between states, metropolitan areas, and races. Warf notes that five states (California, Texas, Virginia, New York, and Massachusetts) and five metropolitan areas (San Francisco, Dallas, Chicago, New York, and Washington/Baltimore) contain one-half and one-third of all Internet hosts in the United States, respectively (2001). Similarly, across states, computer ownership (a prerequisite for accessing the Internet) ranged from a high of 55% in Alaska to a low of 20% in Mississippi in 2001.

An examination of Kenya’s fixed line telephones shows a concentration in urban areas. That is, the average ratio of urban to rural fixed lines for the 11 years reviewed (1999 – 2009) is equal to 22. Explained by several socio-economic factors (e.g., population and incomes), the above ratio shows very little variation over the years except for the years 2008 and 2009. In these two years, rural fixed lines connections show a sharp decline. Kenya’s experience is also prevalent in other developing countries. Thus, the potential of ICT adoption and diffusion to
widen ICT-related disparities within urban and between urban and rural areas in developing countries is cause for alarm. The expected clustering of adopters and users in urban areas with the hope that diffusion will follow, through spillover effects into the periphery due to work, school, or family ties, may be misleading or have mixed results (Baliamoune-Lutz 2003). This is evident in how the effects derived through this “process” are varied and unequal. To the extent that ICTs broaden existing trends between the ICT haves and ICT have-nots, ICTs can contribute to a number of social problems, including skewed economic outcomes and enhanced risk of social and political conflict (Rodriquez and Wilson 2000). For instance, Meng and Li have observed skewed regional development across the Chinese territory as a result of difference in the “degree of informatization” and uneven ICT investment and use (2001).

Graham, by denouncing the “death of distance” or the “end of geography” as being unreal, further notes that ICTs affect cities unevenly at all scales. He gives the following four reasons for why ICTs are responsible for the intensification of urban polarization: extending the power of the powerful, intensifying unevenness through tying together international divisions of labor, allowing socio-economically affluent groups to selectively bypass the local scale, and causing cultural and economic biases, especially in terms of the international marketplace (2002, 36).

Alarmed by the above scenarios, but informed by our understanding that ICTs continue to assume a greater foundational role in our societies’ and economies’ achievement of specific social and economic development, the threat to those citizens, who for one reason or another, are denied the option to participate in the New Economy is unacceptable (Wilson 2004). The possibility of worsening unequal access to ICTs and the bequeathing of “backwash effects” to the have-nots through the self-reinforcing process of continuous change (in line with Myrdal’s
theory of cumulative causation) have advanced the need to address the various digital divides.\(^4\) Such efforts aimed at achieving convergence in access to digital technologies must address the (looming) widening of incomes between and among individuals, households, businesses, regions, and countries of the world. Many scholars argue that more attention needs to be paid to this issue to ensure that the vulnerable majority (i.e., residents of developing countries and disadvantaged groups within countries) is not left behind in the New Economy. Unless this is done, what is now observed only as an Internet-access divide may turn into other divides, the latter with severe results (Rogers 2001; Castells 2001; Servon 2002).\(^5\) While it is worthwhile to study all the above-named major types of digital divides, this research will address the intra-national digital divide in Kenya by employing spatial analysis on regional (also district) empirical data.

**B. Justification of the Study**

To date, most of the existing literature on ICT adoption and use in developing countries has focused on the macro-scale. That is, previous studies in least developed countries (LDCs) have focused on cross-sectional investigation between countries, limited time series investigation within countries, and have been political in orientation. This means that meso, and better still, micro-level substantial investigations are required to obtain convincing results (Wilson 2004; Buskard 1999; Nyaki 2001; Barzilai-Nahon 2006, 271). In fact, Baliamoune-Lutz suggests that it may be more interesting to explore whether spatial inequalities (e.g., rural versus urban, or coastal versus inland areas) may have an influence on ICT diffusion (2003, 157).


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\(^4\) With respect to different digital divides.

\(^5\) Simply put, the present-day infrastructures (i.e., modern ICTs) are likely to cause more divergence in the accruing socio-economic benefits.
Dryburgh for Canada (2001), Nunes for Portugal (2004), Lopez and Curra for Spain (2004), Mariscal for Mexico (2005), Meng and Li (2001) and Wensheng (2002) for China – have focused on the intra-national digital divide. With the exception of Bonaccorsi, Piscitello, and Rossi (2005) and Grubesic (2008, 2004, and 2002), most of these studies have not employed spatial analysis techniques. Besides, the Bonaccorsi, Piscitello, and Rossi and the Grubesic studies have focused on the developed world. With this in mind, this study focuses on a specific country and carries out a detailed study of ICT development potentials and challenges at a regional level within that country (Kenya). In other words, this research argues that to explore and understand the true potential of ICT in regional development, a micro-level investigation (in this case, Kenya’s intra-national or regional digital divide) is required.

It is expected that this study will contribute to regional empirical and policy analyses of the ICT sector, especially in setting benchmarks for future studies – not only in Kenya but also in other developing countries with comparable economic profiles – in the New Economy. So far, several studies in Kenya have either focused on the national or aggregate, sectoral (Oyeleran-Oyeyinka and Adeya, 2004), telecenter case study (Evusa 2005), or on small- and medium-size enterprises (SMEs) (Moyi, 2003; Chogi, n.d.; Adeya, 2001; Waema, 2007). None of the existing studies have focused on regional differences in access and use of ICTs in detail as this research will. Thus, this study will shed light on how the intra-national digital divide relates to regional development by running multivariate statistical analysis on regional (also district) data.

C. Selection of Study Area

In Figure 1.1, the location of Kenya at the global and regional level is shown. Kenya, an East African country, covers a surface area of 582,664 square kilometers. With varying
topography and physical conditions (e.g., temperatures and rainfall), only 20% of the Kenyan land has high to medium agricultural potential. The rest of the country is arid or semi-arid. This geography has shaped the pattern of economic development in the country. Areas such as the wet belt along the Indian Ocean, western Kenya just east of Lake Victoria, and regions coinciding with the main mountain ranges have witnessed concentrated development vis-à-vis other regions of the country. Demographically, Kenya’s population is about 36 million people at present (Government of Kenya 2007). With this population predominantly rural and characterized by high growth rates (over 2.7%), far-reaching implications for Kenya’s development options are numerous. These include increased pressure on land and other resources, high unemployment, and enormous demand for social services (Alila 2000).

In Figure 1.2, Kenya’s capital city and other major urban areas are shown. The figure also shows the country’s major roads and railway network. The railway line, the oldest major infrastructural development, was constructed beginning in 1896 at Kenya’s port city of Mombasa, and stretched towards Nairobi and western Kenya en-route to Uganda. This historical development has largely influenced the pattern of development in the country. As a result, all the major urban areas, ports, and other infrastructural developments like roads, telephone, and the electricity grid lines have developed in line with the railroad. Thus, besides being a developing country, the study area qualifies as a feasible site given the way past infrastructural developments have resulted in the persisting current regional development problems. This calls for supporting research. Figure 1.3 shows the 66 districts used in the study.
Figure 1.1. Kenya in the global and the regional context. 
Figure 1.2. Kenya's major urban areas, roads, and railway network.
Source: Author 2009.
Figure 1.3. Kenya's 66 districts used in the study.

Source: Author 2009.

Note: District listing exclude 34 and 45.
D. Research Questions

This research, guided by the argument that mixed results have stemmed from infrastructure investments in the past, hypothesizes that the persisting mixed results will be heightened in Kenya and other developing countries in the present ICT-dominated New Economy. It thus set out to answer the following specific questions:

- What is the extent of the intra-national digital divide that exists in Kenya?
- What are the key factors that determine the intra-national digital divide in Kenya?
- How can the intra-national digital divide be substantiated using regional-level data?

E. Organization of the Remainder of the Study

The research is organized into six chapters. Chapter I introduces the research problem, describes the significance and scope, and the research questions as well as outlines how the various chapters are organized. Chapter II synthesizes the existing literature on the meaning of regional development and the impacts of ICTs on regional development. The chapter also covers the meaning and role of technology, in the general sense, and ICTs, in particular, on economic development. Chapter III further synthesizes the existing literature by focusing on ICT development and the digital divides in Africa and in Kenya. Chapter IV reviews methodological literature on the digital divide and outlines the strategy the research employed in collecting and analyzing data. Chapter V describes the results of the spatial digital divide in telephone and Internet diffusion and related discussions while, lastly, conclusions, recommendations, and implications for further research are advanced in Chapter VI.
F. Definition of Key Terms

*Information and communication technologies (ICTs)* are the set of activities that facilitate the processing, transmission, and display of information by electronic means (Rodriguez and Wilson 2001). Broadly, ICTs include information technology (e.g., computers), communication technology (e.g., fax, mobile, phones, e-mail) and electronics in manufacturing and/or service activities (e.g., Computer Aided Designs) (Narayana 2005).

*Leapfrogging* involves “the implementation of a new and up-to-date technology in an application area in which at least the previous version of that technology has not been deployed” (Davidson, Sooryamoorthy, and Shrum 2000, 2). This means that new technology assimilates faster by switching from the old without necessarily replacing the existing capital stock or beginning from nothing. In this research, leapfrogging is used within the context that countries on the political and economic periphery of the world usually join at a later stage (Eko 2004).

*New Economy* is concerned with the economic, organizational, social, and geographic impacts of modern ICTs including the Internet and World Wide Web (Engelbrecht 2002). Broadly, these incorporate ICT production and ICT-using sectors that are characterized by an increased flow of goods, services, capital, and ideas (O’Rian, Parthasarathy, and Zook 2004).
CHAPTER II: INFORMATION AND COMMUNICATION TECHNOLOGIES AND REGIONAL ECONOMIC DEVELOPMENT

A large body of existing literature shows that the period following the Second World War heralded efforts towards addressing development challenges among and within countries. As a result, regional development has been used as one of the approaches intended to bring convergence in economic development. To get a clear understanding of these efforts, this chapter synthesizes the existing literature on the meaning of regional development (as a development dilemma), reviews key regional development theories, and regional development experiences in Kenya. Finally, it explores the role of technology, in general, and ICT, in particular, on economic development. The latter review is important in teasing out the potential and challenges Africa and Kenya face as they adopt ICTs as development tools.

A. Regional Economic Development

1. What is a Region?

Literature shows that the term region, referred as a spatial area, is used with a great variety of meaning. Harris underscores three ways of how regions are delimited or defined. These are (a) arbitrary regions as defined by authors or some agency to suit a particular purpose or use, (b) uniform or homogenous regions, which are essentially characterized by a similar economic feature, such as type of production, and (c) regions of organization or nodal regions, which is unified by contact or movement through or with a central point (1964). Importantly, he adds that the definition of the preceding regions has a single basis – all locations within the region have properties in common, for example, political/administrative, economic, or socio-cultural relations.
In regional development planning, Friedmann argues that uniform or homogenous and
regions of organization or nodal regions identified above are relevant. He shows that
superimposing the above-named types of regions leads to the identification of five development
regions. These regions are (a) core regions characterized by their high promise for economic
growth, (b) upward-transitional regions including all settled regions whose endowments and
location relative to core regions suggest the possibility of a greatly intensified use of resources,
and (c) resource frontier regions are zones of new settlement in which virgin territory is occupied
and made productive. Others regions are (d) downward-transitional regions which are old,
established settlement regions whose essentially rural economies are stagnant or in decline, and
(e) special problem regions, regions that because of the peculiarity of their resources or location
demand a specialized development approach (1966). A mosaic of interdependencies intertwines
all these regions.

Perroux pointed out that incorrectly defining what a region is means that that any efforts
made towards formulating policies and drawing plans will be self-defeating. He asserted that a
region or “space” (as he called it) should not be defined as a “container” holding a specified
group of people (“the contained”) but as “an abstract economic space, spaces as “field of force”
or as space defined by “a plan or as homogenous aggregate” (Higgins and Savoie 1995, 90).
Implicitly, economic space could include a field of forces scattered around a “larger territory of
common concern of a functioning pattern of human settlements, which has the greatest
opportunity to match problems and potential with resources” (Sweet 1999, 10). In turn, such
accurate definition ensures that the desired growth and development is achieved within the
region, since the regional economy functions effectively in reducing governmental barriers, and
improving its housing stock, education, environment, infrastructure services, and web of
communication (Sweet 1999, 24; Melanie 2004, 35). In a globalized world, where competitiveness and mobilization of a region’s endogenous resources are paramount, the importance of the preceding cannot be overemphasized.

Regions can be of different scales – local, sub-national, intercontinental, or global. Traditionally, the definition of regions, as used in regional development planning, has changed over time. For instance, in the early years of regional development theory, regions were defined primarily by natural resources or administrative or political boundaries within national boundaries. At that time, factors of production (i.e., labor and capital) were less mobile across national boundaries, thus requiring the formulation of regional policy to fit the status quo. However, in the recent past, and especially with the reinvigorated globalization, the definition of a region has evolved to reflect the changing reality. For example, compared to the past when borders inhibited cross-border developments, new regions described by cross-border or trans-national developments have evolved. These regions represent a “continuum of development” transcending two or more national boundaries. In these regions, political reasons that hitherto limited the definition of regions within national boundaries have given way to economic reasons as the primary drivers in defining regions. In the literature, cross-border development between Arizona, USA, and Sonora, Mexico, is an example of these new regions.6

2. The Meaning of Regional Development

Regional development, especially in developing countries, as a discipline, began after the Second World War. Its beginning was a response to the persisting presence of spatial and regional disparities between nations, sub-regions, and local areas amidst substantial economic

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growth. Accordingly, regional development aims at bringing social change through the formulation of economic growth and development policies within any of the above spatial scales. The desired social change is the equal distribution of economic welfare among all regions and citizens in line with equity and egalitarian principles. And, to achieve the desired social change in any given situation, the formulation of regional development policies should capitalize on the region’s existing comparative advantage. For instance, in countries where the mainstay of the economy is still agriculture, any regional development policy should aim at optimizing the benefits that accrue from that sector. Primarily, an appropriate regional development policy should make the sector self-sustaining in terms of generating income and surplus, if possible.

Regional development has been implemented in different ways: locational programming of investments within a sector, creating development agencies, setting up physically defined resource base authorities (e.g., river basin authorities), and adopting decentralization or growth center strategies (Gore 1984, 1). Benefits are expected to accrue from the following: the employment of factors of production in view of comparative advantage, generation of economies of scale because of expanded markets, stimuli for investment, and better utilization of economic resources and enjoyment of multiplier effects, among others (Lawrence and Thirtle 2001, 110).

In the past, areas that have undergone deliberate government-led regional development have experienced mixed results. For instance, even distribution of incomes has been partially achieved, as anticipated; rural out-migration has not been fully capped; dependencies persist; and so forth. A number of bottlenecks can explain these shortcomings. They include: population and land pressures, inadequate physical infrastructure, poor information gathering and dissemination, limited markets for products, and remnants of the negative effects of structural adjustment.

3. **Overview of Key Regional Economic Development Theories**

This section gives an overview of key theories that address the question: how do regions grow? In the literature, three broad categories of theories addressing the question of how regions grow are distinguishable. These are theories of regional economic convergence, theories of regional economic divergence, and structural theories of regional economic development.

a. **Theories of Regional Economic Convergence**

Export base theory, formulated by North, explains the historical economic development of the United States (1955). The theory is applicable equally to regions that have grown within capital institutions and without the strictures imposed by population pressures. It argues that regional growth is a function of exogenous demand for regional products. The theory describes two types of industries – basic and non-basic industries – that make the regional economy. Between the two types of regional industries, the basic industries are important in determining the growth of the region’s export sector, without which the region will not grow. The external demand for the region’s products affects regional growth through the export multiplier. Depending on the size of the export multiplier, the growth in the regional economy as measured by regional employment and incomes in the region’s export sector, similarly changes. While the basic industries determine the growth of the region, the non-basic industries (e.g. insurance, banking, and education) facilitate the former to achieve higher regional productivity. It is important to point out that export base theory was strengthened by what turned out to be North-
Tiebout four article debate. In particular, it is Tiebout’s introduction of the regional multiplier concept that improved the above theory’s capability in bringing understanding of regional economic growth.

Neoclassical growth theory focuses on regional growth from the supply side. The theory assumes adequate regional demand and regional growth are achieved by given combinations of factor inputs – capital and labor. Other assumptions the theory makes are (1) growth occurs under constant returns to scale and (2) the level of technology is constant in the short run. In the earliest form of the theory, dubbed *exogenous*, all the parameters (e.g., the level of technology) entered the model externally. Given the preceding, the theory recognizes that regional growth faces diminishing returns in the long run. Romer and later neoclassical theorists argue that diminishing returns can be overcome and growth boosted through knowledge and information spillovers that are achieved endogenously. It is through this latter conception by Romer and others that the *exogenous* growth theory became the “new growth theory” or simply the “*endogenous* growth theory.” Under *endogenous* growth theory, regional growth is boosted by improvement in human capital (thus, enhancing labor productivity). Learning by doing is critical for the preceding to occur.

**b. Theories of Regional Economic Divergence**

Theories of regional economic divergence are founded on the writings of Marx and later followers including Frank (1967) and Amin (1974). Marxist theories claim that because capital is exploitative to its core, in itself and through the structures it creates, capitalists will seek out new markets, cheaper sources of raw materials, and cheaper labor wherever they can be found. As this occurs, capitalists achieve higher incomes to the detriment of equitable development. This phenomenon can be traced back to the industrial revolution, the colonization of most parts of the
global south, and the promotion of imperialist activities by the elite class after independence through to the role of multinational corporations. Smith shows, succinctly, how capital creates and/or amplifies uneven development:

Capital is like a plague of locusts. It settles in one place, devours it, moves on to plague another place. Better, the process of restoring itself after one plague the region makes itself ripe for another. At the very least, uneven development is the geographical expression of the contradictions of capital (cited in Higgins and Savoie 1995, 136-7).

Myrdal built his cumulative causation theory by questioning the neoclassical assumptions that form a foundation for neoclassical economists’ market-based self-sustaining equilibrium. These assumptions include the following: constant returns to scale; zero transportation costs; identical production technologies across regions; perfectly competitive markets; identical preferences; and homogenous factors of production, that is, labor and capital (Dawkins, 2003). Instead, Myrdal argues “market economies, left to themselves, will generate disequilibrium, imbalance, uneven development, and growing inequalities among regions and social groups” (Higgins and Savoie 1995, 73). For instance, he argues that increasing returns tend to feed themselves, and in the process cause cumulative causation: the creation of circular and cumulative effects in the form of backwash (negative) and spread (positive) effects. With the cumulative process working in both directions, the achievement of balanced economic growth and development is dependent on which of the preceding cumulative effects dominate.

Kaldor elaborates on Myrdal’s theory by introducing external demand as an important factor that leads to a higher level of regional production and efficiency wages (1970). He argues that a region increases its production and thus enjoys economies of scale by responding to an external demand. Economies of scale reduce efficiency wages and allow the region to further
produce competitively. With these regional changes in place, a self-feeding cumulative process, as originally explained by Myrdal, is set in motion within the region.

Dependency and dualism theories postulate that capital and the structures it creates play a fundamental role in causing uneven development and poverty within and among regions. For instance, the “modern” sector, by suppressing or exploiting the “traditional” sector – the dependent peasants and farmers with low incomes – ensures a “reserve army” of cheap labor (Higgins and Savoie 1995, 131). Colonialism, neo-colonialism, and “internal colonialism” are examples of how capital is destructive in itself and through the structures it creates. At the intranational level, areas or cities with a massive concentration of capital and investments continuously pull resources such as cheap labor and agricultural produce from the periphery. In return, they sell value-added and higher priced products back to the periphery. Nevertheless, the validity of dependency theory in explaining regional disparities is dependent on unequal bargaining power between capitalists, governments, peasants, and farmers. If the bargaining power between the preceding actors is uniform throughout the entire space in a country, then the theory fails to explain regional disparities. Nevertheless, its application at the international level in explaining international disparities between industrialized capitalist countries (ICCs) and less developed countries (LDCs) is unquestionable.

Hirschmann’s theory of unbalanced growth argues that economic growth and development tend to get polarized or concentrated as a result of economies of scale that are enhanced by forward and backward linkages. Spatially, the center benefits more than the periphery. Hirschmann argues that this is necessary since investing scarce resources in many areas will not lead to economies of scale as envisaged. With time, he argues the accrued benefits will be expected to flow from the core to the periphery in the form of “trickle down” effects.
Riddle argues that this rarely occurs in reality and that the development process leads to unequal regional growth and development causing friction between the core and the periphery (Riddell 1985, 40). Perroux’s growth pole theory is another key theory of regional economic divergence that has influenced regional development. This theory will be reviewed in the context of Kenya’s post-independence regional development experiences.

In sum, regional development divergence theorists argue that to avoid uneven development, the government has a role in moving the economy towards prosperity. Given the potential role of the intra-national digital divide to accentuate regional disparities, this research has particularly used the Myrdal theory of regional development divergence as its foundation.

c. Structural Theories of Regional Economic Development

Early theories of regional economic growth suggest that regions follow a sequence of stages and sectoral change as they grow and develop. Hoover and Fisher, as the first theorists in this tradition, describe the following five stages of regional development (1949). First is that regions must have a self-sufficient economy with little investment or trade. At this stage, the local population is primarily involved in agricultural and other extractive industries. Second, the region develops some trade and local specialization because of improvements in transportation infrastructures. Third, the increase in interregional trade means the region intensifies the geographic division of labor, that is, from “extensive grazing to cereal production to fruit-growing, dairy farming, and truck gardening” (North 1955, 244). With a growing population and diminishing returns in agriculture and other extractive industries, the region is forced to industrialize in the fourth stage. Here, enhanced industrial development relies on agricultural products and other extractive materials like minerals and provides a market for the same.
Achievement of these stages enables the regions to move from primary to secondary and to tertiary sector development, which is characterized by equitable income distribution. In the fifth stage, regional growth is achieved when a region specializes in tertiary sector production for export. Exportable commodities at this stage include capital, skilled personnel, and special services (North 1955). North, by criticizing the above stages as unrepresentative of American development, whereby efforts of capitalists exploited regional resources for world markets, proposed a new theory of regional economic growth – export base theory (discussed earlier).

Other key theorists have used different concepts to explain why regional growth occurs. Schumpeter argues that the presence of innovators and entrepreneurs in a region determines the rate of regional growth and development (1934). However, the two groups – innovators and entrepreneurs – are not synonymous. Schumpeter argues that the presence of the latter is paramount since it is the entrepreneurs who see an opportunity to introduce an innovation and undertake risk by investing financial resources, largely with credit. And since leading regions need to keep market lead against the “cluster of followers,” old ideas must always give way for new ideas through “creative destruction.” On his part, Rostow, in his stages of growth theory, argues that countries and regions undergo a number of stages as they grow and develop (1960). He identified these stages as traditional society, the pre-condition for take-off, take-off, drive to maturity, and lastly, the age of high mass consumption. Rostow stresses that for sustained growth, each preceding stage must set the necessary conditions for the succeeding stage.  

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7 For a complete review of the above theories, see Higgins and Savoie (1997) and Dawkins (2003).
4. Regional Development in Kenya

a. Pre-Independence Regional Development in Kenya

At independence (1963), Kenya, similar to other developing countries, faced widespread uneven development (mainly poverty, illiteracy, and diseases) owed to the colonial legacy, differences in resource endowments, and natural phenomena like prolonged drought. In particular, the colonial government, by relying on A.W. Lewis’ structural transformation model of development, carried out selective infrastructural investments (notably the Kenya-Uganda railway) that were solely intended to facilitate the optimum extraction of resources from the hinterland for use in the motherland (Britain) (Kosura 2000). This exacerbated disparities brought by other factors. It is widely agreed that prior to colonial occupation, Kenya’s indigenous development was mainly determined by nature. As they settled, however, colonialists heightened pre-existing tensions between different groups, such as agriculturalists and pastoralists, to their advantage. Even more, colonialists held back indigenous development by disrupting indigenous cultural groups and ecological systems.

As alluded to above, indigenous communities carried out their various economic activities, for example, in agriculture, livestock keeping, and trade according to their “comparative advantage.” At this time, the use of space was communal without individualized land rights. However, with the entry of the colonialists and enforcement of boundaries, land demarcation and the establishment of group ranches, grazing blocks, and reserves in the early 20th century changed the status quo. This deliberate “regional development” policy led to the demarcation of Kenya into “white highlands” and the “African native reserves” in the early part of the 20th century. The white highlands coincided with the best and most productive land, while
the African native reserves coincided with spatially limiting and marginal settlement areas. The existing policy deliberately concentrated funding and development support in the white highlands. Little, if any, attention was paid to rural development in the African settlement areas. Instead, the native areas acted as reservoirs of cheap and, at times, forced labor. Thus, at independence, core-periphery dualism, predominance of foreign capital, the dominance of agriculture, the limited development of industry and heavy reliance on the export of primary products, and imports of capital and manufactured consumer goods characterized the economy (Ogot and Ochieng 1995, 83).

b. Post-Independence Regional Development in Kenya

Given the above economic conditions, the newly independent African government, through the formulation of the first Sessional Paper No. 10 of 1965, on *African socialism and its relevance in development in Kenya*, prioritized the narrowing or elimination of the above disparities. The government felt that a centralized economy was appropriate since a “fundamental characteristic of African socialism is that society has a duty to guide and control the use of all productive resources” (Alila 2000, 69, citing Government of Kenya 1965). The Sessional Paper further exuded confidence that “the state has an obligation to ensure equal opportunities to all citizens, eliminate exploitation and discrimination, and provide needed social services such as education, medical care and social security” (cited in Ogot and Ochieng 1995, 89). Soon after, the adoption of five-year development plans and other Sessional Papers became important instruments for addressing the regional development dilemma over the years.”

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8 Such regulations were contained in 1902 and 1915 Crowns Lands Ordinances (Kenya 1948 as cited in Gooneratne and Obudho 1997, 242).
Growth pole theory, traced back to the writings of Perroux in 1949, shaped the formulation of Kenya’s regional development policy. The theory was influenced by Schumpeter’s (1934) innovation concept. Its role in spatial planning emerged from Boudeville (1966) translation of Perroux’s work by arguing that the spatial behavior of an area will be affected by the location behavior of certain propulsive industries (i.e., major firms or plants). In principle, the theory entails the manipulation of development forces aimed at triggering self-sufficient development momentum within the development core region in the long run. Supply-side development forces emanate from the region’s “core,” as the core specializes in meeting the needs of the non-core (i.e., periphery) region through concentration economies. In turn, the non-core region should exert demand-side development forces in the form of products and services demanded from the core. As this happens, the region enjoys internal multiplier effects as propulsive forces and momentum from growth are generated from the core and manifested throughout the entire regional economy through upstream and downstream production linkages. Several welfare indicators including increase in per capita income and other social indicators like education, health, nutrition, and environmental protection measure these propulsive effects (Higgins and Savoie 1995, 92).

Growth pole theory further argues that deliberate government policy that advocates for investments (e.g., construction of backbone infrastructure) as well as incentives or regulations for private investments in one or a few cores generates the needed propulsive effects. In the Kenyan case, these government-led infrastructure investments followed a policy of selective concentration where agriculturally high potential areas and selected urban centers benefited. These urban centers, including Nairobi (the capital city), Mombasa, Kisumu, and Nakuru,
became centers of capital, industrial, and commercial concentration.\textsuperscript{9} Policies driven by growth pole theory performed poorly in the end. Large areas covering approximately 88\% of Kenya’s land surface were ignored or given less priority in the government-led development. The situation was so bad that in 1972 the International Labor Organization (ILO) report pointed out:

The development of the Kenyan economy has been accompanied by a growing imbalance within the country. The tendency of Nairobi and other urban areas to grow at the expense of the rural areas, the richer regions in relation to the poor, has led to growing imbalances between regions and different groups of the population.\textsuperscript{10}

Kenya’s regional development planning occurs in three planning contexts. First, the preparation of development plans takes place in sectors (i.e., within ministries) where policies, programs, and projects have various scales of focus. Second, preparation of development plans takes place within the framework of broad-based, regional resource development authorities. Currently, there are six such development authorities covering different regions of the country. Third is an integrated approach that focuses on creating a regional and physical framework to facilitate the integration of sectoral and local physical or spatial development concerns (UNCRD et al. 2003, 3; Kosura 2000). In short, the complicated planning environment dominated by conflicting hierarchies (i.e., vertical vis-à-vis horizontal) has not been conducive to coordinated regional development. As a consequence, Kenya’s implementation and use of various types of instruments has “undergone trials, adjustments and readjustments” (Fan 1997, 620). Despite deliberate efforts by the Kenyan state, disparities between regions and communities persist.

\textsuperscript{9} For a complete review of the historical development of Kenya’s transport and communication infrastructure and its relationship to modernization, see Soja (1967). Similarly, Johnston gives a good description of how infrastructure developments (i.e., ports, railways, and roads) led to the development of dendritic spatial forms in developing countries (1970).

\textsuperscript{10} For further discussion, see Ogot and Ochieng (1995, 89-91).
B. ICTs and their Role in Economic Development

1. *The Meaning of Technology and its Development Worldwide*

Technology can hold several meanings depending on who is defining it. For neoclassical development economists it broadly means “everything that affects the level of economic output except capital or labor” (Kenny 2006, 16). This relationship is represented as follows:

\[ Y = f(K, L, N) \]

where \( Y \) is the size of economic growth, \( K \) is the amount of capital, \( L \) is the amount of labor, and \( N \) is the level of technology. Impacts on economic growth are measured through absolute growth and the growth rate of total factor productivity (TFP). TFP being the manner in which capital and labor are combined to increase value. TFP varies in form and ranges from Adam Smith’s classical efficient organization of labor in his pin factory, output of lab-coated technicians, total quality management, and double-entry book keeping, through to just-in-time delivery networks (Kenny 2006).\(^{11}\)

Pohjola argues that ICTs are current manifestation of the ongoing sequence of technological revolutions and can be seen as the key factors driving economic growth in industrial societies at present (2003). Thus, differences in ICT adoption and use among countries cause a great deal of concern to development experts, as these disparities could be a precursor for widening income differentials. Because of the preceding explanations, Pohjola further argues in favor of identifying factors that can equalize differences in technology adoption and diffusion across countries. In particular, this factor identification is important for policy-makers in their effort to bridge the persisting “digital divide” and in eradicating “information poverty” gaps. Reasons for advocating ICTs’ digital convergence are varied and will be examined later.

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\(^{11}\) See Kenny (2006, 63-4) for more illustrations of how technologies have been essential for economic development since Albert O. Hirschmann’s telephone network elaborations.
In Sub-Saharan African countries, Lall and Pietrobelli stress that the laxity of Sub-Saharan African countries in prioritizing technological efforts has led to the parlous state of manufacturing (2002). This has meant a lack of local industrial capabilities as well as lagged technological systems compared to advanced economies. In addition, the inability to take advantage of the manufacturing sector’s role as the main agent for the creation, transfer, and application of new technology has meant that a vicious cycle in the form of the existing parlous state of manufacturing and low technology has continued to prevail in the continent.

As noted above, the acquisition of new technologies is seen as an important pre-requisite *inter alia* for improving competitiveness. Lall and Pietrobelli add that what African countries need to do is to build capabilities, organizations, and industrial structures, which are currently deficient. Simply put, the lack of these essential elements means that African firms (and by extension African economies) are out-competed by foreign firms and economies with much stronger capabilities. Lall and Pietrobelli emphasize that unless African countries build capabilities, organizations, and industrial structures through favorable economic, policy, and institutional environments, then they will not be able to master, adapt, and improve on foreign technologies (2002, 2). This is crucial since weak technological systems lead to deficient capabilities and ineffective use of technology, thus resulting in uncompetitive firms (Ibid., 3).

Similarly, most African countries have not gained from the inflow of technologies via foreign direct investment (FDI) or licensing and capital goods since these countries have implemented restrictions (e.g., trade barriers) and may have government-owned firms that direct resource allocation. Lall and Pietrobelli note that with these restrictions, transnational corporations (TNCs) are unable to share new technologies and markets they control without assuming on an equity stake (2002). As this unfolds, many technologies and much information
that otherwise readily would be available to local firms to access new markets and collaborators are choked. The net result of all the preceding implies that technical inefficiency, technological lags, poor capabilities, and uncompetitive firms continue to prevail in the African continent.

James blames the continent’s failure to advance technologically on the nature of development aid and associated conditions (2002). In the past, he notes that aid lending has primarily been capital-intensive with total disregard to the abundant factors of production (i.e., labor) already in the continent. To him, labor has the potential to promote economic efficiency (for labor is associated with lower costs of producing a given level of output) in the continent vis-à-vis overemphasis on capital-intensive techniques. Additionally, citing Stewart (1981), James adds that the essential aspects of the process of development, broadly defined, involves the ability to make independent technological choices, to adapt and improve upon techniques, and eventually to generate new technology endogenously. After all, the accumulation of technological capacities in this manner is as important to development as the accumulation of capital. He concludes that three policy areas need to be emphasized: “intensified recipient relationships with large, industrialized developing countries; alteration in donor-recipient relationships towards reduced recipient technological passivity; and donor follow-up on alternative technologies” (James 2002, 123).\footnote{For further discussion, see Abubakar (1989, 105-120) and Davidson, Sooryamoorthy, and Shrum (2002, 7).}

Kenya, like other countries in Africa, has technological shortcomings that work against faster economic development. Lall and Pietrobelli note that government documents identify the re-evaluation of R&D investment as necessary to enhance the adoption of imported technologies and provide adequate advice to information technology users, \textit{inter alia} (2002). They note that this is more important in economies characterized by liberalization and falling transport costs. Presently, they mention that Kenya faces competition from two fronts: low technology...
economies of South and Southeast Asia and medium- to high-technology economies of East Asia and Organization for Economic Co-operation and Development (OECD) countries.

Lall and Pietrobelli also add that Kenya’s technological development lags behind that of many countries in Asia and Latin America (2002). The private sector is expected to spearhead technical dynamism but invests very little in R&D or in adopting or upgrading imported technologies. Equally, the government’s policies lack coherence, as witnessed in overemphasis on the supply side. Inevitably, the low regard for demand-side policies disenfranchises the private sector.

The National Council for Science and Technology Act of 1977 oversees all the Kenyan government’s science and technology policies. The government amended the act in 1979 to establish semi-autonomous national research institutes and advisory research committees. In turn, respective ministries and departments oversee these established institutions. This organizational hierarchy creates overlapping jurisdictions and potential territorial conflicts and is the precursor for incoherent and poorly-coordinated strategic decision making on economy-wide issues (Lall and Pietrobelli 2002).

Lall and Pietrobelli further elaborate that a semi-autonomous governmental institution, the Kenyan Industrial Property Office (KIPO), administers the promotion of indigenous technologies, protects foreign patents, and encourages the acquisition and diffusion of technology (2002, 61). They note that, since 1990, KIPO has registered several patents (e.g., in agrochemicals, pharmaceutical, and mechanical equipment). The government’s share in the locally registered patents is paltry, showing the weak role of the state in the area of technology development.
2. **ICT Impacts on Economic Development**

Kenny argues that if TFP’s association with ICT is significant, then developing countries are likely to benefit. These benefits, which have increased steadily in a number of developing countries, come in the form of investment, employment, and export growth in the ICT sector. In particular, Kenny further states that East Asian countries have witnessed huge improvements in TFP in ICT-producing sectors. For instance, Singapore and Malaysia have experienced 7.04% and 3.47% growth, respectively. Both Taiwan and Thailand have experienced 1.9% TFP in ICT producing sectors (Kenny 2006, 57).

Baliamoune-Lutz claims that greater access to information and knowledge brought by ICTs reduces information asymmetry and transaction costs and increases the awareness of more effective institutional organizations (2003). This way, information asymmetry between producers and consumers is minimized substantially. This has been witnessed as developing countries compete with the developed world for industries and jobs by offering lower costs (through cheap but highly skilled professionals) and upcoming entrepreneurial capabilities.\(^{13}\)

ICTs access, diffusion, and use also have a bearing on the degree of competition among firms. Wallsten notes that in Eastern European transitional economies, controlling for endogeneity, firms with Internet access have shown a higher propensity to export than firms that do not have Internet access (2003, citing Clarke 2002). Additionally, by citing Bhavani (2002), Wallsten further notes that the use of technology has been beneficial to firms in the Indian auto components industry. Other empirical studies show that ICTs and related investments have been

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\(^{13}\) In the past, Schramm noted that African countries used old ICTs strategically: dissemination of information and messages aimed towards improving agricultural production, health, education, national security in particular, and towards creating a conducive environment for national development in general (1964).
responsible for enhanced regional economic development in many places. Overall, neoclassical economists view this as fostering economic welfare (Baliamoune-Lutz 2003).

The Internet, with its perceived transformative power, is a particularly valuable technology for economic growth and development. Various explanations support this assertion. The first is that the Internet, by its nature, is a “general purpose technology” and thus is an innovation that affects the whole economy simultaneously. Daly further clarifies that information technologies are more pervasive than past technologies as they have spread widely across industries and penetrated deeply into corporations in a relatively short period of time (2000). In addition, the Internet’s benefits accrue from its associated network externalities (both direct and spillover effects). These benefits occur as ripple-related impacts happening through the entire economy (Quah 2002).

Secondly, the Internet lowers transaction costs, shortens transaction time, and short-circuits barriers in a way that nothing else has done in history. In the process, the Internet expands markets into new territories by allowing the transfer of information goods that are otherwise not tradable. While the Internet has not “eliminated” distance-related barriers between sellers and consumers per se, it has increased the possibility of reaching the highest number of potential customers. In fact, as the Internet operates “around the clock and around the world” it has ensured that orders can be placed anytime, thus allowing high volumes of economic transactions, increased productivity, profits, and market share to be attained (Moyi 2003). Forestier, Grace, and Kenny add that a number of small- and medium-enterprises (SMEs) portals and online stores, although relatively small-scale, have penetrated global markets to sell their

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14 For further discussion, see Wallsten (2003, 3).
15 James, for instance, notes that for an activity that would take 25 minutes to complete on a telephone, it could take a minute using the Internet and some special software. Similar patterns of gains are also witnessed in reordering an inventory item and updating an equity portfolio (2002).
artisanal goods (2002). On their part, Dasgupta, Lall, and Wheeler point out anecdotal evidence of the benefits that arise from the Internet in developing countries (2005, 230-1).

Even further, Davidson, Sooryamoorthy, and Shrum show that, under the “elixir” argument, the Internet does not represent a potential problem but only an opportunity. Here the Internet is taken as a developmental tool on par with educational and agricultural programs (citing De Roy 1998). In developing countries the need for Internet connectivity in general and increased bandwidth in particular is a necessary condition for economic development. If this is done, the argument goes on to assert, then developing countries will compete equally in the New Economy rather than be laggards as before.

James emphasizes that the level of international trade depends on the transaction costs between buyers and sellers in different countries (2002). Currently, communications costs have replaced transportation costs as the main driving force of international trade. This has been possible, for example, because telephone costs declined by a factor of six between 1940 and 1970 and by a factor of ten between 1970 and 1990 (Ibid., 55). The use of Voice over Internet Protocol (VoIP) has reduced communications costs even further. These changes have enabled all countries, and especially developing ones, to participate in international trade. Thus, it comes as no surprise that “valuable locales and people will be found everywhere, even in Sub-Saharan Africa” (Graham 1999, 930).

James also emphasizes that the use of information technology will influence the comparative advantage of countries (2002). That is, through adoption of industrial technologies such as computer-aided design and computer-aided manufacturing (CAD/CAM) or numerically controlled machine tools, adopting countries enhance their competitive advantage over those that do not do so. In the newly industrialized countries (NICs), especially the East Asian block of
countries, ICTs have assumed a sizeable portion of exports. It is expected that with developing countries taking on a greater role in ICT exports, their share of these products will grow more rapidly than all other sectors. Citing Hanna et al. (1996), James further notes that advancement in user-friendly computing and telecommunications enabled Singapore to reap huge returns from the information technology revolution and pride itself as a successful model (2002). While he cites the preceding as a successful case of leapfrogging witnessed in NICs, the results may not apply to all developing countries, since the results are contingent on context-specific variables.

ICTs also can enable developing countries to leapfrog and enjoy faster growth and a larger share of the world’s development due to their inherent features (Steinmueler 2001). Leapfrogging in itself is useful as it enables developing countries to abandon investments in obsolete technology, adopt new technologies at lower costs,\(^\text{16}\) and in the process take advantage of ICT (Davison, Vogel, and Jones 2000). This adoption of new technology would lead to possible convergence in productivity and output that separate industrialized and developing countries (Steinmueler 2001, 194).\(^\text{17}\)

Also, fears of a widening income gap if the global Internet were to develop under *laissez-faire* conditions support the need for deliberate ICT investment. Even more, for many people across the world who are already deprived of many other basic requirements for life, this means that to be “cut off from telecommunications services is a hardship almost as acute…and may indeed reduce the chances of finding remedies to them” (Kofi Annan, former Secretary-General of the United Nations, cited in Norris 2001). Similarly, it is acknowledged that participation and

\(^{16}\) Pohjola states that, once invented, they can be copied and transferred at negligible costs (2003). In addition, this is possible as explained by Moore’s law that cites empirical evidence showing that real investment requirements in new technology decline over time. Moore’s law was espoused by Gordon Moore’s 1965 finding that in the long run transistor costs were going to shrink and in so doing enable consumers to afford cheaper, ubiquitous, and strong computing power. This is significant to most developing countries as they can easily acquire and adopt new ICTs for their development.

\(^{17}\) For further discussion, see Steinmueler (2001), Pohjola (2003), Kenny (2006, 63), and Mansell (2001, 283-286).
communication in the information society is a public good and a basic right since, overall, the prospects for social benefits outweigh the social costs (Tarjanne 1998, cited in Davison, et al. 2000; Galperin and Mariscal 2007).

3. ICTs and Regional Development

Just as ICTs are important in enhancing the competitiveness of national economies, they are equally important in enhancing the competitiveness of regional economies in the New Economy. With this in mind, the regional economic growth of industries and services is reliant on the extent of access and the adoption or use of ICTs in both developed and developing countries. Narayana states that ICTs’ contribution to regional growth and development measurements include the following indicators. First is the level of communication services as measured by postal (e.g., postal and money order) and telecommunication services (e.g., telephones and telegrams). The second is data processing, software development, and computer consultancy as measured by either the size of the ICT-related workforce, percent share of ICT industries in the gross regional product, or the percent share of ICT industries in the total registered manufacturing gross regional product (2005). In most developing countries like Kenya, however, ICTs’ contribution to both the national and the regional economies is more to the ICT-using service sectors than the manufacturing sectors.

Given the above, any disparities in access to information technologies between rural and urban citizens is cause for worry, particularly because most developing countries, especially in Sub-Saharan Africa, have a higher percentage of rural residents than rest of the world. Worse still, this population stratum is already denied other basic infrastructural services (e.g., telecommunications, health, and education) compared to their urban counterparts. In the United
States, for instance, Parker states that rural areas lag behind urban areas in broadband digital networks that are suitable for data, voice, video, or any other information that is convertible to digital bits. In other words, rural America has a narrowband network that is slow, inefficient, and expensive for data communication. Similarly, as the telephone, the railroad, and the highway system networks led to rural winners and losers, by bypassing many communities and regions, the possibility that unequal access to new ICTs will create winners (especially urban residents) and losers (especially rural residents) is unacceptable (Parker 2000, 281-282).

Existing literature on the role of ICTs in regional economic growth and development shows varied benefits. Broadly, ICTs have the potential to democratize political participation and policy formulation, reduce regional, rural-urban, and gender imbalances and redefine the parameters of development thinking and practice (Cline-Cole and Powell 2004, 5). Reducing regional imbalances is possible since information technologies can offset the economic disadvantages of rurality by reducing the “barriers of time and distance from major markets” (Hollifield and Donnermeyer 2003, 136). Akca, Sayili, and Esengun argue that ICTs, at the regional level, are useful in enhancing natural resource management through GIS, increasing electronic trade by allowing competitive prices of both inputs and outputs, and supplying extension and training activities for rural dwellers. ICTs are also useful in improving governance (e.g., better land records and tax collection), developing human resources through knowledge transfer between rural and urban areas, and advertising rural tourism products (2007, 406).

In the tourism sector, which has been the leading adopter and user of ICTs in most developing countries/regions, the benefits of ICT adoption and use abound. ICTs (i.e., the Internet) offer global reach and multimedia capability and have enabled the tourism sector to market itself to local and distant customers. This is crucial since tourism is a product that exists
only as information at the point of sale and cannot be sampled before the decision to purchase is made (Doolin, Burgess, and Cooper 2002, citing WTO Business Council 1999). Doolin, Burgess, and Cooper also note that vis-à-vis traditional ICTs that entailed simple broadcasting, the Internet allows consumers to interact with web content, thus directly engaging consumers’ interests and participation. This is possible since interactions “directly influence the perceived image of the destination and creates a virtual experience for the consumer” (Doolin, Burgess, and Cooper 2002, 557). In addition, ICTs have enabled rural tourism products (e.g., rural handicrafts) to be advertised and marketed in the local, national, and international markets at low costs (Akca, Sayili, and Esengun 2007).

However, to achieve the above benefits, a number of factors that may stand in the way need to be addressed. For instance, a pool of skilled personnel and a cluster of an adequate threshold of ICT producing and using sectors need to be accumulated. Cline-Cole and Powell state that the availability of technology, in itself, is not enough (2004). In other words, the benefits accruing from the adoption and use of any technology depend on how users are able to take advantage of the opportunities offered by the technology in question. Thus, the old assumption, which prevailed in the 1990s, that believed adoption would naturally follow access has been replaced by the understanding that access to new ICTs is not synonymous with adoption or, perhaps even more importantly, with effective use (Hollifield and Donnermeyer 2003).

The roles of many actors in improving ICT development in rural, “underserved,” or “economically disadvantaged” areas are many and are dependent on the local environment. For instance, the government could subsidize private firms that are discouraged from investing in rural areas because of low demand levels resulting from the dispersed population. Lowering
costs in rural areas that are constrained by the lack of infrastructure clusters (e.g., availability of cable TV) can be useful in driving innovative technical and market solutions (Akca, Sayili, and Esengun 2007). In addition, the government can establish innovative projects like digital villages. Even further, Hollifield and Donnermeyer state that “institutional structures in people’s lives play an important role in encouraging or discouraging the adoption of information technologies” (2003, 146). Thus, they argue that government policies should “encourage locally-owned rural businesses to adopt information technologies as a means of maximizing local diffusion and increasing demand levels” (2003, 135). Narayana explains that India’s Karnataka State, by spearheading the development of Software Technology Parks (STPs) as a way of increasing the economic performance of software and hardware companies, has led to the state benefiting immensely from ICT-related development vis-à-vis other states in India (2005).

4. Potential Constraints of ICT as a Development Strategy

Recent studies estimate that since many of the least developed countries largely import ICT goods, their contribution to a paltry 0.3% of the world’s high-technology exports means the expected benefits of ICT-related growth may be negligible (Kenny 2006). For instance, the influence of TFP growth in the Indian economy for the period 1995-1999 amounts to only 0.05% of the whole economy. Several reasons explain this scenario. The first is that developing countries that produce ICTs do not gain because of gains transfers that benefit consumers at the expense of producers, regardless of the fact that the latter are responsible for initiating improvements in TFP. For instance, despite the increased power of computers, consumers continue to pay falling prices for computer. Kenny argues further that if these consumers are in a developed country (e.g., the United States), then the accrued benefits from the gains transfers and
TFP increases the overall benefits to the developed country. Gain transfers are possible since developing countries do not own patents and thus have little say in controlling monopoly profits. Rather, they are disadvantaged vis-à-vis (largely rich-country) consumers from the lower cost of ICT capacity (Kenny 2006, 59).

Related to the above is the interplay of forces between patent consumers (mostly in developing countries) and patent producers (in developed countries, including expatriates in developing countries). This interplay stems from the fact that in general most developing countries’ R&D expenditures are much lower than those in the developed world (Lall and Pietrobelli 2002). Kenny points out that, in 1999, low-income countries together spent approximately US$5 billion while the United States alone spent US$234 billion on R&D. More still, in low-income countries local residents filed less than 1% of all local patents. Thus, it is no coincidence that royalties and license payments accrue more to the developed world than to low-income countries. Kenny concludes that, despite most developing countries being endowed with human capital stock, widespread use of English, and strong ICT networks, they may only enjoy “normal” ICT-related growth benefits (2006, 60). Simply put, higher rates of growth or profit go to developed countries.

Another reason why ICT-related benefits may not fully accrue to developing countries vis-à-vis developed countries is the presence of the international and domestic “digital divide.” This divergence is possible especially when one looks at the differences in access and use of ICTs. The expected benefits from access and use of ICTs are strangled by what Kenny refers to as a broader environment that is ill-suited to exploit ICT technology (2006, 60). He further notes that there is higher teledensity\(^{18}\) of both fixed and cell telephones in high-income countries vis-à-vis-

\(^{18}\) The number of telephone (fixed or cellular) connections per a given number of inhabitants (e.g., 100,000 inhabitants).
vis developing countries. For the period 1975-2000, Kenny and Fink found there was an increase of 900 phones per 1,000 people in high-income countries, compared to just 24 phones per 1,000 persons in poor countries (2005). With respect to the Internet, Kenny points out that an average of one-third of the population in high-income countries used the Internet, compared to just 0.4% in low-income countries (2006, 61).

In terms of per capita income, there is also a disparity between high-income and low-income countries. This disparity translates directly to the level of investment and services of both telecommunications and the Internet. Kenny notes the ICT expenditure accounts for a larger percentage of R&D expenditure in rich countries than in poor countries: 9% and 5% in rich and poor countries, respectively. Demographic composition (i.e., the ratio of urban to rural population), limited infrastructure access (e.g., electricity), and relative per capita income between consumers in rich and poor countries work against the latter in the cost of accessing the Internet (2006, 61). Kenny explains that if the preceding is any indication of how investment in telecommunications and the Internet is expected to bring economic development and associated benefits to poor countries, then the whole enterprise is moot to say the least. Davidson, Sooryamoorthy, and Shrum also cite several problems (e.g., inadequate backbone infrastructure and low literacy levels) that must be overcome before the perceived net benefit from the Internet as a leapfrogging tool can eventually accrue to developing countries (2002).

In addition to the above, Quah outlines interesting paradoxes related to the effects of ICTs on economic development (2002). First, skeptics point out that the correlation between computer investments and economic growth is insignificant. Second, and related to the preceding, is that the correlation between the two variables is sometimes negative, and third, that there is irony in how the United States, being the world’s leading technology economy, actually
imports more ICTs than it exports. The United States’ TFP growth has also lagged behind that of other countries. In the Arab region, Nour notes that ICTs have the ability to impose “creative destructive effects” by providing opportunities and challenges for development simultaneously (2006). These paradoxes might increase skepticism on whether the perceived benefits will turn “real” in the end.19

Wade, playing the role of a “devil’s advocate,” warns “that efforts to bridge the digital divide may have the effect of locking developing countries into a new form of dependency on the west” (2004, 185). He offers two reasons for this. First, existing ICTs and regimes are west-centric and, as developing countries use the related complex hardware and software, they become increasingly dependent on the quasi-monopolistic power of key ICT providers. Second, western countries, by linking aid to good governance as they advocate for public sector e-governance, are reinforcing the overall dependency of developing countries. Accordingly, Wade argues that developing countries should always advocate for standards and pricing regimes that are suitable for their requirements and contexts. Otherwise, the technological (software-hardware) race will “keep widening the digital gap between the prosperous democracies and the rest of the world” (Wade 2004, 193).

Wade also questions the extent to which ICT as a development paradigm in developing countries should be prioritized. He states that, while he is not against the entire ICT-for-development (ICT4D) enterprise, existing evidence shows that perhaps ICT is oversold. He supports his thesis by stating that evidence primarily draws from pilot projects and a “pot-pourri of anecdotes.” Without a clear correlation to evidence, he notes these “benefits” are “scaled-up” over a much larger number of sites than individual project sites. He cites the World Bank’s

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19 For further discussion, see Nour (2006, 171-183), Quah (2002, 10-17), and DiMaggio, et al. (2001) on the social implications of the Internet.
funded multipurpose community telecenters (MCTs) project in rural Mexico and an e-governance project in Andhra Pradesh, India, as well as several donor-aided local government computerization projects in Tanzania and elsewhere, to show how the relationship between plans and reality can be illusionary. Eko also warns that unless developing countries encourage investments in the *sine qua non* of Internet technology (e.g., electricity and telecommunications infrastructure) they will be enhancing western electronic commerce and reducing their economies to dependencies (2004). Similarly, Alvarez and Calas warn that the powerful transnational corporations (TNCs), which have constructed a “Transnational World Order,” threaten national sovereignty and reduce developing countries to “colonies” (1996, citing Raghavan 1993).

5. *Conceptual and Theoretical Framework*

Conceptually, Torero and von Braun note that ICTs and development are related as shown in Figure 2.1. They argue that varied driving forces (i.e., extent of technological innovation, public policy, private investment, and external and international policies) mediate the demand and supply environments in which the level of ICT diffusion is actualized. The mediation process is crucial to what economic and social benefits finally accrue. Building on Torero and von Braun’s conceptualization, this research further conceptualizes that the relationship between various elements in the figure is time dependent (2006). In other words, the magnitude of the driving forces and the kind of mediating environment, all interact in a time-space arena that leads to the realization of economic and social benefits. Thus, given the differences between driving forces and mediating environments, there are bound to be differences in the type and magnitude of economic and social benefits that accrue to different citizens, businesses, and regions over time.

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20 For further discussion, see Wade (2004, 187-189).
Several other theories can be used to explain the role of ICTs in development. First, diffusion theory underscores that diffusion rates (in time) of technologies in reaching saturation levels are important in explaining the patterns of development that may emerge. Mediated by “several factors, including price, government regulation, available content, and network effects” (Leigh and Atkinson 2001, 5), van Dijk notes that two models can explain whether diffusion will bring forth convergence or divergence in development (2005, 66). The first model, the normalization model, explains that, regardless of where the various segments of society (e.g., low, middle, or high-income categories) begin in adopting technologies, the different strata will

![Figure 2.1. ICT and development: A conceptual base](image-url)

Figure 2.1. ICT and development: A conceptual base
Source: Adapted from Torero and von Braun (2006, 7).
eventually converge as a given technology reaches its saturation level. At that level, any benefits that accrue will be felt uniformly by all. The second model, the stratification model, explains that the initial differences in various segments of society will persist until the time a given technology reaches its saturation levels. In this case, van Dijk suggests that deliberate government policies might be required to achieve convergence in the diffusion of technologies and concomitant accrued benefits (see Appendix A).

Secondly, knowledge gap theory is applicable in explaining the relationship between ICTs and development. Huesing and Selhofer use the communication research perspective to explain how socio-economic impacts result from information access, or lack thereof (2002). Simply put, the asymmetry of obtaining information through ICTs explains the different development trajectories various segments of society undergo. For development to be all-encompassing, access to information must be equally available to all at various levels.

Finally, Myrdal’s cumulative causation theory is useful for its emphasis on the ability of pre-existing socio-economic conditions and other variables to lead to either divergence or convergence. In other words, the inability of some to access technologies within and between countries or regions and across societal strata is likely to work against them vis-à-vis those with such technologies. Merton, quoted in Hargittai (2003), calls the preceding the “Matthew Effect” according to which “unto everyone who hath shall be given” or simply whereby initial advantages translate into increasing returns over time (1973). Thus, as a current development dilemma, criticisms of the digital divide as a manifestation, cause, and effect of social exclusion are part of a fight against poverty and social exclusion (Selhofer and Husing 2002).
C. Summary

The review of literature has covered regional economic development and the role of ICTs in economic development. The review has illustrated that regional development owes its origin to the paradoxical development: the presence of substantial economic growth on the one hand, and the persisting presence of spatial and regional disparities on the other. These conditions demand that governments and other players initiate deliberate policies and programs to correct such paradoxes. In turn, these efforts have been guided by various key regional economic development theories and approaches. These theories include dependency and dualism theory, cumulative causation theory, theory of unbalanced growth, and growth pole theory. The first section of the chapter ends with a review of Kenya’s experiences in implementing regional development. The review shows that, despite Kenya’s concerted effort to implement regional development approaches, primarily guided by growth pole theory, disparities among regions and communities persist.

The second section of the literature review covered ICTs and their role in economic development at the national and the regional level. At both levels, ICTs are useful in reducing information asymmetry, lowering transaction costs, and enhancing competition so consumers have a wider choice of merchandise and prices available to them. ICTs also enable developing countries to leapfrog and enjoy faster growth and a larger share of the world’s development due to their inherent features. Previous literature shows that in the past, African countries have used ICTs to disseminate information and messages aimed at improving agricultural production, health, education, and national security in particular, and to create a conducive environment for national development in general.
However, the potential constraints of ICTs as development tools include the presence of the digital divide, income and other socio-economic and infrastructural disparities, and threats to socio-cultural stability in adopting countries. Finally, the literature review conceptualized and theorized on the perceived relationship between ICTs and economic development. Here, the review adopts Torero and von Braun’s conceptualization, diffusion theory incorporating van Dijk modeling, knowledge gap theory, and Myrdal’s cumulative causation theory as important foundations. The next chapter (Chapter III) addresses the development of ICTs and the digital divide with a focus on Africa and Kenya.
CHAPTER III: DEVELOPMENT OF ICTS AND THE DIGITAL DIVIDE
WITH A FOCUS ON AFRICA AND KENYA

The body of literature reviewed in this chapter shows differences in the development of ICTs among African countries and Kenyan regions. An understanding of these differences is crucial as various governments and other players embark on promoting ICTs as development tools. Exploring Kenya’s regional differences in ICT development is important as it points out the various factors that may stand in the way as the country moves towards the New Economy. A review of the digital divide, including its meaning, causes, and major types improves our understanding of the key concept at the center of this dissertation. Therefore, this chapter is devoted to the review of ICT development and the digital divide in Africa and Kenya.

A. ICT Development in Africa

In general, Kenny notes that, since 1980, information and communication technologies have been growing rapidly in developing countries. This is observed in the way telephone penetration has been fast, moderate, and low in low-income, middle-income, and high-income countries, respectively. The expansion of cell phone use has also shown considerable growth in developing countries, as indicated by the cell phone footprint. However, while access and use of telephones has improved overall, variations exist among different regions of the developing world. Internet growth has shown similar trends. Kenny notes that, unlike past communication technologies – the telephone which took 100 years, and the TV which took 50 years – it appears the Internet will equal the cell phone’s 15 years to reach “saturation level” (Kenny 2006, 62). This way, developing countries will achieve high penetration rates early.

21 The area in which people can make and receive a cell phone call (Kenny 2006, 62).
1. **Why the Urgency for Information Revolution in Africa?**

According to Wilson and Wong, the term “information revolution” refers to the bundle of technological, commercial, and institutional changes in the information and communications sectors that have had a tremendous role in determining the scope and speed of ICT diffusion globally (2003). These changes involve accelerated and integrated technical innovation of various technologies (print, broadcast, telephony, video, and computing) into local to global networks that facilitate powerful information processing and communication for various activities. Two reasons explain enthusiasm surrounding the adoption of ICT in Africa and developing countries (Wilson and Wong 2003).

The first reason is the failure of the old telecommunication systems to create a reliable, open, and widespread system for transmitting information and their inability to meet consumer demand adequately. By citing ITU (1998), Wilson and Wong note that in the mid-1990s Africa had a telephone supply shortfall of 3.4 million (2003). Worse still, telephone applicants had to wait for an average of 3.5 years to be connected. According to ITU, the situation in Sub-Saharan Africa in particular was even slower, with nearly 1.2 million customers waiting an average of 5.4 years to be connected (1998). Existing broadcasting services were government propaganda tools. However, this changed with the entry of liberalization, as private broadcasters moved fast to tap the existing unserved consumer base.

Second, the rise of economic globalization and accelerated international competition led to the spread of ICTs. In the New Economy, a modern and effective telecommunications system is necessary in order to attract potential investors and FDI. These systems must be inexpensive, reliable, and accessible at all times (Wilson and Wong 2003). This is important because, as ICTs lower costs they facilitate reliable and ready access to information and ideas required by
developing countries to enable them to participate in the New Economy. For Africa, the stakes are high since it is the most marginalized and excluded region of the world (Fuchs and Horak 2006). Additionally, ICTs can be useful in bringing new participants into the political arena by providing information on elections, voter registration, and candidates. In this manner, there is a shift in the balance of power between states and citizens, with citizens pressing their governments for the appropriate policies needed for development (Adam 1996).

Adam also views the role of ICTs in Africa as a tool for attacking the vexing problems prevailing in the continent. He notes that Africa can use ICTs to tackle the “seven Ds” (i.e., demography, desertification, drought, dependency, disequilibrium, debt, and destabilization) inhibiting its development path (1996). Adam concludes that unless Africa seizes ICTs’ opportunities, its underdevelopment gap will continue to broaden alarmingly. Additionally, he argues that Africa must develop new human capabilities and address other socio-economic problems prevailing in the continent.

2. Current Status of ICT Diffusion in Africa

a. Old or Traditional ICTs: Broadcasting and Telephones

Traditional ICTs represented by broadcasting and fixed telephones have grown by an average of 5%, with telephone mainline growth exceeding 10% in some countries. A recent ITU report also notes that SSA’s fixed telephone compounded annual growth rate for the years 2003-2008 stood at 2.4%, compared to the world’s compounded annual growth rate of 2.5% for the same period (2009). The same ITU report states that SSA’s teledensity for fixed telephones has

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22 Wilson and Wong cite Senegal as a country that benefited from the use of ICTs during its 2000 election (2003). I can add Kenya’s experience in the new constitution referendum.
reached a penetration rate of 1.5%. This SSA penetration rate lags behind world’s (19%) and developing countries as a group (13%) penetration rates (2009).

Wilson and Wong report that in many countries the number of television and radio broadcasting services increased to include private owners, domestic content, and wider continental coverage (2003). Citing Bilodeau (1999), they give an example of Mali’s community radio that grew from less than a handful to more than 60 radio stations. On the same note, ITU shows the dominance of both radios and televisions in the continent. For instance, for every main (or fixed) telephone line, there are 14,000 radios and 2,500 televisions, respectively (1998). Wilson and Wong attribute radio dominance as the primary means of mass communication to low literacy rates, which range from 25% to 50% (2003).

b. New or Modern ICTs: Cellular Phones, Computers, and the Internet

New ICTs represented by cell phones, computers, and the Internet have shown remarkable growth from the beginning of the 1990s. Wilson and Wong show that cell phone sub-sector liberalization, by licensing several operators, has meant that all people of works of life are able to use it. This resulted in a near triple per capita cellular telephone penetration, from 0.16% to 0.39% between 1996 and 1999 (Wilson and Wong 2003). At this time, cell phone penetration in Africa exceeded fixed line with 53% of telephone subscriptions (ITU 2001). By 2006 and 2008, SSA’s cell teledensity had reached 27.48% and 32.6%, respectively (ITU 2007, 2009).

In the late 1990s, estimates show that slightly over three million personal computers (PCs) were spread unevenly across the continent. Citing ITU (1998), Wilson and Wong point out that over one-half of the over three million PCs in Africa were in South Africa, one-sixth in

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23 The current status has to be compared to the past when only the rich could afford and use cell phones.
Northern African countries, and the rest shared equally between Nigeria and the remaining countries (2003). The preceding translates to a PC penetration rate of 3.8% in South Africa, 0.5% in North Africa, 0.5% in Nigeria, and 0.3% in the remaining SSA countries taken together (ITU, 1998). Another ITU report puts South Africa’s PC penetration rate at 8.4% and Nigeria’s PC penetration rate at 0.91% as of 2005 (2008). ITU (2009) indicates that Seychelles and Mauritius are leaders in SSA with percentage of household computer ownership of 30% and 28%, respectively.

Despite improvement in Internet connectivity, the sub-sector has lagged behind that of other new ICTs. With the first African country getting connected to the Internet in 1992, all countries in the continent were connected by 2000 (Jensen 2000; Eko 2004). Wilson and Wong show that Internet users grew substantially in SSA, with estimates in some countries showing growth rates of up to 15% per month (2003, 158). Wilson and Wong identify the period between mid-1996 to the end of 1998 as the periods in which the number of countries connected to the Internet more than doubled. In particular, these two periods (i.e., mid-1996 and end of 1998) witnessed 20 countries and then 49 countries attaining Internet connections of one megabit per second (Mbps), respectively. During the same period, countries with Internet circuits of 64 bps increased from 1 in 1996 to 59 in 1998 and maximum access costs dropped from US$240 per month in 1996 to US$100 in 1999 (2003, 159). At the end of 2008, ITU states that the African continent had more than 11 million Internet subscribers and over 52 million Internet users (2007). About 32 million of the 52 million Internet users in the continent belong to SSA. This translates to penetration rates of 4.2% in Internet users, 0.9% in cell phone broadband subscriptions, and 0.1% in fixed broadband subscriptions in SSA (ITU 2009).

Outside South Africa, Eko (2001, 482) states that Burkina Faso was one of the first African countries to recognize the potential role of the Internet as a tool of development by incorporating it into its development plan.
Other ICT infrastructures such as wireless technologies (i.e., fixed (non-mobile), cellular telephones, and microwave links\textsuperscript{25}) have also spread. This has been possible since these new technologies leapfrogged high costs associated with fixed lines and were easy to install. Where this happened, the cost of telecommunications services decreased by half as bandwidths doubled. Other benefits from these technologies arose from the fact that once networks are built and configured for data transmission (to carry voice traffic); they “are much more efficient than voice configured networks” (Wilson and Wong 2003, 159).\textsuperscript{26}

c. Sub-Saharan African Regional ICT Diffusion

Wilson and Wong state that the above-named ICTs have spread unevenly across Africa (2003). As expected, the Southern Africa region (inclusive of South Africa) has the dense network of old and new technologies. As a pioneer country, South Africa has (on average) 20 times more main telephone lines, 10 times more PCs, and twice as many home satellite antennas as the rest of SSA (Wilson and Wong 2003, 160). Earlier (from 1998 to 2000), the East and South led with respect to the Internet but the trend changed so that from 2001 onward the West took the lead (Wilson and Wong 2003). However, for cell phone and television, West Africa has led consistently. They identify deeply-rooted structural variables such as the kind and type of economic – sectoral and income (as represented by GDP) differences, price, and regulatory regimes – and political conditions as accounting for the above differences.

A recent ITU report shows that a few SSA countries dominate percentage of cell phone subscriptions. The leading SSA countries are Nigeria (26\%) and South Africa (19\%). Others are

\textsuperscript{25} A microwave link is a transmission device which allows video/audio/data to be sent using radio waves between two locations from just a few feet to several miles apart. Television broadcasters commonly use it to transmit a program across the country, for instance, from an Outside Broadcast back to the studio (http://encyclopedia.thefreedictionary.com).

\textsuperscript{26} For further discussion, see ITU (2009), McKenzie (2007, 1), Gyamfi (2005, 22-23), and Jensen (2000).
Kenya (7%), Ghana (5%), Tanzania (5%), and Ivory Coast (4%). The rest of the SSA countries share the remaining 34% (ITU 2009, 5). In terms of regional distribution of the 32 million Internet users in SSA, Nigeria leads with 10.9 million Internet users while only six other SSA countries surpass one million Internet users each. In terms of penetration rates, leading countries are Seychelles (38%) and Mauritius (30%). In fact, these two countries are the only SSA countries with penetration rates above the global average of 23% (ITU 2009). Other African countries (non-SSA) surpassing the global average are Tunisia (27%) and the Indian Ocean island of Reunion27 (27.4%) (Internet World Stats 2009).

Finally, Wilson and Wong state that, despite promising growth of ICTs in Africa, the overall performance vis-à-vis the rest of the world is still low (2003). For instance, they state that while Africa’s World Wide Web growth had made startling progress, with annual Internet host growth rates of 85% between 1994 and 1997, one study reported that Africa’s total web sites, as a share of the world’s total, fell from 0.25% to 0.22% in the same period. Overall, ITU states that SSA continues to lag behind the rest of the world in ICT penetration rates (ITU 2009). This has many implications for the continent’s performance in the New Economy.

B. ICT Development in Kenya

I. A Historical Overview

Prior to 1977, the telecommunication sector in Kenya was part of the larger East African regional network administered under the East African Community (EAC). With the collapse of the EAC, the Government of Kenya established Kenya Posts and Telecommunications Corporation (KP&TC) to run its postal and telecommunication sectors.28

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27 Administrative unit of France.
28 Also, see Evusa (2005, 51-6).
In 1997, the government, at the instigation of the World Bank’s Structural Adjustment Programs, produced the telecommunication policy statement embodying the vision to guide the development of the telecommunication sector from a monopoly to a liberalized telecommunication market by the year 2015. This policy statement ushered in reforms in the management of telecommunications issues in the country. These reforms included separation of roles in sector management (policy and regulation), liberalization (creation of a multi operator environment and competition), and privatization (PKF Consulting Ltd & International Research Network [P&I] 2005, 2). Accordingly, the government split the existing public monopoly (i.e., KP&TC) into three separate entities: Telkom Kenya Limited (Telkom), Postal Corporation of Kenya (Posta), and the Communications Commission of Kenya (CCK).

Posta remains fully owned by the government. Its specific role is to ensure universal access of postal services. Telkom, established under the Company Act, Laws of Kenya, has universal requirements in its license as well as obligations to provide interconnection facilities to other licensed operators (P&I 2005, 2). Currently, the government has minority shares in Telkom. CCK, established following the enactment of Kenya Communications Act (1998), serves as a regulatory body to both the postal and the telecommunications sectors in the country. It regulates prices, establishes interconnection principles, approves equipment, and manages radio frequencies (Muiruri 2007). Additionally, the National Communication Secretariat, a division in the Ministry of Information and Communications, serves as the government’s info-communications sector policy advisory arm.

Several structural changes that brought the above reforms include redefinition and clarification of roles for policymaking, market regulation, dispute resolution, and operation of services among multiple players (P&I 2005). In turn, the above reforms led to growth in
telephones (both fixed and cell), teledensity, Internet, Public Data Network Operators, and satellite communication services. Table 3.1 shows comparable ICT indicators per 100 persons. Compared to neighboring countries, Kenya has a superior position with regard to fixed and cell phone teledensities and Internet users per 100 inhabitants. However, it lags behind the global ICT indicators and SSA’s fixed line teledensity.29

<table>
<thead>
<tr>
<th></th>
<th>Fixed telephone</th>
<th>Cell phone</th>
<th>Internet users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kenya</td>
<td>0.68</td>
<td>43.64</td>
<td>8.70</td>
</tr>
<tr>
<td>Uganda</td>
<td>0.5</td>
<td>31.4</td>
<td>7.8</td>
</tr>
<tr>
<td>Tanzania</td>
<td>0.3</td>
<td>26.8</td>
<td>1.3</td>
</tr>
<tr>
<td>SSA</td>
<td>1.4</td>
<td>31.8</td>
<td>4.2</td>
</tr>
<tr>
<td>World</td>
<td>19</td>
<td>59</td>
<td>23</td>
</tr>
</tbody>
</table>


2. **Fixed and Cell Telephone Growth**

Fixed line telephone growth has increased since the government liberalized the telecommunication sector in 1997. Figure 3.1 shows that fixed exchange capacity exceeds fixed line subscriptions. For the period 1998-99 and 2006-07, the average growth change for fixed exchange capacity was 23%, while that of fixed line subscriptions was 0.03%. The number of people on the waiting list has been uniformly decreasing over the same period. The rise in the use of cell phones during the same period explains the increasing variance between fixed line capacity and fixed line subscription connections. This gap (i.e., unused capacity) equaled 34.79% at the end of the 2006-07 fiscal year. Provincial estimates from CCK show that, as of December 2008, the number of fixed line subscriptions continued to drop (2009).

The number of people on the waiting list declined manifold between June 1999 and June 2009. The decline after June 2006 is highly visible. Two reasons explain this decline. First is the

29 For further discussion on ICT performance in Uganda and Tanzania, see Bertolini, et al. (2002).
rise in the number of fixed telephone subscriptions between June 2006 and June 2007 because of the roll out and restructuring of the state telecom monopoly (CCK 2007). Second is the increase in the use of cell phones; cell phones are easy to obtain and most individuals would prefer to have a cell phone rather than a fixed line. Overall, the growth in fixed and cell sectors is crucial to the development of other telecommunication services such as the Internet (CCK 2004; Muiruri 2007, 77).

![Figure 3.1. Changes in fixed line exchange capacity, subscribers, and waiters in Kenya, 1999-2009](source)

Source: CCK (2006, 2009, 2010). Data are as of June each year.

Tables 3.2 and 3.3 show international outgoing and incoming telephone traffic in minutes for eight African countries. Kenya’s ratio of incoming to outgoing traffic varied from a factor of one to five during the 1998-99 to 2006-07 fiscal years. The difference between outgoing and incoming traffic reflects the disparities in tariffs, while international outgoing call traffic has been reducing due to other means of traffic transfer available (P&I 2005). Tables 3.2 and 3.3 also show that other African countries experience similarly unequal traffic flow patterns. Liberalization, competition, and other tariff rebalancing measures have had the impact of
increasing the magnitude of international outgoing calls, especially up to 2005-06. However, due to the introduction of alternative means of calling (e.g., Voice over Internet Protocol – VoIP), international outgoing calls (and by extension costs) have continued to decline.

The data in Figure 3.2 show a phenomenal growth in the number of cell phone subscribers. The number of subscribers grew from a paltry 15,000 in June 1999 to 11,986,007 in March 2008. By December 2008 and December 2009, the number had reached 16,233,833 and 19,364,559 subscribers, respectively. In turn, these numbers represent a cell phone penetration rate of 43.64% and 49.7%, respectively (CCK 2009, 2010). The tremendous growth in cell phone penetration, since its introduction in 1992, is attributed to reduced connection fees (e.g., low handset and connections fees and denomination calling cards), increased consumer coverage as a result of an increased number of cell phone service providers, and packaging of services (P&I 2005, 7; CCK 2010). With a low (49.7%) cell phone penetration rate there is still a potential for its growth.

Table 3.2. Changes in international outgoing telephone traffic (in thousands of minutes) in selected African countries, 2001-2006

<table>
<thead>
<tr>
<th>Country</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egypt</td>
<td>223,000</td>
<td>268,000</td>
<td>289,000</td>
<td>397,000</td>
<td>449,000</td>
<td>502,000</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>13,000</td>
<td>13,000</td>
<td>14,000</td>
<td>18,000</td>
<td>21,000</td>
<td>29,000</td>
</tr>
<tr>
<td>Kenya</td>
<td>21,035</td>
<td>26,298</td>
<td>26,496</td>
<td>29,635</td>
<td>42,558</td>
<td>46,957</td>
</tr>
<tr>
<td>Mauritius</td>
<td>36,000</td>
<td>37,000</td>
<td>43,000</td>
<td>61,000</td>
<td>66,000</td>
<td>60,000</td>
</tr>
<tr>
<td>Nigeria</td>
<td>61,000</td>
<td>87,000</td>
<td>113,000</td>
<td>218,000</td>
<td>323,000</td>
<td>…</td>
</tr>
<tr>
<td>S. Africa</td>
<td>510,000</td>
<td>439,000</td>
<td>427,000</td>
<td>415,000</td>
<td>515,000</td>
<td>…</td>
</tr>
<tr>
<td>Tanzania</td>
<td>9,371</td>
<td>11,786</td>
<td>14,000</td>
<td>17,000</td>
<td>19,000</td>
<td>…</td>
</tr>
<tr>
<td>Uganda</td>
<td>7,000</td>
<td>28,000</td>
<td>38,000</td>
<td>32,000</td>
<td>39,000</td>
<td>…</td>
</tr>
</tbody>
</table>

Note: (…) indicates unavailable data.
Table 3.3. Changes in international incoming telephone traffic (in thousands of minutes) in selected African countries, 2001-2006

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egypt</td>
<td></td>
<td>818,000</td>
<td>1,036,000</td>
<td>1,082,000</td>
<td>1,288,000</td>
<td>1,743,000</td>
<td>...</td>
</tr>
<tr>
<td>Ethiopia</td>
<td></td>
<td>43,000</td>
<td>34,000</td>
<td>55,000</td>
<td>134,000</td>
<td>200,000</td>
<td>240,000</td>
</tr>
<tr>
<td>Kenya</td>
<td>56,298</td>
<td>36,235</td>
<td>121,832</td>
<td>146,946</td>
<td>157,836</td>
<td>109,000</td>
<td></td>
</tr>
<tr>
<td>Mauritius</td>
<td>56,000</td>
<td>63,000</td>
<td>69,000</td>
<td>100,000</td>
<td>120,000</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>Nigeria</td>
<td>238,000</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>S. Africa</td>
<td>600,000</td>
<td>812,000</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>Tanzania</td>
<td>9,370,612</td>
<td>39,586</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>Uganda</td>
<td>12,683,235</td>
<td>44,000</td>
<td>46,000</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td></td>
</tr>
</tbody>
</table>

Note: (…) indicates unavailable data.

In addition to meeting their targets as laid out in their licenses, the two existing cell phone operators added new areas as dictated by business considerations and industry growth (CCK 2006). The cell phone market revenue for Kenya stood at US$941.51 million in June 2007. Market success in the cell phone sub-sector is reflected in the 2006-07 pre-tax profits (equivalent to US$275.96 million) of one of the two cell phone service providers at the time. These pre-tax profits represented the highest pre-tax profits ever of a private company in East Africa (Kang’aru 2008).

Figure 3.2. Growth in cell phone subscribers in Kenya, 1999-2009

30 Safaricom and Celtel (now Zain, part of India’s Bharti Airtel) were cell phone operators at the time.
31 Using the Central Bank of Kenya’s exchange rate on April 18, 2008. The same rate is used throughout the research.
After 1999, the introduction of competition following the licensing of two cell phone operators heralded competition that led to a decline in the cost of both cell phone handsets and airtime. In turn, declining costs led to higher cell phone subscriptions compared to the early years (i.e., 1993-1999), where the elite were the lucky few to own “luxurious” cell phones. So far, with four licensed cell phone providers in Kenya, cell phone subscriptions have grown. At the same time, tariffs have continued to drop while customer services have both broadened and improved tremendously (CCK 2009).

The dominance of the cell phone sub-sector over the telephone sector is exhibited in Table 3.4. That is, at the end of December 2009, the cell phone sub-sector represented 96.64% of the total telephone users in the country. The fixed wire line and wireless sub-sectors share the remaining 3.36% of the total market share. Further, while initially short message system (SMS) communications showed a very large growth, CCK states that in December 2008 there was a decrease in growth compared to the previous periods. For instance, between June 2006 and June 2007, SMS grew by 57% to reach 315,557,601 total messages (CCK 2007). The fluctuation in the number of SMS sent over the years is partly attributed to a reduction (and at times promotional packaged service fees) in voice tariffs, whereby subscribers chose to use voice calls over SMS to communicate (CCK 2010).

<table>
<thead>
<tr>
<th>Phone Service Type</th>
<th>No. of Subscribers</th>
<th>Market Share (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed Wire Line</td>
<td>243,656</td>
<td>1.22</td>
</tr>
<tr>
<td>Fixed Wireless</td>
<td>429,289</td>
<td>2.14</td>
</tr>
<tr>
<td>Cell Phone</td>
<td>19,364,559</td>
<td>96.64</td>
</tr>
<tr>
<td>Total</td>
<td>20,037,504</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Source: CCK (2010).
a. Public Payphones

Public payphones in Kenya are of two types: fixed and community payphones. Fixed payphones provide universal service, and installation is the responsibility of the state telecoms company (Telkom Kenya Ltd – partially owned by the government). In addition, cell phone service providers eager to tap into a wider customer base introduced community payphones beginning in the 2003-04 fiscal year. Community payphones are operated by individuals and are available in convenient and strategic points for public use. They are found on streets, where individual operators offer ready accessibility to users. Figure 3.3 shows the changes in the number of lines for the two types of payphones. Fixed payphone growth has experienced a uniform decline, while community payphones, which showed initial growth, have also declined. Reasons for the general decline include the increasing affordability cell phone handsets, lower cell phone calling charges, increased cell phone network coverage, and diminished returns in the fixed telephone sub-sector stemming from market competition and other dynamics (CCK 2007, 19). As of December 2008, the latest CCK provincial estimates show that there were 5,210 fixed payphones in service. No estimates for community payphones are available.

![Figure 3.3. Payphones roll out trends, 1999-2009](image)

b. Teledensity

Figures 3.4 and 3.5 show Kenya’s network and coverage areas, respectively, in green and dark purple for the two leading cell phone service providers. Figures 3.4 and 3.5 indicate that highways and most urban hierarchies are covered. The prevailing coverage areas follow high-density human settlements. As of December 2009, CCK states that population and land coverage were 84.5% and 34%, respectively (CCK 2010).

Kenya’s total versus fixed line teledensity from 2002-2010 are shown in Figure 3.6. The figure shows that total teledensity has increased manifold, while fixed line density has remained comparatively steady during the same period. However, owing to the huge increase in cell phones subscriptions, total teledensity has risen from a meager 2.94% in 2001-02 to 45.29% in December of the 2008-09 fiscal year (Note that cell phone density is 43.24%). With existing potential for more cell phone service subscriptions, total cell phone teledensity is expected to continue to contribute more to the total teledensity than fixed line.

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32 Teledensity, as used here, refers to the number of telephone connections per 100 inhabitants.
33 Other cell phone service providers are Telkom (Orange brand) and Econet Wireless.
Figure 3.4. Safaricom network and coverage (in green)
Figure 3.5. Zain network and coverage (in dark purple)
In Table 3.5, which shows fixed teledensity per region (i.e., provinces) as of June 2003, Nairobi region leads with a high teledensity of 7.92%. With the exception of the coastal region (teledensity of 1.43%) where Mombasa (the second largest city) is located, the other regions have less than 1.0% teledensity. In addition, fixed line distribution, as expected, is concentrated in Nairobi, with 58.36% of the total subscribers in the country. The coast and Rift Valley regions follow with 12.27% and 10.86%, respectively. In both fixed line teledensity and distribution, CCK states that the same pattern has persisted over the years (2003).  

The persisting fixed line teledensity is attributed to the steady increase in population over the years. I have no reason to believe this will change much in the future unless deliberate efforts including population control and more investments in related infrastructure are implemented.
Table 3.5. Fixed line teledensity and distribution Kenyan by region, June 2003

<table>
<thead>
<tr>
<th>Region/Province</th>
<th>Number of Lines</th>
<th>Teledensity*</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nairobi</td>
<td>191,202</td>
<td>7.92%</td>
<td>58.36%</td>
</tr>
<tr>
<td>Central</td>
<td>21,837</td>
<td>0.52%</td>
<td>6.67%</td>
</tr>
<tr>
<td>Eastern</td>
<td>16,645</td>
<td>0.32%</td>
<td>5.08%</td>
</tr>
<tr>
<td>North Eastern</td>
<td>2,380</td>
<td>0.22%</td>
<td>0.73%</td>
</tr>
<tr>
<td>Coast</td>
<td>40,184</td>
<td>1.43%</td>
<td>12.27%</td>
</tr>
<tr>
<td>Western</td>
<td>6,948</td>
<td>0.18%</td>
<td>2.12%</td>
</tr>
<tr>
<td>Nyanza</td>
<td>12,840</td>
<td>0.26%</td>
<td>3.92%</td>
</tr>
<tr>
<td>Rift Valley</td>
<td>35,590</td>
<td>0.45%</td>
<td>10.86%</td>
</tr>
<tr>
<td><strong>Kenya</strong></td>
<td><strong>327,626</strong></td>
<td><strong>1.04%</strong></td>
<td><strong>100.00%</strong></td>
</tr>
</tbody>
</table>


Note: *based on CCK (June 2001) data.

Table 3.6 shows that the bulk of fixed line telephones are concentrated in urban areas: the average ratio of urban to rural fixed lines for the 11 years under review is 22. Nairobi’s share of the urban connections is large compared to other urban areas. With the ratios showing signs of widening, this means that narrowing the rural-urban divide in fixed telephone connections would likely require some form of external or government intervention.

Table 3.6. The number and ratio of the urban and rural fixed telephone connections in Kenya

<table>
<thead>
<tr>
<th>Year*</th>
<th>Totals</th>
<th>Nairobi subscriptions</th>
<th>Urban Connections*</th>
<th>Rural Connections</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>291,706</td>
<td>164,986</td>
<td>278,280</td>
<td>13,426</td>
<td>21</td>
</tr>
<tr>
<td>2000</td>
<td>312,086</td>
<td>171,092</td>
<td>294,600</td>
<td>17,486</td>
<td>17</td>
</tr>
<tr>
<td>2001</td>
<td>322,234</td>
<td>181,386</td>
<td>303,996</td>
<td>18,238</td>
<td>17</td>
</tr>
<tr>
<td>2002</td>
<td>329,154</td>
<td>186,487</td>
<td>309,866</td>
<td>19,288</td>
<td>16</td>
</tr>
<tr>
<td>2003</td>
<td>328,358</td>
<td>185,000</td>
<td>309,070</td>
<td>19,288</td>
<td>16</td>
</tr>
<tr>
<td>2004</td>
<td>299,226</td>
<td>…</td>
<td>284,264</td>
<td>14,962</td>
<td>19</td>
</tr>
<tr>
<td>2005</td>
<td>278,867</td>
<td>…</td>
<td>264,509</td>
<td>14,358</td>
<td>18</td>
</tr>
<tr>
<td>2006</td>
<td>293,364</td>
<td>…</td>
<td>279,079</td>
<td>14,285</td>
<td>20</td>
</tr>
<tr>
<td>2007</td>
<td>263,122</td>
<td>…</td>
<td>251,924</td>
<td>11,198</td>
<td>23</td>
</tr>
<tr>
<td>2008</td>
<td>252,615</td>
<td>…</td>
<td>246,927</td>
<td>5,688</td>
<td>43</td>
</tr>
<tr>
<td>2009</td>
<td>247,972</td>
<td>…</td>
<td>240,533</td>
<td>7,439</td>
<td>32</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>22</td>
</tr>
</tbody>
</table>


Notes: *the data are as of June each year; (…) indicates unavailable data; *Inclusive of Nairobi connections.
3. Internet Development in Kenya

In Kenya, like other parts of Africa, the Internet was introduced in the early 1990s as a demand-driven technology. That is, Kenyans returning from studies overseas, Western expatriates, and personnel from international governmental organizations and non-governmental organization demanded the Internet and were the first to use it (Muruiki 2000). A study by the Center for International Development and Conflict Management (CIDCM) at the University of Maryland – college Park, indicates that since its emergence in 1992, the number of people using the Internet mainly for e-mail grew to 100 and 3,000 by 1995 and 1996 in the Nairobi area, respectively (1998). By 1998, there was an average of 10,000 Internet users. According to a CCK Internet Market Study, there were an estimated 2,770,296 Internet users at the end of the 2006/07 fiscal year (2007). At the end of December 2009, there were almost four million Internet users (CCK 2010) (see Table 3.1 for ICT sector-related growth trends).

The growth of the Internet is closely associated with the emergence and growth of commercials ISPs. With KP&TC’s ISP monopoly ending in 1994, African Regional Computing Center (ARCC) was the first Kenyan-licensed ISP in 1995. Subsidized by an Overseas Development Agency (ODA) grant, ARCC primarily served non-governmental organizations. In 1996, another two commercial ISPs – Africa Online and Form-Net – were launched to offer both dial-up and content services. At the time, the cost of accessing leased lines, *inter alia*, was exorbitant, but with reforms and associated competition, the costs fell by 96.8% between 1998 and 2004 (Muiruri 2007). In turn, this led to significant reduction in consumer connectivity fees, thus a large growth in Internet users. In 1998, there were 16 ISPs, eight of which had full Internet services. In the same year, KP&TC established Jambonet, designed to support 24 ISPs, due to
the need for a national Internet backbone by the faster growing ISPs and Internet users expecting to benefit from the Internet boom.

To date, other major ISPs are Nairobinet, Insight Technologies, Net2000, and Telemedia Communications. In 1999, ISPs formed an association, Telecommunication Service Providers Association of Kenya (TESPOK), with the aim of growing Kenya’s telecommunications industry. A few years later, TESPOK, through negotiation and lobbying, succeeded in establishing the Kenya Internet Exchange Point (KIXP), the first Internet exchange point in SSA, outside South Africa, to provide cheap and high bandwidths.

Muruiki underscores that private ISPs have no universal service obligations except their licence targets (2000). In 1999, existing ISPs had 750 telephone lines, while public access points were estimated at 160. Most of the Internet users were served by over 1,000 Internet cafés and telephone bureaus (P&I 2005). Currently, such Internet cafés and telephone bureaus are found not only in Nairobi but also in secondary towns and small outskirts (Muiruri 2007). CCK states that Internet backbone providers, ISPs, and Internet cafés, as a group, contributed US$80.34 million (in 2007) in revenue. CCK further states that, of the preceding amount, 20 active ISPs alone contributed US$29.07 million, up from US$8.42 million from the active 16 ISPs the previous year (2007). Recent CCK provincial estimates show that revenue from Internet services was approximately US$37.57 billion at the end of 2008. Benefits accruing to firms from the use of the Internet for international e-mail communications and for long-distance telephone and fax, the latter achieved via Voice over Internet Protocol (VoIP).

However, compared to other ICTs, the Internet is the least accessed (CCK 2007). At the end of December 2009, Internet penetration remains low with a penetration rate of 10.2% (CCK

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35 The regulatory commission, Communication Commission of Kenya (CCK), has licensed 127 ISPs but only 50 were active at the end of 2008 (CCK 2009).
It also shows very high-density usage (90% of users) in Nairobi and Coast provinces. In terms of economic sectors, the commercial and education sectors account for 80% and 1% of Internet users, respectively (CCK 2007, 23). As of the end of 2008, the leading cell phone service providers launched wireless broadband services using third generation (3G) technology (CCK 2009). Internet bandwidth capacities grew from 9.6 Kbps at its introduction to 759 Mbps in 2007 (CCK 2007). The launch of SEACOM undersea fiber optic has increased Internet bandwidth manifold to 1.28 Terabytes per second (Mwakio 2009).

A number of factors continue to impede Internet development in Kenya. These include insufficient backbone infrastructure required for Internet development such as fixed line teledensity, commercial power, and PC density of 1%, 8%, and 0.7%, respectively (Muruiki 2000). Worse yet, the large urban bias in teledensity is likely to continue (see Tables 3.5 and 3.6 for teledensity and distribution). Other constraints are the low literacy rates of both general users and technicians.

4. Development of Other ICTs

Kenya’s regulatory commission (CCK) states that other ICTs have also grown in the recent past. These include Local Loop Operators (LLOs), Public Data Network Operators (PDNOs), and Very Small Aperture Terminal operators (VSAT). Others are Voice over Internet Protocol (VoIP) and fiber optic. Local Loop Operators (LLOs) are small operators licensed regionally to complement fixed line services by providing the “last miles” in specific districts. Thus, LLO traffic is only limited to a given district level. As of June 2006, CCK had licensed 19 LLOs to provide fixed telecommunication services at the last mile. With the total 25,038 new

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36 See Appendix C for the chronology of the significant milestones in Kenya’s early Internet development.
37 For further discussion, see CIDCM (1998), Oyelaran-Oyeyinka and Adeya (2004), and Muruiki (2000).
fixed phone subscribers, two active local loop providers (i.e., Flashcom and Popote Wireless) had 3,995 subscribers, a 15% market share (2006). Recent CCK estimates show that, over the years, the combined subscriber base of LLOs has decreased so that by December 2008 only 9,908 fixed line telephones were associated with the active LLOs. Serving only the urban areas, the total subscribers (i.e., 9,908) were divided among business (5,647) and residential (4,261) customers. In addition, LLOs continue to provide Internet for as little as US$40 (CCK 2009). The most recent estimates are unavailable.

Satellite communication services in the form of private VSAT operators have also grown (see Figure 3.7). The growth of private VSAT terminals using local hubs have grown faster than private VSAT terminals that use foreign hubs. This latter trend shows that Kenya is beginning to invest in satellite communications services. Local companies and foreign subsidiaries carry out new VSAT investments in the country.

![Figure 3.7. Changes in cumulative number of private VSAT in Kenya, 2002-2008](source: CCK (2007). Note: Data as at June of each fiscal year.)
Public Data Network Operators (PDNOs) have also grown in Kenya. CCK indicates that at the end of June 2007 the active PDNOs had 4,639 subscribers (2007). The same report further indicates that generally the growth performance of the PDNO sector has been sluggish. However, with recent enthusiasm and massive investments in fiber optic networks, the PDNO sector anticipates a very large growth. For instance, the launch of SEACOM undersea fiber cables in 2009 was a big boost in the PDNOs sector. A number of fiber optic networks already exist in the country. Kenya Data Network, a leader in the data services sector, boasts the largest network coverage, with 115 towns covered in the country, including 400 buildings with fiber cable connection in Nairobi and 50 in Mombasa. Other metro areas covered are Kisumu, Eldoret, Thika, and Nakuru (KDN 2009; see Appendix B). In the end, the current enthusiasm and massive investments in fiber optic network development will facilitate more broadband access and faster high-speed data transfers to commercial, residential, and other customers (CCK 2007, 23).

At the end of December 2008, CCK estimates also showed that incoming VoIP minutes were 6,979,693, while outgoing VoIP minutes were 696,274. Compared with the previous quarter (September 2008), these represented growths of 2,314% and 93.2% of incoming VoIP and outgoing VoIP minutes, respectively (CCK 2009). By allowing users to make calls directly from a computer, VoIP service has led to reduction in telephone costs to individuals and firms. Premium rate services also witnessed growth. This service serves utility and bank customers by enabling them to access the status of their bills and accounts, respectively. The service can also be used to conduct polls and competition by FM and TV stations, among others. Finally,

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38 Other undersea fiber cables are The East African Marine Systems (TEAMS) and Eastern African Submarine Systems (EASSy). Kenya Data Network reduced the prices by 90% on Internet and international connectivity upon the launch of SEACOM (www.kdn.co.ke).
business processes outsourcing (BPOs) has also grown.\textsuperscript{39} Kenya’s BPO and call center society shows that there were more than 16 BPOs and call centers as at the beginning of 2010.\textsuperscript{40}

5. \textit{Sectoral ICT Users}

\textbf{a. Broad Economic Sectors}

CIDCM states that the intensity of Internet uses by different sectors of the economy shows wide variation (1998). The service sector, comprised of tourism, finance, and banking, leads in Internet usage. Import and export businesses and the industrial sectors follow services sector in dominance (Muruiki 2000). The agricultural sector has lagged behind because of expensive and less reliable communication in areas outside Nairobi, which makes the cost for agricultural applications on the Internet simply too high (Muruiki 2000, 8).

Comparing the private and the public sectors, the former owns over 70\% of all web sites and shows a higher level of PC density and Internet connectivity. With the major of Internet high connectivity possessed by companies with international businesses, the private sector is the main driver for Internet sustainability (Muruiki 2000). Within the private sector, the non-governmental organizations and media publishing sub-sectors shows the highest rates of Internet connectivity. The public sector, represented by government line ministries and quasi-governmental corporations (or parastatals), lags behind and has varied Internet connectivity and usage. Generally, the public sector has a low penetration of PCs and limited Internet connection and web presence. The quasi-governmental corporations, however, enjoy better penetration of PCs and have higher propensities for Internet connection. Current efforts by the government in enhancing e-government show promise for improving the use of the Internet in the public sector.

\textsuperscript{39} BPO entails contracting operations and responsibilities of specific business services (e.g., legal and accounting) to a third-service provider.

\textsuperscript{40} See http://www.kenyabposociety.or.ke.
Finally, low Internet use is disadvantageous to the national economy. These disadvantages include less efficient means of production because of the inability to benefit from network externalities (both direct and spillover effects) and inability by firms to increase accessibility to merchandise, reduce delivery time, and compare prices. The latter leads to business decisions that are only partially-informed. Generally, these all lead to slower national and regional economic development.

b. ICTs and Small- and Medium-Size Enterprises (SMEs)

Moyi states that SMEs in developing countries operate both in imperfect markets and in incomplete information environments characterized by limited awareness of markets, technology, policy, regulations, and finance (2003). As such, many scholars fear that information (especially with respect to new technologies ICTs), a precondition for enterprise creation, growth, and survival, may bypass the sector. Moyi further states that adequate information flow, which must take into account “organic information systems” and “indigenous knowledge,” is important for making contacts, checking prices, displaying goods and entering into contracts (2003, 222). In this case, ICTs, by blending with local knowledge, contribute significantly to the economy and quality of life in developing countries. He illustrates with a project in Pondichery (Southern India), where implementation was preceded by in-depth study of users and their requirements in order to understand the state of existing communication habits and channels in the project areas (Ibid., 223).

From his study, Moyi found that government, non-governmental, and community-based organizations offer limited business advisory services to the SME sector. Evidence from his study showed that only seven enterprises (8.5% of the total sample) were getting business-related
information from formal institutions such as government corporations, NGOs, and donor agencies. With lack of business-related information from formal institutions, informal networks proliferate to fill the void.

Moyi also shows that ICT connectivity in the SME sector, as determined by the presence of crucial infrastructure (e.g., electricity and telephone), the regulatory environment, and poor managerial capacity is low. These events have restricted cheap transmission of information, thus inflation of business costs. In turn, this has led to the production of less competitive products from the SME sector. In terms of Internet, he states that a paltry 6.7% of the enterprises he interviewed had access. Worse still, Internet access tends to concentrate in the larger enterprises. Moyi warns that this inequality does not empower rural communities and other marginalized populations to use ICTs for their development concerns. Unless innovative concepts (e.g., telecenters) are implemented, he argues, the resultant growth is likely to be “inequitable, disharmonic, and asymmetric” (Moyi 2003, 230).

c. Internet Use at Institutions of Higher Learning

Muiruri states that efforts to facilitate educational institutions to access and use the Internet were spearheaded by the government and donor organizations (e.g., USAID Leland Initiative, President Clinton’s Greater Horn of Africa Initiative – GHAI, and later Education For Democracy and Development Initiative – EDDI) (2007). However, she notes that by 1999, only the University of Nairobi and the United States International University – Nairobi Campus could afford to pay US$4,500 per month for a 64-Kbps leased line. Some of the remaining 21 Kenyan universities could only afford dial-up services for their academic staff. Later lobbying and coalition building between most university vice chancellors, KP&TC, the Kenyan government,
and USAID led to the establishment of the Kenya Education Network (KeNet), with all represented universities becoming charter members. Much later, the rest of the universities became interested in joining, with the expectation of enjoying Internet access at affordable rates (Muiruri 2007, 76).

In their study, Oyeleran-Oyeyinka and Adeya examined different Internet uses, users, and various constraints users face by administering questionnaires and carrying out in-depth interviews of university teachers and professors (2004). They found that most of the respondents (90.7%) had used the Internet in the previous one to five years, spending an average of one to two hours per day. Specific uses of the Internet, in rank order, were as follows: e-mail (85.7%), academic research (79.6%), teaching materials (57.1%), and current affairs (51.0%). Others were networking with peers (34.7%), publishing work in progress (12.2%), sports and other entertainment (8.2%), e-commerce (4.1%), and other (10.2%) (2004, 75). According to Oyeleran-Oyeyinka and Adeya, problems in the financial sector range from underdeveloped local e-commerce for those who want to make online purchases, higher access costs for online commerce, lack of credit cards, and poor financial services. In particular, domestic financial institutions’ stringent requirements of a healthy bank balance and above-average income compound the lack of credit cards (Murelli and Okot-Uma 2002, 97-100). In addition to lack of appropriate legislative framework in the country and the general problems of an underdeveloped financial sector, the lack of credit cards has led to low e-commerce usage (Waema 2007). Oyeleran-Oyeyinka and Adeya also found that the main sources of Internet access are institutional, private (home-based), and/or public through Internet cafés. Institutional Internet provision is limited to e-mail rather than full Internet access (2004, 77).
With respect to the determinants of Internet use, Oyeleran-Oyeyinka and Adeya found that broadly, connectivity infrastructure, costs, ease of use and skills, and physical infrastructure constrain the use of the Internet in that order of severity. In the Likert scale of one (not severe) to five (very severe), telephone costs and Internet subscription fees both scored an average of 2.93. Availability of Internet connections, access points (PC) availability, connection speed, and telephone access scored 3.13, 2.53, 3.41, and 3.06, respectively. Language of content scored 1.90, which was the lowest. Compared to the Nigerian score of 0.73 in the same comparative study, language of content (in this case, the use of the English language) seems a minimal barrier, if not negligible.

Oyeleran-Oyeyinka and Adeya further explain that the low language of content score is supported by history: both countries are former British colonies and the medium for educational instructions for all ages is primarily the English language. Besides, given that academic credentials of the respondents were high (i.e., university teachers and professors), it can be argued that language of content score was expected to be lower. These findings support the need for training aimed at enhancing computer skills. Nevertheless, the authors do not attempt to qualify or explain why there is a big difference between the Nigerian content language score and that of Kenya, given their background similarities. Finally, given that universities are the gatekeepers of advanced technologies as well as the first users of the Internet in most countries, these findings suggest that, unless the state support system is increase, “Internet penetration will remain a problematic proposition in poor countries” (Oyeleran-Oyeyinka and Adeya 2004, 81).
C. Digital Divide: Current Development Dilemma

1. Defining the Digital Divide

Digital divide, a term attributed to Larry Irving,\(^{41}\) originates from the divisive aspect of ICTs and takes different forms. Broadly, it refers to the gap between those who benefit from digital technology (ICTs) and those who do not (ITU 2001). At the citizens’ level, the digital divide represents the existing gap between citizens who are advantaged or disadvantaged by ICTs (Rogers 2001; Sukkar 2004). Rogers, writing on the digital divide within the U.S., states that past definitions of the digital divide have broadly included access to telephones, personal computers, or the Internet based on socio-economic characteristics of the individuals involved: race, gender, age, income, and education (2001). Dasgupta, Lall, and Wheeler found that the prevailing digital divide reflects the persistent gaps in the available main telephone lines. It is crucial to point out that when they wrote their findings, the main telephone line was still the major conduit to the Internet (2001). Selhofer and Huesing (2002) and Rogers (2001) state that the measure of digital divide is represented conventionally by the latest technology available (i.e., the Internet).\(^{42}\)

2. Causes of the Digital Divide

Several reasons are responsible for the digital divide. First is that access to the Internet by any user is directly related to PC ownership and telephone connection. This means that disparities (or lack thereof) in owning or accessing a PC and a telephone connection translate directly to disparities (or lack thereof) in access to the Internet (Rogers 2001). Here, Internet

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\(^{41}\) Larry Irving works (or worked) with the United States Department of Commerce’s National Telecommunications and Information Administration – NTIA (Hackler 2006; U.S. Department of Commerce 2002). Nevertheless, “as a good idea often has many parents,” Colby recognizes Lloyd Morrisett, former President of the Markle Foundation as the originator (2001, cited in Rogers 2001, 108).

\(^{42}\) For further discussion, see Fuchs and Horak (2008, 100-102).
access is inhibited by the costs of purchasing and maintaining a PC and paying the installation and monthly cost of a telephone connection. This captive scenario, however, has been alleviated in some circumstances by technological advances that now provide alternatives to PCs and telephone connections for Internet access.

Second, Rogers concludes that in the United States demographic variables relate directly to telephone and PC ownership, and thus Internet access (2001). A 1999 NTIA report estimated that the telephone, a basic technology and a requirement to access the Internet, showed a huge ownership disparity with respect to demographic composition of the United States’ population. For instance, 50% of female-headed households living at or below the poverty line and 43.5% of families who depend totally on public assistance had no access to telephones. Other demographic characteristics – household incomes and age – determine access to and use of the Internet. For instance, disability in the form of impaired vision, a lack of manual dexterity, or any other physical disability, as well as race, language, and other characteristics, determine Internet access and use.

Third, what is now just an Internet access-divide, if not narrowed through deliberate efforts, can evolve into some other divides: “learning-divide or a content-divide or some other disparity (based on citizens’ ability to use the Internet in certain ways),” if it is not narrowed through deliberate efforts (Rogers 2001, 100). Rogers argues that this is likely when the rate of Internet adoption reaches that of the telephone (about 94% of Americans) or that of television (about 98%) (2001, 103). He notes that, given that skills and complexities related to the Internet are higher, the resultant divides might be more harmful than the present one. Sukkar adds that it
may deepen the “development divide among countries and within countries,” which in turn may “threaten political peace among countries and societal peace within countries” (2004, 27).  

3. Major Types of the Digital Divide

a. The Global or International Digital Divide

Hargittai found that, despite the number of Internet users having grown drastically from approximately 20 million users worldwide in 1995 to 520 million users in 2001, less than 10% of the world’s inhabitants had ever used the Internet (2003, 14). On his part, Wallsten argues that existing evidence shows people in richer countries have better access to ICTs and use them more intensively than do people in poorer countries (2003). Explained by higher per capita income, Internet usage and number of users is higher and growing in rich countries (especially North American and OECD countries). This phenomenon has raised worries that, with the Internet being accessed differently by different people across the world, the development gap is widening between the rich and the poor countries.

Several efforts have fostered ICT investment. Wallsten states that several institutions (e.g., United Nations agencies especially ITU and UNDP, InfoDev at the World Bank, G8’s Task Forces, ITU, and World Economic Forum) have stressed the need to narrow the digital gap between poor and rich countries (2003). This bridging entails encouraging poor countries to build ICT infrastructures through some kind of direct provision, investment, or demand-push from government use (Wallsten 2003). This developmentalist approach advocates investments in telecommunications infrastructure and government support, but within an efficiently regulated private sector and a liberalized and competitive environment (Eko 2004).

For further discussion, see Servon (2002, 11-16).
i. **Extent of Global Digital Polarization**

Several comparative proxies can be used to explain the extent of the digital divide.\(^{44}\) Nua Ltd’s 2002 report showed that of the 606 million people using the Internet: 30% resided in Canada and the United States, 32% in Europe, 31% in the Asia-Pacific region, and the remaining 7% in Africa, Middle East, and Latin America, taken together (2002 cited in Pohjola 2003). Pohjola, using ITU 2002 data, notes that “while every second person was online in North America, only four persons in a thousand were connected to the Internet in South Asia and nine in a thousand in Africa” (2003, 8). ITU (2007) reports that for every Internet user in Africa there were about six Internet users in North America.

Dasgupta, Lall, and Wheeler used a digital Lorenz curve plot\(^{45}\) of Internet connectivity (subscriptions per capita) versus the percentage of the population of 55 countries to show severe inequalities in the global digital divide (2005). They estimated that 90% of the world’s Internet subscribers resided in countries whose population represented 15% of the global total. They note that with this imbalance likely to persist, the future development prospects of many low-income countries are in jeopardy (2005, 230).

Rodriguez and Wilson calculated the Index of Technological Progress (ITP) to estimate the extent of the digital divide between developed and developing economies (2001). In itself, ITP indicates the common source of variation as a composite of five indicators of technological outputs: personal computers, Internet hosts, fax machines, mobile phones, and televisions. In turn, ITP growth has a positive relationship with investment rate, public spending in health and education, civil liberties and democracy, (log of) GDP, human volition, institutional arrangements, and policy choices (Rodriguez and Wilson 2001, 13). Rodriguez and Wilson’s

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\(^{44}\) The reader is advised that these comparative proxies show the past and present extent of the digital divide.

\(^{45}\) This will be discussed in detail in Chapter IV.
2001 estimation shows that, even with an upward bias, the level of the ITP, ranging from zero to 100, does not show an encouraging performance for developing countries. The United States and other OECD countries occupied the top of the ITP scale, while SSA countries occupied the last ten positions. In particular, Mozambique occupied the very bottom of the scale.

Additionally, Rodriguez and Wilson state that calculation of the World Gini coefficient\textsuperscript{46} for Technological Progress can shed light on the extent of disparity between different countries (2001). In their 2001 study, they note that the World Gini coefficient for Technological Progress deteriorated considerably from 0.67 to 0.78 between 1992 and 1997.

Roche and Blaine, using millions of instructions per second (MIPS) to measure various countries’ ICT capacities, showed in their 1997 estimates that most of the developing world suffered from an “MIPS gap ratio” in the range of 1:26 with the developed world. Additionally, Hanna suggested in 1991 that, while developing countries represent around 80% of the world’s population, their ICT expenditure as a percentage of the total global expenditure on informatics is a paltry 2%. Even more, Pohjola, in his 2003 study, showed that the spending of the world’s seven richest countries on R&D and related new innovations accounted for about 90% of the world total, leaving 10% to be shared by the rest of the world (2003).\textsuperscript{47}

Cukier highlights several reasons that explain why countries outside the United States, and especially OECD countries, route most of their Internet traffic through the United States (2003).\textsuperscript{48} Explanations for this dominance of the United States’ Internet infrastructure include the lack of regional infrastructure such as low-cost and high-speed international circuits and the lack of dominant regional interconnection points to exchange traffic. The implications of this are twofold. First, the Internet traffic travels longer connection distances rather than direct routes,

\textsuperscript{46} This will be discussed in detail in Chapter IV.
\textsuperscript{47} For a comparison of Asian and non-Asian countries’ ICT development, see Wong (2002).
\textsuperscript{48} For further discussion, see Quibri et al. (2002, 11–14).
and, second, the Internet traffic travels on an international link, with local ISPs paying prices to United States-based carriers. Disappointed with this manifestation, Cukier christens this a U.S.-centric Internet: an Internet that is not global, but centered in the United States. He characterizes the system and its disparities as bandwidth colonialism.

Cukier further highlights how the flow of Internet traffic shows disproportionate bandwidth capacities whether measured in megabits or gigabits per second. Country-to-country flow in 2003 indicated the maximum link between any two European countries was under 450 megabits per second (Mbps), while U.S.-bound bandwidth was over 3.5 gigabits per second (Gbps). The rest of the world’s capacities lagged behind the two regions above. Wade also talks of United States’ and major global firms’ privileges in Internet access and telephone connections over the rest of the world, with the latter relegated to operate at cost disadvantages in the two technologies.\(^\text{49}\)

The Internet Traffic Report uses its “traffic index” to show the speed and reliability of connections (2009). Updated every five minutes, the “traffic index” is a score from zero to 100 with zero being “slow” and 100 being “fast.” It is determined by comparing the current response of a ping echo to all previous responses from the same router over the past seven days. Depending on the recorded responses, a score of zero to 100 is assigned to the router. The only router in Africa (Gauteng in South Africa) registers an average score of 65 compared to North America’s and Europe’s 91 and 81, respectively. At the same time, Asia, Australia, and South America, on average, record 74, 83, and 87, respectively. The same source notes that the Global Index stabilizes at 85. Overall, the low scores for Africa and parts of Asia mean that these regions experience slow and less stable Internet traffic.\(^\text{50}\)

\(^{49}\) For further discussion, see Wade (2004, 195-198).
\(^{50}\) For further clarification, see http://www.internettrafficreport.com/. Accessed on July 3, 2009, at 13:45 hours.
Finally, Cukier underscores the need for more regional bandwidth, lower prices, robust
competition, and international cooperation to create central regional hubs for routing Internet
traffic. Several authors agree that these issues should be tackled by broader institutional
cooperation among the private sector, government, and academia at all geographical scales
(Cukier 2003, 12; CIDCM 1998, 12; Wade 2004).

\textit{ii. Africa’s Status in the Global Context}

Despite the fact that Africa’s growth in ICTs is robust and developing, Wilson and
Wong\textsuperscript{51} state that existing literature shows Africa is trailing other developing regions and does so
from a very low base (2003). Arguing that Africa’s growth is not uniform, they note that with
12\% of the world’s population in the early 1990s, SSA had only 2\% of global telephone lines.
By 1997, the situation had deteriorated, as SSA’s share declined to only 0.8\% (quoting ITU
meager 0.1\% in 1998 (Oyeleran-Oyeyinka and Adeya 2004, 68) to reach the current 5.34\% (ITU
2009). Internet World Stats estimates that Africa’s Internet penetration at the end of March 2009
was 5.6\%. At this penetration rate, Africa’s share of global Internet users is only 3.4\% vis-à-vis
its share of the world population (14.5\%).

Besides the presence of Internet connectivity in all African countries, connection in most
cases must pass through an industrialized nation (usually its former colonial power). In other
words, with the exception of continental interconnection traffic points in South Africa, Namibia,
and Swaziland, interconnection traffic points are outside the continent. To illustrate, Cukier gives
an example of Benin and Burkina Faso, two West African countries that share a common border,

\textsuperscript{51} Citing Freepong and Atubra (2001).
yet whose traffic travels via France (for the former) and Canada (for the latter).\(^\text{52}\) However, this is likely to change as the public and the private sectors collaborate to invest in new ICT infrastructure such as the fiber optic cable.

Additionally, Africa invests a paltry amount in telecommunications infrastructure – an infrastructure arguably the main backbone towards narrowing the digital divide (Dasgupta, Lall, and Wheeler 2005). For instance, Wilson and Wong show that between 1994 and 1998, Africa invested only US$1.7 billion vis-à-vis the US$95 billion invested in the telecommunications sector worldwide (2003). They lament that this happened despite the relative profitability of telecommunications investments, especially the telephone, in the continent. Given the evidence that the benefits of ICT progress are very real for people who gain greater access, there are fears that the whole of Africa may be eclipsed by the pace of the revolution in other regions. If this happens, it implies that there will be grave consequences for the continent’s inhabitants.\(^\text{53}\)

**b. Intra-National or Regional Digital Divide**

Literature on intra-national digital divides is scarce. Therefore, this section will review literature that is available in developed and the developing countries. In the developed countries (e.g., Australia, Canada, and the United States) and the developing countries alike, the need to focus on the intra-national divide stems from the desire to attain universal service provision. In Africa, universal service (or access) means a telephone is available either within a certain geographical radius or within a particular density of population (Pitt and Niall 2003). Recent liberalization of telecommunication services, however, is feared to have reduced chances of

\(^{52}\) For further discussion, see Wade (2004, 195-198).

\(^{53}\) For further discussion, see Wilson and Wong (2003, 162-163).
attaining universal service (or access) to ICTs since market-driven investments may bypass markets where financial returns are potentially low.

Madden and Coble-Neal argue that state monopolies have implemented universal service provision primarily directed towards persons located in rural and remote areas (2003). In this arrangement, revenue pools from more profitable services subsidize universal service provision. This has been necessary because several barriers limit the spread of telecommunications into rural and remote areas. These barriers include inadequate backbone infrastructure, lack of awareness of the benefits of ICT use, relatively less-educated communities, high costs of rolling out services due to the dispersed population, and high prices coupled with the predominance of low-income households, all of which exacerbate affordability. Using Australia as an example, Madden and Coble-Neal further state that personnel training and provision of specialized ICT services costs are approximately ten times those of acquiring and servicing a PC for Internet access (2003, 254).

Madden and Coble-Neal identify several economic, technological, and social variables as determinants of Internet subscriptions in rural and remote regions of western Australia. Citing the Australia Bureau of Statistics, they note that high-income households are three times more likely to have an Internet subscription, while households with a resident less than 18 years of age are 1.5 times more likely to subscribe. Furthermore, while household Internet connection rates are, on average, 20% lower than rates in non-metropolitan areas, they have been growing. Similarly, the rate of Internet subscription on farms is directly related to the distance from the nearest town (2003, 255). Similarly, the authors found that firms (64%) are more likely to subscribe to the Internet than either farms (41%) and households (38%). They also found that

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alternative local Internet access points are possible via telecenters or libraries (20%), workstations (15%), associates’ accounts (13%), or Internet cafés (3%). Madden and Coble-Neal conclude that policies must consider both the supply- and demand-side approaches (2003).

Though the United States has the world's highest ratios of hosts per capita, a digital divide in the form of computers and computer skills still exists (Warf 2001). This creates fear that some citizens are disadvantaged to compete equally in the New Economy. He further states that the United States’ Internet geography is centered mainly on large metropolitan areas, a pattern that follows concentrations of affluent users associated with very large economies of scale and high rates of profit. In addition, such metropolitan areas have high Internet connections and high-capacity fiber-optic lines, while many other areas (such as low-income areas in the Midwest and the rural South) have few connections. Nationally, Warf states that five states (California, Texas, Virginia, New York, and Massachusetts) and five metropolitan areas (San Francisco, Dallas, Chicago, New York, and Washington/Baltimore) contain one-half and one-third of all Internet hosts in the United States, respectively (2001). In terms of computer ownership (a prerequisite to ready access), variation ranging from a high of 55% in Alaska to a low of 20% in Mississippi exists among states. Household incomes determine the divide. For the most part, rural households lag behind urban households and, as such, on average, a metropolitan resident is twice as likely as a rural one to be connected to the Internet at home or school.

In China, the standard of living reflects the existing level of regional economic development. The southern provinces and coastal areas’ standard of living surpass those of the western regions by a large margin. Similarly, Meng and Li state that China, with its spatial vastness, is characterized by a “degree of informatization” that is very uneven across the country (2001). To elaborate on the pattern of adoption and diffusion of ICTs, they compared the
changing patterns of GDP per capita and per capita investment in ICT in three major Chinese regions (western, central, and eastern). Meng and Li show that China’s GDP per capita changed slightly and with the same degree of disparity for the three regions (2001). That is, between 1997 and 1999, the change in ratios of GDP per capita among the three regions was from 1 to 1, 1.29 to 1.28, and 2.32 to 2.39 for the western, central, and eastern regions, respectively. For the same period, ratios of per capita investment in ICT in the three regions changed from 1 to 1, 1.1 to 0.754, and 2.64 to 2.13, respectively. Meng and Li assert that, if these levels of investment are the drivers of the ICT-based New Economy, then heavy ICT investments in the eastern region may further accentuate the development gap vis-à-vis the other regions (2001, 10). Meng and Li also note that in terms of the new ICT-indicators (i.e., Internet, e-commerce, and wireless technologies), the disparity among the three regions is obvious (2001). For instance, the telephone penetration rate in 1999 was 5.53% in the western region, 7.58% in the central region, and 15.41% in the eastern region. At the same time, the same three zones had 0.56%, 0.14%, and 0.18% of Internet users as a percentage of total population, respectively.

c. Intra-Metropolitan or Urban Digital Divide

Graham denounces the notion of “death of distance,” or the “end of geography” that, on the one hand is founded on a global economic, cultural, and social space that is “one click away” or exemplified by a “cyberspace that is cast as a single, unitary, and intrinsically unifying electronic space” (2002, 35) and on the other, is “unreal.” In other words, Graham reminds us that cities in the global information age also exhibit processes and practices of intensifying urban polarization. This phenomenon distances the powerful from the less powerful at all scales and is experienced globally and across all aspects of human activity.
Graham articulates evidence that the societal diffusion of ICTs has remained starkly uneven at all scales, but with more pronounced unevenness in cities and other concentrated human settlements. He notes:

In cities, clusters and enclaves of “super-connected” people, firms and institutions, with their increasingly broadband connections elsewhere (Internet, mobile phones, satellite TVs) and their intense access to information services, often rest cheek-by-jowl with large numbers of people with non-existent or rudimentary communications technologies and very poor access to electronic information (2002, 34).

In India, Madon states that the integration of Bangalore into the global network has made it the fastest growing city in India with a global focus on high manufacturing, research and development, software engineering, and advanced call center investments serving a global customer base (1997). Alongside the global role the city is playing, growing and intensifying inequalities have resulted. And, while the past disparities emanated from the colonial era, Madon concludes that the current disparities are “based on participation in the information-intensive global economy by a core elite and non-participation by masses” (Madon 2004, 309). She states that the upsurge of high manufacturing industries have attracted more people to migrate to the urban area to work in these industries. In their participation in the new urban economy, they are forced to live in informal settlements devoid of basic physical and social infrastructural services. Similar patterns have been witnessed in Lima, Peru, and Singapore (Graham 2002).

For his part, Castells notes that while the global economy will grow substantially in the 21st century following the improvements in telecommunications and information processing. He further argues that these opportunities are being configured unevenly within and between geographies of space (1998). This is because the search for profit-making opportunities will be selective, “linking valuable segments and discarding used up or irrelevant locales and people” (Castells 1998, 21 cited in Graham 1999). James highlights that the same disparities have been
noticed in the Philippines, a country that supposedly leapfrogged fast (1998). Thus, James concludes that “foreign rather than locally-owned enterprises, urban rather than rural areas, and those who make long-distance rather than local telephone calls have benefited more” (1998, 53).

Graham gives four reasons for urban polarization. These reasons relate to how ICTs:

- *Extend the power of the powerful.* As pointed out by Rogers (2001), access to ICTs is based on the socio-economic characteristics of the individuals involved. This means that those who are highly skilled, have adequate disposable income and backbone infrastructure, and speak the “appropriate” language will undoubtedly be key beneficiaries of the ICT revolution.

- *Underpin intensified unevenness through tying together international divisions of labor.* Due to the advancement in ICTs, factors of production, and specifically, capital, are mobile compared to the past. Capital owners (e.g., TNCs) exploit geographical differences as they search for enclaves where they can reap maximum returns. The unparalleled choice and flexibility derived from ICTs enables TNCs to construct a highly elaborate division of labor that is integrated in “real time.” As TNCs do this, they differentiate and disperse their operations to different enclaves around the world. In the end, the preceding results in city regions that are characterized by mosaics of intensifying unevenness and products of cherry picking of hot spots.\(^{55}\)

- *Allow socio-economically affluent groups to bypass the local scale, selectively.* Beyond the local divide characterized by dual urban societies, the affluent urban residents, with the aim of maintaining dominance, extend and intensify their access to distant places. This selective bypassing of immediate constraints is possible since ICTs such as the

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\(^{55}\) These include the downtown business districts, high-tech spaces, media clusters, and upper-income residential districts of prosperous, internationally-oriented and global cities (Graham 2002, 40).
Internet can be connected to distant services, social groups, and people across local, national, or international boundaries without any fear or risk.

- **Culturally and economically causes biases, especially in terms of the international marketplace.** Graham decries the “commodification” of cyberspace with items that are culturally biased. Worse yet is that this involves the centralization of electronic economic power by a smaller number of people, institutions, and places. This has led to a hegemonic landscape where northern corporations, affluent metropolitan elites, and leading firms and elites in the developing countries control production systems and almost all aspects of life. Hargittai argues that this is possible since “gatekeepers” who control Internet information block the flow of some material while allowing other information to pass through (2003).\(^\text{56}\)

4. **Need to Address the Digital Divide**

Access to ICTs has varied consequences for nations and people worldwide. Wilson asserts that these consequences pose a threat to those citizens who, for one reason or another, are denied access to participation in the globalized New Economy because they lack access to ICTs (2004). As such, Myrdal’s cumulative causation theory, which questions neo-classical stable equilibrium, is useful in explaining how differences in technological endowment (in this case, access to ICTs) are likely to frustrate efforts towards convergence. The inability of some people within and between countries or regions to access some technologies is likely to work against them vis-à-vis those who do have access to such technologies. James states that ICTs can create a global economic environment in which Myrdalian patterns of cumulative causation operate

most intensively (2002, 61). This is worrisome since lack of technology, or the inability to adopt and use it, will cause more divergence in the globalized New Economy, where price (hitherto the main determinant of competitiveness) is no longer sufficient. In other words, other competing variables such as increasing product quality, timeliness, flexibility, and rapid and continuous innovation have come to prevail.\(^\text{57}\)

James further illustrates this phenomenon using the textile and clothing industry whereby, due to electronic document interchange (EDI), factories in East Asia are linked with their New York headquarters. This process has enabled the East Asian textile and clothing industry to remain competitive. Unsurprisingly, East Asian countries have benefited more than other developing countries since they have been steadfast in diffusing information technology abundantly in their economies. In the case of African countries, however, though they have surplus labor, Myrdal states that they will be excluded from emerging competition unless they prioritize ICTs. In Myrdal’s terms, these excluded countries will suffer from “backwash effects” as more advanced countries adopt ICT use with vigor (James 2002, 63). Even more worrying is that this phenomenon can be self-reinforcing in a process of cumulative change.

**D. Summary**

This chapter has reviewed literature on the development of ICTs and the digital divide with a focus on Africa and Kenya. It has been shown that there is low development of both the old and the new ICTs across Africa compared to developed and NICs countries. Similarly, regional disparities in ICT development are observable across the continent. The failure of the old technologies and the rise of economic globalization along with accelerated international

\(^{57}\) Citing OECD (1993, 98).
competition mean that the need for an information revolution in Africa cannot be overemphasized.

In the Kenyan case, this review has shown the historical development of ICTs. The review has also shown that a number of reforms were initiated by the government of Kenya (under the watch of the World Bank) to address several structural bottlenecks in the telecommunications sector. In turn, these reforms led to the growth of fixed, cell, Internet, and other ICTs in the country. There was also been a decline in the cost of equipment acquisition and calling and an increase in penetration rates across socio-economic groups in the country. In terms of regional teledensity, Nairobi and other major urban regions are pitted against the rural areas. A similar pattern is witnessed with respect to the development of other ICTs.

This chapter also reviewed literature on the digital divide. The review includes arguments for the need to address the digital divide, its causes, and major types. Several socio-economic, infrastructural, and geographic variables explain the extent of the digital divide. The review cites major types of the digital divide as global (or international), intra-national (or regional), and metropolitan (or urban) digital divides. The next chapter reviews various studies that have modeled the digital divide using non-spatial and spatial regression. It also covers the methodology employed by the research to explore the extent and determinants of the intra-national digital divide in Kenya.
CHAPTER IV: MODELING THE DIGITAL DIVIDE AND RESEARCH

METHODOLOGY

This research focuses on Kenya by carrying out a detailed regional-level study of the potential and challenges of ICT development. It investigates the extent and determinants of the intra-national digital divide in Kenya. The first part of the chapter reviews studies that have modeled the digital divide. This review is important to highlight the various dependent and explanatory variables used in modeling the digital divide. The second part outlines the strategy the research employed in collecting and analyzing data, beginning with the data frame and choice of variables. It then proceeds to describe data sources, data types, choice of analytical techniques, and data analysis.

A. Modeling the Digital Divide

This section reviews studies that have examined the digital divide by employing ordinary least squares (OLS) and spatial analysis at different geographical scales: local-level (e.g., zip code), regional-level (e.g., counties and provinces), and global (i.e., cross-country). These studies have used different variables to measure ICT diffusion and use. For instance, these variables include log-transformed counts of domain registrations (a measure for the spatial dimensions of Internet activity) (Grubesic 2002), the number of broadband providers (Grubesic and Murray 2004), and the percentage of firms with registered second-level domain names in a given province as a measure for Internet diffusion (Bonaccorsi, Piscitello, and Rossi 2005). Existing literature shows that these proxies and others have been regressed on socio-economic and demographic, infrastructural, and geographic variables.
1. **Descriptive Analysis**

Using data surveys from several developing countries, McKenzie highlights how youth (14-25 years) accounted for a larger proportion of new ICT users, especially for the Internet and more advanced features of cell phones such as text messaging, also known as short messaging service (SMS). For instance, in 2005, his data survey showed that youth accounted for 43% of all Internet users age 15 and older in China, 50% in Armenia, 53% in Bolivia, 60% in Egypt, 61% in the Kyrgyz Republic, and 70% in Indonesia (2007, 2). He further notes that other factors such as level of urbanization, education, and household income enhance youth’s use of ICTs (e.g., computer, cell phone, Internet, and SMS). For example, they show that in Indonesia, 59% of university students had used the Internet and 95% of them had used SMS, compared with 5% or less among youth with only primary education. Similarly, Halewood and Kenny, using data surveys from several countries, confirm that youths are the leading adopters and users of the new ICTs (2008). More still, their use is enhanced by higher educational levels and urban living.

2. **Concentration Analysis**

Concentration analysis is achieved by calculating the Herfindahl-Hirschmann Index (HHI) and the Gini index (or coefficient). Generally, concentration analysis describes the distribution of a quantitative character inside a statistical population. A *null concentration* means equal distribution (or absence of the divide) when all units hold the character with the same modality, while *maximum concentration* arises when only one unit centralizes *all the character* and the rest hold nothing (in this case, maximum digital divide). In theory, both indices lie between 0 and 100. The existing literature indicates that concentration analysis is useful for both static and dynamic analysis. When used for dynamic analysis, it sheds light on the potential
diffusive effect of the Internet (or any technology, for that matter) (Riccardini and Fazio 2002; Bonaccorsi, Piscitello, and Rossi 2005).

Riccardini and Fazio point out that, overall, measuring the digital divide involves criteria concerning *infrastructure access, human capabilities, knowledge and education, and IT expertise* (2002, 2). *Infrastructure readiness* involves measurement of fixed telephone density, cell density, PC density, and Internet host density or secure servers density. *Socio-economic enablers* to use the Internet include Internet access cost, levels of education, computer or digital literacy, and ICT penetration (e.g., computer and other ICT technologies’ diffusion to households, businesses, and government). Once the preceding variables have been identified, an estimation of the *concentration ratio* (Gini coefficient) as a measure of the presence or absence of the digital divide can then be constructed. As an illustration, Bonaccorsi, Piscitello, and Rossi found the distribution of the second level country top-level domain (ccTLD) to be more concentrated than the population: ccTLD’s HHI was 0.0418 versus population’s HHI of 0.0215. Similarly, the ccTLD’s Gini index of 0.567 versus population’s 0.429 showed the same pattern of concentration (2005, 5).\(^{58}\)

3. **Non-Spatial Regression Models (i.e., Ordinary Least Squares – OLS)**

Saunders, Jeremy, and Wellenius show that the *telephone index* had a positive relationship with the *development support index* (1994). The *telephone index* was constructed using three measures of telephone availability and use. First was the number of telephones per 100 literate persons over 15 years of age as an indicator of the availability of telephones to the

\(^{58}\) A second level domain name comes after country code top-level domain (ccTLD – e.g., .ke for Kenya) and best corresponds to the type of activity the owner engages in. For instance, educational institutions typically have .edu or .ac to the left of the ccTLD. A Kenyan educational institution will have .edu.ke or ac.ke.
population. Second was the number of business telephones per 100 agricultural workers as a measure of telephone penetration in the telecommunications-intensive sectors of the economy. Third was the average number of telephone calls per telephone as a measure of intensity in the use of telecommunications services. The *development support index* was defined in terms of capital expansion and quality of the work force, both of which, they noted, were essential ingredients of development. Under capital formation, Saunders, Jeremy, and Wellenius included GDP used in fixed capital formation and the value of gross fixed capital formation per capita. Under the quality of labor variables, they included the literacy rate for those over 15 years of age, the median number of years of education of the population as a measure for quality of educated labor, and per capita intake of protein and calories as a measure for health. Other variables were per capita expenditure on education, the proportion of the population that is urban, and population growth rate (low rates being considered favorable for development).

Similarly, in a benchmark cross-country study carried out under the auspices of the International Telecommunication Union (ITU), Saunders, Jeremy, and Wellenius showed that high correlation coefficients indicate a strong relationship between telephone density (as the dependent variable) and GDP per capita (as the explanatory variable). The $\beta$ coefficient of 1.4 in their study meant that if GDP were to grow by 5% per year, telephone density would grow, on average, by 7% per year (Saunders, Jeremy, and Wellenius 1994, 89). Later analysis using mixed time-series and cross-sectional data yielded findings not significantly different from the above. They noted the observed high correlations and how this translates to disparities between developed and developing countries (vis-à-vis the level of telecommunications investments and
levels of GDP). Their findings suggest that investments in the telecommunications sector and economic growth occur in tandem.\textsuperscript{59}

Kraemer, Dedrick, and Shih modeled the level of information technology (IT) investment from 1985-1995 for 31 developed and developing countries. The explanatory variables were the national wealth (measured by GDP per capita), structure of the economy (particularly the size of information-intensive sectors such as finance and business services), IT infrastructure (including human resources and telecommunications networks), and price or performance of IT, hardware, software, and services (2000). Their analysis showed that a country’s economic structure and level of wealth were the main drivers for IT investment. The other variables – telecommunications penetration, education levels, and prices – did not provide additional explanatory power in estimating IT investment.

Lee examined the complementary role of human capital (measured by average years of schooling) and technology imports (measured by machinery imports and foreign direct investments – FDI) on technology diffusion (measured by annual average growth rate of total factor productivity – TFP) for 59 developing countries (2001). His results show that initial human capital stock has a positive and significant effect on technology growth. Foreign direct investments and machinery imports also have a positive effect on technology growth, but with a statistically insignificant coefficient. The statistically significant impact caused by the interactions of human capital with the two measures of technology imports (machinery imports and FDI) individually, are also of particular interest. The latter results imply that the level of technology adoption and diffusion depends on the magnitude of human capital stock available in the economy.

\textsuperscript{59} Nonetheless, they caution that this correlation should not be treated explicitly as causation.
In addition, Lee found a significant positive relationship between the level of human capital and ICTs as measured by PCs per 1,000 people and main telephone lines per 1,000 people. He adds that raising the level of education by one standard deviation (2.8) raises the number of PCs per 1,000 people and main telephone lines per 1,000 people by about 50 and 0.7, respectively (2001). His results further showed that human capital had a significant effect on the number of cellular phone subscribers, cable TV subscribers, and Internet hosts. Finally, when breaking down human capital into primary, secondary, and tertiary education levels, he found that the relationship is more significant for both secondary and tertiary education than for primary education.

When studying a sample of 89 countries, Casseli and Coleman II regressed the log of computers per worker (as a measure for investments in information and communication technologies) on the log of real income per worker, log of investment per worker, share of agriculture in GDP, and share of manufacturing in GDP (2001). Other explanatory variables included the share of government in GDP, the level of property rights on a scale of 1-10, the fraction of the population that speaks English, human capital (the labor force over 15 years of age who have completed primary education), the log of imports per worker (as a measure of trade openness), and the level of education (measured by primary, secondary, and tertiary education). Among the above explanatory variables, the log of income per worker, the log of investment per worker, the level of education, the share of agriculture in GDP, and the log of imports per worker all returned significant results. Other variables, notably property rights protection, a limited role of government, and a large share of manufacturing in GDP appeared to accelerate computer adoption. Surprisingly, the share of the population that speaks English inhibited computer adoption.
Kiiski and Pohjola employed the Gompertz model\textsuperscript{60} to estimate the level of Internet hosts per 1,000 inhabitants for the period 1995-2000 in 60 OECD and developing countries using several explanatory variables (2002). These variables included level of income (measured as GDP per capita), costs of Internet access, telecom competition, average years of schooling, and English proficiency (measured as the percentage of pupils in secondary education learning English). They found that the first two explanatory variables – GDP per capita and Internet access costs – were powerful determinants of the level of ICT diffusion. Telecom competition and education level turned out to be insignificant predictors of Internet diffusion.

Baliamoune-Lutz, following Kiiski and Pohjola (2002), but focusing on a sample of 47 developing countries, estimated the level of ICT diffusion using the diffusion rate of four measures between 1998 and 2000. These proxies were the number of cellular mobile subscribers per 100 inhabitants, the number of personal computers per 100 inhabitants, the number of Internet hosts per 10,000 inhabitants, and the number of Internet users per 10,000 inhabitants (2003). Her explanatory variables included per capita income, levels of education and adult literacy, index of political rights, index of civil liberties, economic freedom, the financial liberalization indicator, and trade liberalization.\textsuperscript{61} Her results showed that, contrary to expectations, ICT diffusion was not associated with education, while freedom indices might or

\textsuperscript{60} The Gompertz model, after Chow (1983), is used to estimate the technology (e.g., ICTs) diffusion rate. The technology diffusion rate is a function of the log of the spread of technology between time \(T_2\) (post-diffusion time) and time \(T_1\) (initial time of diffusion) as indicated by \(T^*\) (i.e., \(\ln T_2 - \ln T_1 = \delta (\ln T^* - \ln T_1)\)) (equation 1). But \(T^*\) is a function of several exogenous variables \(X_j\). Thus, equation 1 can be re-written as \(\ln T_2 - \ln T_1 = \delta \beta_0 + \delta \beta_j \ln X_j + \delta \ln T_1 + \varepsilon_{12}\), where \(\varepsilon\) is white noise, \(\beta_j\) is the vector of beta coefficients, and \(\delta\) is the rate of diffusion.

\textsuperscript{61} The index of civil liberties is published by Freedom House (www.freedomhouse.org), while the economic freedom index is published by the Heritage Foundation (www.heritage.org). The financial liberalization indicator is defined as the ratio of broad money (M2) to GDP. Trade liberalization or openness is measured by the ratio of total exports to total imports in world prices and foreign direct investments (FDI). In contrast to Kiiski and Pohjola (2002), Baliamoune-Lutz excluded the Internet pricing costs arguing that they are incorporated into the economic freedom index.
might not affect ICT diffusion. The results showed that per capita income and government trade policies influenced ICT diffusion.

In their rural western Australian study, Madden and Coble-Neal used two measures – number of Internet subscriptions and number of hours spent online – to estimate ICT diffusion. For the Internet subscription model, they sampled 148 households, 29 farms, and 157 firms. For the households model, the following explanatory variables were used: distance between the respondent’s residence and the nearest town in kilometers (DISTANCE), the number of residing household members (PERSONS), annual income (INCOME), and a dummy variable SELF-EMPLOYED (= 1, if the respondent operates and owns the business; = 0, if otherwise). The farms model used the following explanatory variables: distance between the respondent’s residence and the nearest town in kilometers (DISTANCE), the number of residing household members (PERSONS), and two dummy variables, that is, TRAINING (= 1, if the respondent has vocational, trade, or tertiary qualification; = 0, if otherwise) and FAX (= 1, if the respondent owns a facsimile machine; = 0, if otherwise). The firms model used the number of full-time employees (EMPLOYEES), monthly communications budget (EXPENSE), number of installed communications lines (LINES), and the number of installed personal computers (PCs) as explanatory variables. Madden and Coble-Neal found that in the households model, DISTANCE, PERSONS, and SELF-EMPLOYED were key drivers. In the farms model, FAX and TRAINING were drivers of Internet subscriptions, while DISTANCE was an inhibiting variable. The firms model had PCs as the only significant determinant.

To model the number of hours spent online, Madden and Coble-Neal sampled 29 households, 41 farms, and 48 firms. For the households model, the following explanatory variables were used: PERSONS, average hourly cost of Internet access (PRICE), EXPENSE,
FAX. Their results show that PRICE and EXPENSE were inhibiting variables, while PERSONS and FAX had a positive influence on the number of hours households spend online. The farms model used the following explanatory variables: DISTANCE, FAX, PRICE, and TERTIARY (= 1, if the respondent is degree qualified; = 0, if otherwise) variables. Model results show that DISTANCE and FAX had a negative influence, while PRICE and TERTIARY had a positive influence on the number of hours farms spend online. The firms model had EMPLOYEES, LINES, INCOME, and PRICE as explanatory variables. Of the above explanatory variables, LINES enhanced the number of hours a firm would spend online. PRICE and EMPLOYEES seemed inhibiting variables. The β coefficient for INCOME was zero and lacked influence on the dependent variable.

Chin and Farlie examined penetration rates for personal computers and Internet per 100 inhabitants for 161 countries in the period 1999-2001 (2004). They regressed the two dependent variables, individually, on four broad groups of variables: infrastructure, demographic, economic, and measure of institutional policy. Infrastructure variables included main telephones per 100 inhabitants, electricity consumption as kilowatt-hour (kwh) consumption per capita, and two measures of Internet access (i.e., monthly telephone subscription charges and the cost of a three-minute call). Demographic variables included the share of population below 14 years of age and above 65 years of age and the share of urban population, the latter being a measure of the level of urbanization. Economic variables included gross national income per capita and the level of human capital as measured by the years of schooling or the illiteracy rate. Trade barriers and regulatory quality were measured by the ratio of the sum of exports and imports to GDP.

Chin and Farlie’s results show that main telephone density emerged as an important determinant of PC penetration, while electricity consumption had a marginal role in determining
PC penetration rates. The shares of the youth and senior populations had positive and negative contributions in determining PC penetration, respectively. The share of the urban population had an unexpected negative relationship with PC penetration. Results showed that both the gross national income per capita and human capital measures were powerful determinants of PC penetration. Finally, measures of institutional quality and policy (especially regulatory quality) showed a high level of significance. Trade openness turned out to be a negative determinant of PC penetration. With Internet penetration rates as the dependent variable, results show that electricity consumption, the share of the youth population, and the share of the urban population were statistically significant determinants at 10%. In addition, gross national income per capita and regulatory quality were also important determinants of Internet penetration. The human capital variable had an expected positive sign but was statistically insignificant.

Dasgupta, Lall, and Wheeler used a Gompertz technology adoption model to estimate two proxies for the digital divide: mainline Internet intensity (Internet subscriptions per telephone mainlines) and access to telecom services (mainline telephones per capita) for a sample of 44 countries (2005). Their explanatory variables included the log of the urban population, the log of income per capita, the log of competition policy index, the log of secondary education, governance index, and a regional dummy variable indicating 1 if a given country is located in Asia, Latin America, Middle East, North Africa, or Sub-Saharan Africa, or 0, if otherwise. Modeling results for Internet intensity as the dependent variable showed that the urban population and the competition policy index had positive and highly significant coefficients. Contrary to expectation, income level did not have a significant impact on the growth of Internet intensity. The governance index and secondary education did not return any significant results. Dasgupta, Lall, and Wheeler modeled the second dependent variable, access
to telecom services, and found a positive contribution for income per capita and the urbanization rate, but not for secondary education, the competition policy index, or the broader governance index.  

4. **Spatial Regression Models**

Grubesic regressed log-transformed counts of domain registrations (a measure for spatial dimensions of Internet activity) on a number of diverse socio-economic and demographic variables at the local level (zip code) and regional level (counties) for the State of Ohio (2002). The explanatory variables included household density (measure for settlement geography) and two variables – median income and county-level unemployment rates – as measures for socio-economic conditions at the county level. Other variables included a dummy variable of the presence (= 1) or absence (= 0) of a college or university to act as a “community or human capital” measure and interstate frontage in total miles, which acted as a general measure of access and local infrastructure. The last variable acted as a measure of the level of urbanization. It was a dummy variable of 1 or 0, depending on whether the county belonged to a Metropolitan Statistical Area or not, respectively.

By running the ordinary least squares (OLS) and the spatial model and incorporating spatial dependence in the modeling procedures, Grubesic found that there was an improvement in the Moran’s $I$ value and the elimination of the autocorrelation of residual values found in the OLS model. From his findings, he concluded that there was a marked disparity in Internet activity for the State of Ohio. He further suggested that, given temporal components, the Internet

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62 They used the same explanatory variables, except that the urban population was converted to the percent urban in the second model.
63 Moran’s $I$ is a measure of spatial autocorrelation, the latter meaning that adjacent observations of the same phenomenon are correlated in space.
activity currently exhibited in urban areas would eventually diffuse to more rural or peripheral areas over time. However, contrary to expectations, the development of the Internet has not led to the rapid decentralization of economic and social activities that was once predicted (2002, 384).

Grubesic and Murray modeled the number of broadband providers located in each U.S. zip code area on demographic, socio-economic, and geographic variables (2004). Population density and the percent white population acted as proxies for broadband market density and demographic composition, respectively. Median income and percent rent were used as measures of socio-economic status. In particular, percent rent (the share of housing under rental) was used to reflect more densely populated areas such as the downtown core, where much of the housing is rental based. Percent rent was also used to capture the suburban areas where multi-family housing and large apartment complexes have flourished over the past decade (2004, 155). In addition, urbanized area acted as a dummy variable where 1 meant a zip code area was a business district and 0 meant otherwise. A zip code area qualified as a business district based on the criterion of having fewer than 100 people but a significant day population. Finally, log-transformed computer expenditure was used to map the total expenditure, by zip code, on computers and computer peripherals for 2000 (2004, 156). The last variable implied that more computers indicated a better potential market for broadband providers or otherwise.

Grubesic and Murray ran the OLS and a spatial autoregressive model (SAR). In the latter, they added a spatial lag adjusted for any spatial effects in the data, since the basic test of spatial

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64 Citing Gillespie and Williams (1988) and Cairncross (1997).
65 In spatial-based regression, spatial lag involves the inclusion of a lagged dependent variable as an additional explanatory variable. This is where tests of spatial autocorrelation confirm that a dependent variable in a given location is influenced by both explanatory variables in the same location and by other variables in the neighboring locations.
autocorrelation yielded a significant global Moran’s I of 0.403. Their OLS results showed, first, that both the population density and the median income were significant and positive factors in explaining broadband Internet competition. Second, the percent white population was significant but with a negative coefficient. They interpreted this as evidence of an increased level of competition in the more urbanized areas (i.e., areas with a greater minority population and high business demand). Third, the rental variable was positive and significant, meaning higher urbanization implies higher levels of broadband competition. Last, the urbanization variable returned a positive coefficient and significant p-values. Thus, the addition of a spatial lag in the spatial model accommodated the local geographic relationships between competition and the explanatory variables.

Bonaccorsi, Piscitello, and Rossi modeled Internet diffusion in their Italian study ($N = 103$ administrative units or provinces), which used the percentage of firms with registered second-level domain names in a given province in 2001 as the dependent variable (2005). Explanatory variables included the ratio of the number of patents granted in given provinces and the number of firms in that province (PATENTS), the ratio between the number of scientific publications by university researchers in each province and the number of firms in that province (PUBLICATIONS), and the percentage of administrative local units (DISTRICTS). Other variables were the percentage of firms less than 10 years old (AGE), the percentage of firms in agriculture (= 0, below national average; = 1, if otherwise, STRUCTURE), the ratio of IT expenditure and the number of firms in that province IT_EXPENDITURE), and the index of infrastructural endowment (INFRASTRUCTURE).

Bonaccorsi, Piscitello, and Rossi also carried out further spatial dependence tests of the dependent variable. Spatial dependence tests included the global Moran’s I, local Geary’s C, and
Getis & Ord’s $G$.\(^{66}\) They used a SAR model to measure the average influence of the neighboring regions’ adoption of the Internet on each region’s adoption of the Internet. In general, the model results led Bonaccorsi, Piscitello, and Rossi to assert that adoption of ICT by each province $i$ is related to the adoption of ICT by the neighboring provinces, thus highlighting the existence of knowledge spillovers (2005, 8). In particular, they noted that the geographical distribution of domains is highly concentrated compared to both population and income. This concentration is shown by the calculated Herfindahl-Hirschman and Gini indices and the penetration rates of population and income. Finally, they found the following as having a critical role in explaining the local\(^{67}\) digital divide: traditional highly material investments (measured by IT_EXPENDITURE and INFRASTRUCTURE) and the level of knowledge available in a province – its absorptive capacity (measured by PATENTS and PUBLICATIONS). Firms’ characteristics (measured by AGE), regional spatial contiguity (measured by DISTRICTS), sectoral composition (measured by STRUCTURE), and distance from major urban areas were significant determinants of the penetration rate of registered domains as well.

Two key conclusions can be drawn from the above studies. First, various socio-economic, infrastructural, and geographical factors determine the extent of the digital divide. These broad explanatory variables determined the extent of the digital divide either individually or in an interactive manner. Second, a better or more comprehensive understanding of the digital divide phenomenon is achieved when spatial dependence, if significant, is incorporated in the modeling procedures. This is because spatial contiguity is important as diffusion flows across provinces or administrative units. Nevertheless, the spatial digital divide studies have focused on the United States (Grubesic and Murray articles) and Italy (Bonaccorsi, Piscitello, and Rossi

\(^{66}\) Geary’s $C$ and Getis & Ord's $G$ measure the level of spatial autocorrelation and local spatial clusters in group-level data, respectively.

\(^{67}\) Local digital divide means intra-national digital divide in this research.
2005). This research will address the void in the literature by focusing on a developing country, namely Kenya.

**B. Research Methodology**

1. *Data Frame and Choice of Variables*

   This study takes the 66 districts in Kenya as geographic units of analysis. Several variables described below were obtained for each of the districts (where data allowed). The data were collected in Kenya between June and September 2008. Follow-up data collection was carried out via e-mail.

   The resultant district-level aggregated data were placed in a dBase file with each row corresponding to a district and each column representing one of the identified variables. The dBase file was merged with a geographical base file of Kenya’s district boundaries (polygon) in ArcMap to create a geodatabase. Further analysis of the created geodatabase was carried out in spatial statistics in the GeoDa statistical package (Anselin 2005). To the author’s knowledge, this is the first study so far to use spatial analysis for studying the digital divide in a developing country.

2. *Data Sources*

   The district data were collected from multiple primary and secondary data sources. In most cases, there was no information available on the quality of service. The district was chosen as a unit of analysis since the alternatives were not appropriate for the research at hand. The use of province (a higher administrative unit than a district) would have been too general,\(^6\) leading

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\(^6\) At the time of the research there were only eight provinces, which would not provide sufficient data for statistical analysis.
to loss of the considerable amount of variability and important information, and the use of
division or lower-level administrative units would have been too cumbersome and the data
would likely be unreliable. In addition, the lack of comparable data could have hampered the
research at these lower levels.

The study used primary and secondary data from the following sources:

• Government District Development Plans (main source)
• 1999 National Population and Housing Census, Kenya National Bureau of Statistics,
  Government of Kenya
• Communication Commission of Kenya
• International Telecommunication Union

3. Data Types, Specifications, and Explanation of Model Variables

The research employed spatial regression analysis to model ICT adoption and use. Two
proxies – the number of telephone connections per 100,000 inhabitants (hereinafter teledensity)
and the number of Internet cafés per 100,000 inhabitants – acted as the dependent variables.
Teledensity (Tel_Den), as an old ICT, measures the “old” digital divide, while the number of
Internet cafés per 100,000 inhabitants (Cafés_Den), as a new ICT, measures the “new” digital
divide. Tel_Den and Cafés_Den were regressed on a number of explanatory variables that
broadly reflect socio-economic, infrastructural, and geographical variables. Socio-economic
variables include demographic variables, the degree of urbanization, industrial structure,
educational variables, and the level economic well-being in the district. Infrastructural variables
include teledensity\textsuperscript{69} and electricity capacities. \textit{Geographical} variables (which measure district’s connectivity) were measured by the length of all-weather roads per square kilometer in the district and the distance from the respective district headquarters to the nearest major urban area. Major urban areas identified include eight provincial headquarters and two other urban areas (Eldoret and Meru) (see Figure 1.2). The choice of variables paid attention to the availability and comparability of data between districts. Below are the specification, description, and unit of measurement for the dependent and explanatory variables.

\textbf{Socio-economic Variables:}

1. \textit{Degree of urbanization}

   Historically, cities are generators and diffusers of change. Thus, cities characterized by dense population will demand and diffuse more ICTs than cities that are lower on the urban hierarchy (Graham 2002). The degree of urbanization was measured using the ratio of the district’s urban population to its total population (Rat\_Urb\_Pop).

2. \textit{Industrial structure}

   It is expected that pattern of production will determine technology adoption and use. Here, districts that are predominantly agricultural are expected to have low adoption and use of ICTs, in general, compared to districts with a sizeable manufacturing sector. The industrial structure variable used was the ratio of the district population engaged in agricultural activities to the total district’s population (Rat\_Wor\_Agr).

3. \textit{Other demographic variables}

   The share of the population between ages 15 and 29 (Youthful population – Rat\_Y\_Pop) was used, since the younger generation is “the main user of the new ICTs, especially the

\textsuperscript{69} Apart from being the first dependent variable, teledensity also enters as an explanatory variable in the second model, where the number of Internet cafés per 100,000 inhabitants is the dependent variable. Thus, the first model has fewer explanatory variables (i.e., 13), while the second model has more explanatory variables (i.e., 14).
Internet and more advanced features of mobile phones such as text messaging, also known as short messaging service (SMS)” (McKenzie 2007, 2).

4. **Educational variables**

Lee states that there is a significant positive relationship between the level of human capital and the adoption and use of technology (2001). The relationship is more significant for secondary and tertiary education than for primary education. For this research, the following educational variables were used.

- Share of the school-going population enrolled in primary and secondary schools (Enr_Pri and Enr_Sec, respectively).
- Percentage of the district population over 15 years of age that is able to read and write (Lit_Level).

5. **Level of economic well-being in the district**

Differences in income affect propensities to subscribe and use ICTs. For instance, wealthy households will have more potential to adopt and use ICTs than poor households. The same logic can be applied to districts. For lack of other variables that conventionally measure economic wellbeing (e.g., median income), the following two variables were used. The expected relationship of the dependent variables is opposite, as the results would indicate when the median income, for instance, is used a regressor.

- The district’s contribution to national poverty (i.e., the absolute number of the district’s poor as a ratio of the national poverty figures – Con_Nat_Pov).
- The percentage of the urban poor to the total district population (Urb_Poor).
Infrastructural Variables:

6. *Internet capacities*

This variable acts as a measure for Internet diffusion. Internet cafés supplement Internet subscriptions by households, firms, and other institutions. They offer affordable services to a wider range of customers but specifically to those with no access at home or at work. The following variable was used in this research:

- The number of Internet cafés per 100,000 inhabitants (Cafés_Den).

7. *Electricity supply*

This variable is one of the backbone infrastructures of ICT development. Thus, higher access to electricity supply leads to higher ICT development. The following variables were used in this research:

- The percentage of households in the district with electricity connections (HH_Elec).
- The percentage of urban centers with electricity connections compared to the total number of urban centers (Rat_UrbElec).

8. *Telecommunication capacity*

Telecommunication capacity is also one of the backbone infrastructures and acts as a measure for telecom performance. It is expected that higher ICT development is contingent on higher telecom performance.

- Teledensity (the number of telephone connections per 100,000 inhabitants – Tel_Den).
Geographical variables: Connectivity with major towns

9. District connectivity

Theoretically, the farther away a district is from a major town, the more remote that district is likely to be. This means that the diffusive effect of technology from a major town to that district is expected to be lower (see Bonaccorsi, Piscitello, and Rossi 2005).

- The length of all-weather roads per square kilometer in the district (RDist_SqK).
- The distance from the respective district headquarters to the nearest major urban area, in kilometers (HqDist_Mt).

Table 4.1 summarizes the model variables including their labels and expected signs in regression modeling.
**Table 4.1. Description of model variables**

<table>
<thead>
<tr>
<th>DEPENDENT VARIABLES</th>
<th>Label</th>
<th>Expected sign</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teledensity (number of telephone connections per 100,000 inhabitants)</td>
<td>Tel_Den(^a)</td>
<td></td>
</tr>
<tr>
<td>Number of Internet cafés per 100,000 inhabitants</td>
<td>Cafés_Den</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EXPLANATORY VARIABLES</th>
<th>Label</th>
<th>Expected sign</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Socio-economic Variables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Degree of urbanization</td>
<td>Rat_Urb_Pop</td>
<td>Positive</td>
</tr>
<tr>
<td>Ratio of district urban population</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level of economic well-being in the district</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contribution to national poverty (%)</td>
<td>Con_Nat_Pov</td>
<td>Negative</td>
</tr>
<tr>
<td>Percentage of district urban poor to the district's total population</td>
<td>Urb_Poor</td>
<td>Negative</td>
</tr>
<tr>
<td><strong>Other demographic dynamics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Share of population between ages 15 and 29</td>
<td>Rat_Y_Pop</td>
<td>Positive</td>
</tr>
<tr>
<td><strong>Industrial structure</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ratio of workers in agriculture</td>
<td>Rat_Wor_Agr</td>
<td>Negative</td>
</tr>
<tr>
<td>Average household incomes from wage employment (in %)</td>
<td>HH_Inc_Wag</td>
<td>Positive</td>
</tr>
<tr>
<td><strong>Educational variables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Share of school-going population enrolled in primary schools</td>
<td>Enr_Pri</td>
<td>Positive</td>
</tr>
<tr>
<td>Share of school-going population enrolled in secondary schools</td>
<td>Enr_Sec</td>
<td>Positive</td>
</tr>
<tr>
<td><strong>Infrastructural Variables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical supply</td>
<td>HH_Elec</td>
<td>Positive</td>
</tr>
<tr>
<td>Percentage of households with electricity connections</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage of urban centers with electricity connections to the total number of urban centers in the district</td>
<td>Rat_UrbElec</td>
<td>Positive</td>
</tr>
<tr>
<td><strong>Telecommunication capacities</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teledensity (i.e., number of telephone connections per 100,000 inhabitants)</td>
<td>Tel_Den</td>
<td>Positive</td>
</tr>
<tr>
<td><strong>Geographical Variables: Measure of Connectivity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length of all-weather roads per square kilometers in the district</td>
<td>RDist_SqK</td>
<td>Positive</td>
</tr>
<tr>
<td>Distance from the district headquarters to the nearest major urban area</td>
<td>HqDist_Mt</td>
<td>Negative</td>
</tr>
</tbody>
</table>

Source: Author 2009.

Note: \(^a\) In the research, Tel_Den enters as both the dependent variable in the first model and an explanatory variable in the second model where Cafés_Den is the dependent variable.
4. Choice of Analytical Techniques

The research employed several multivariate statistical techniques to analyze collected data. These included simple bivariate correlation and multiple regression analysis. In using regression analysis, the following assumptions were made: error terms are independent and identically distributed (i.i.d.) – $\epsilon \sim N(0, \sigma^2 I_n)$, the predictors are linearly independent (i.e., it must not be possible to express any predictor as a linear combination of the others), and the variance of the distribution of the error term is constant for all observations (i.e., homoscedasticity). The non-significant Moran’s $I$ score for the first dependent variable – teledensity – meant that the use of classical OLS in GeoDa was appropriate. However, the research used a log-transformed measure of the first dependent variable to achieve normality in errors and homoscedasticity. A significant global Moran’s $I$ score of 0.329 (i.e., significant spatial dependence) confirmed the use of spatial lag under Maximum Likelihood estimation for the second dependent variable – the number of Internet cafés per 100,000 inhabitants.

5. Data Analysis and Presentation

a. Preliminary/Initial Tests

Chloropleth mapping in GeoDa allowed visualization of the individual variables to show spatial differences among districts. Chloropleth mapping uses symbols or gradients of color to display, quantitatively and/or qualitatively, sub-entities of a map in a visual way. Thus, it is an effective way of showing regional correlations or differences. The chloropleth maps produced for this study include the representation of backbone infrastructures (e.g., telephone and electricity access) necessary for the development of ICTs across districts.
Descriptive tests in the form of statistical properties (minimum, maximum, mean, and standard deviation) and a correlation matrix of the model variables were also carried out. Pearson correlation coefficients between the individual model variables show the existing approximation of relationships within the data set.

Similarly, the research carried out concentration analysis using Gini coefficients and Herfindahl-Hirschmann indices (HHI). The concentration analysis estimated the extent of the digital divide by describing the distribution of its quantitative character inside the statistical population. To calculate Gini coefficients, the research employed the following simplified version of the classical definition:

\[
G = \frac{\sum_{i=1}^{n} (2i - n - 1)x_i}{n \sum_{i=1}^{n} x_i}
\]

where \(x\) is an observed value, \(n\) is the number of values observed, and \(i\) is the rank of values in ascending order (StatsDirect Ltd. 2008). In theory, a Gini coefficient of zero means perfect equality, while a value of 100 means maximum inequality.

To calculate HHI, the research employed the following mathematical function:

\[
HHI = \sum_{i=1}^{n} \left( \frac{R_i}{N} \right)^2
\]

where \(R_i\) is district \(i\)'s share of the number of the dependent variable (i.e., the relative cumulative frequency), \(N\) is the total number of the dependent variable for all districts, and \(n\) is the total number of districts. In theory, HHI’s value of zero means perfect dispersal (or equality), while a value of 100 means maximum concentration (or inequality).
b. Spatial Regression Models

This section clarifies the spatial regression models used in this research. The use of spatial regression was undertaken to determine whether dependency or autocorrelation exists among the dependent variables for different locations. Spatial regression modeling, unlike ordinary least squares (OLS), accounts for the autocorrelation over space. This is possible because of the availability of geographically-referenced data tracked through geographical information systems (GIS). The preceding is implemented by running spatial regression models in the form of spatial autoregressive (SAR) or other spatial models. In this research, the SAR model tests the null hypothesis \( H_0 \) of spatial independence versus the alternative hypothesis \( H_1 \) of spatial dependence in the measure for ICT adoption and use.

i. Dependent variable # 1: (Log of) teledensity (Tel_Den)

A number of diagnostic tests were performed to assess the presence (or not) of spatial dependence in Tel_Den. Figure 4.1 shows the standardized Moran’s \( I \) scatter plot of Tel_Den and its lagged equivalent (i.e., \( wTel_Den \)). A spatial Queen Contiguity matrix was used, representing a weight matrix constructed between districts with contiguous borders.\(^{70}\) The choice of the Queen Contiguity matrix was to achieve symmetry since Kenya’s district polygons are of varied sizes and irregular shapes. The Moran’s \( I \) tests the null hypothesis \( H_0 \) of spatial independence against the alternative hypothesis \( H_1 \) of spatial dependence. With the lagged \( wTel_Den \) in the y-axis and the Tel_Den in the x-axis, the scatter shows that the Global Moran’s \( I \) score of 0.0046 is insignificant. Thus, there is no significant spatial dependence in the Tel_Den.

\(^{70}\) The same spatial weight matrix \( (w) \) was used in all the models, thus there is no need to specify for any \( i \) (for \( i = 1, 2, \text{etc.} \)). A weight matrix is used to account for the spatial effects of the number of neighboring districts each district has.
Two procedures – random permutation and drawing of random envelopes – were further used to establish the significance of the Moran’s $I$ scatter plot. A random permutation procedure yielded the theoretical mean, mean, and standard deviation of -0.015, -0.015, and 0.023, respectively. Figure 4.3 shows that the pseudo $p$-value of 0.147 and the reference bar (in yellow) falls in the region where we fail to reject the null hypothesis. The drawing of random envelopes on the Moran’s $I$ scatter plot, as in Figure 4.2, shows that the two random envelopes enclose the Moran’s $I$ scatter plot slope (Anselin 2005). All the above procedures dictate that we fail to reject the null hypothesis of spatial independence, meaning that the number of telephones (measured by Tel_Den) in a given district is influenced by explanatory variables only in that district. Thus, Moran’s $I$ shows insignificant spatial dependence in Tel_Den.

---

71 Random permutation procedure recalculates the statistic many times to generate a reference distribution. The obtained statistic is then compared to this reference distribution and a pseudo significance level is computed. According to Anselin, Syabri, and Kho, these results are stable at higher levels; for instance 999 times (2006).

72 Drawing of random envelopes on the Moran’s $I$ scatter plot ensures that the decision on the significance level is drawn from the reference distribution that contains 95% of the distribution of the Moran’s $I$ statistics computed in spatially random data sets. The two slopes correspond to the 2.5 and 97.5 percentiles of the reference distribution, respectively (Anselin 2005).
Further diagnostic tests for spatial dependence, as shown in Table 4.2, confirm a lack of spatial autocorrelation (or dependence) in the model. In other words, the number of telephones (measured by Tel_Den) in a given district is influenced by explanatory variables only in that district. Moran’s $I$ for errors score of 0.009 is insignificant, as are the two simple Lagrange Multipliers (i.e., Lagrange Multiplier (lag) and Lagrange Multiplier (error)) for the missing spatial lag dependent variable and error dependence. The Lagrange Multiplier (lag) tests the null hypothesis of the lack of the missing spatial lag dependent variable ($H_0: \rho = 0$) against the alternative hypothesis of the possible presence of the missing spatial lag dependent variable ($H_1: \rho \neq 0$). The Lagrange Multiplier (error) tests the null hypothesis of the lack of error dependence ($H_0: \lambda = 0$) against the alternative hypothesis of the presence of error dependence ($H_1: \lambda \neq 0$). The Robust LM (lag) and Robust LM (error) tests for model robustness, respectively. The Robust LM (lag) tests $H_0: \rho = 0$ in the presence of the nuisance dependence (i.e., $\lambda \neq 0$). On the other, the Robust LM (error) tests $H_0: \lambda = 0$ in the presence of the spatial lag dependence (i.e., $\rho \neq 0$).
Theoretically, both of the two robust tests are carried out under the joint null hypothesis for the constrained model: $Y = \rho W Y + X \beta + \varepsilon$ given $\varepsilon = \lambda W \varepsilon + \mu$.

Table 4.2. Diagnostics for spatial dependence (teledensity)

<table>
<thead>
<tr>
<th>Test</th>
<th>MI/DF</th>
<th>Value</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moran's I (error)</td>
<td>0.009</td>
<td>0.690</td>
<td>0.49</td>
</tr>
<tr>
<td>Lagrange Multiplier (lag)</td>
<td>1</td>
<td>0.049</td>
<td>0.82</td>
</tr>
<tr>
<td>Robust LM (lag)</td>
<td>1</td>
<td>0.251</td>
<td>0.62</td>
</tr>
<tr>
<td>Lagrange Multiplier (error)</td>
<td>1</td>
<td>0.012</td>
<td>0.91</td>
</tr>
<tr>
<td>Robust LM (error)</td>
<td>1</td>
<td>0.214</td>
<td>0.64</td>
</tr>
<tr>
<td>Lagrange Multiplier (SARMA)</td>
<td>2</td>
<td>0.263</td>
<td>0.88</td>
</tr>
</tbody>
</table>

In Table 4.3, the Jarque-Bera test, which tests the null hypothesis of normality of errors against the alternative hypothesis of the non-normality of errors, indicates that the log-transformation of Tel_Den has led to borderline significant results ($p = 0.04$).\(^{73}\) The Breusch-Pagan and the Koenker-Bassett test for the null hypothesis of homoscedasticity (i.e., constant error variance) against the alternative hypothesis of heteroscedasticity (i.e., non-constant error variance). The two tests’ $p$-values are insignificant, meaning that we fail to reject the null hypothesis of homoscedasticity or constant error variance. Since the multicollinearity\(^{74}\) condition of number was within the recommended 30 upper threshold, multicollinearity was found not to be a problem (Anselin 2005).

\(^{73}\) ArcGIS regression diagnostics show a clear insignificant $p$-value of 0.16. Other diagnostics remain the same. See Appendix D for regression diagnostics for the untransformed teledensity. The Appendix shows highly significant error asymmetry and heteroscedasticity.

\(^{74}\) Multicollinearity is a situation where two or more explanatory variables in regression are highly correlated. High multicollinearity leads to unstable beta coefficients, the latter leading to unreliable conclusions on the linear relationships between the dependent and explanatory variables.
Table 4.3. Regression diagnostics for the log of teledensity

<table>
<thead>
<tr>
<th>Test on Normality of Errors</th>
<th>DF</th>
<th>Value</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jarque-Bera</td>
<td>2</td>
<td>6.67</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Diagnostics for Heteroscedasticity

<table>
<thead>
<tr>
<th>Test</th>
<th>DF</th>
<th>Value</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breusch-Pagan</td>
<td>13</td>
<td>9.813</td>
<td>0.70</td>
</tr>
<tr>
<td>Koenker-Bassett</td>
<td>13</td>
<td>6.601</td>
<td>0.92</td>
</tr>
</tbody>
</table>

Figures 4.4 and 4.5 below represent the two box-plots for the non-transformed and transformed Tel_Den, respectively. Figure 4.4 shows a highly positively skewed distribution of Tel_Den, while Figure 4.5 shows an improvement towards symmetry in the distribution. The improvement of symmetry in the distribution of Tel_Den coincides with the improvement in the normality of errors and correction of heteroscedasticity.

Figure 4.4. Box plot for untransformed teledensity
Figure 4.5. Box plot for the log-transformed teledensity

Generically, the OLS model takes the matrix form

\[ \ln Y = X\beta + \varepsilon \]

In the above reduced equation, \( Y \) represents Tel_Den and is a 66x1 matrix. In the matrix form, the constant vector in the right hand side is implemented inside matrix \( X \), such that \( X \)’s first column has 1s and the rest have the explanatory variables for the 66 districts. Similarly, the \( \beta \) is a vector matrix with its first entry being the constant coefficient (\( \beta_0 \)), while the rest are beta coefficients reflecting the influence of the explanatory variables on Tel_Den in the OLS model. Accordingly, the \( X \) and the \( \beta \) are 66x14 and 14x1 matrices, respectively. Parameter \( \varepsilon \) denotes a specific vector of random disturbances and is a 66x1 matrix. To this end, the research adopted the OLS model of the following functional form.

\[
\ln \text{Tel Den} = \beta_0 + \beta_1 \text{Rat}_\text{_Pop} + \beta_2 \text{Rat}_\text{_Urb}_\text{Pop} + \beta_3 \text{Rat}_\text{_Wor}_\text{Agr} + \\
\beta_4 \text{Urb}_\text{Poor} + \beta_5 \text{Con}_\text{Nat}_\text{Pov} + \beta_6 \text{HH}_\text{Inc}_\text{Wag} + \beta_7 \text{Enr}_\text{pri} + \\
\beta_8 \text{Enr}_\text{Sec} + \beta_9 \text{Lit}_\text{Level} + \beta_{10} \text{HH}_\text{Elec} + \beta_{11} \text{Rat}_\text{_UrbElec} + \beta_{12} \text{Rdisk}_\text{Sqq} + \\
\beta_{13} \text{HqDist}_\text{Mt} + \varepsilon
\]
ii. **Dependent variable # 2: Number of Internet cafés per 100,000 inhabitants**

*(Cafés_Den)*

A number of diagnostic tests for spatial dependence were performed for Cafés_Den using the Queen Contiguity matrix. Figure 4.6 shows the standardized Moran’s $I$ scatter plot of Cafés_Den and its lagged equivalent – $w$Cafés_Den (Anselin 1996). The scatter plot has the $w$Cafés_Den in the y-axis and the Cafés_Den in the x-axis. As before, the Moran’s $I$ tests the null hypothesis ($H_0$) of spatial independence against the alternative hypothesis ($H_1$) of spatial dependence. The Global Moran’s $I$ score is 0.3229 and highly significant ($p = 0.001$). The results indicate a strong spatial dependence in Cafés_Den, meaning that districts with Internet cafés tend to neighbor other districts with Internet cafés and vice versa. In Figure 4.7, the Moran’s $I$ scatter plot slope is outside the random envelopes, implying that the Moran’s $I$ as calculated is significant. Thus, there is spatial dependence in Cafés_Den. This means that the number of Internet cafés (measured by Cafés_Den) in a given district is influenced by both explanatory variables in the same district and by other variables in the neighboring districts.

As before, two procedures – random permutation and drawing of random envelopes – were used to establish the significance of the Moran’s $I$ scatter plot. Randomizing the scatter plot 999 permutations yielded a theoretical mean (i.e., $E(I)$), mean, and standard deviation of -0.015, -0.015, and 0.058, respectively. The significance of the Moran’s $I$ in Figure 4.8 was based on two criteria: the *pseudo p*-value of 0.001 and the reference bar (in yellow). The reference bar fell in the rejection region meaning that the null hypothesis of spatial independence is rejected. In other words, depending on the level of randomization, the values – the mean and the standard deviation – of the above random permutation procedures will vary. However, at a higher level of randomization (say 999 and above) the changes are stable (see Figure 4.8), meaning that the
decision to reject the null hypothesis is correct. This further means that the number of Internet cafes in a given district is influenced by the explanatory variables in that district and other variables in the adjacent districts (Anselin, Syabri, and Kho 2006).

In addition to the above diagnostic tests, Anselin advises that further diagnostic tests for multicollinearity, heteroscedasticity, and determining the kind of spatial dependence (i.e., either spatial lag or error) that might be at work need to be carried out (2005). In Table 4.4, the
diagnostics for spatial dependence confirm significant global spatial autocorrelation in the
model. Moran’s I for errors returned a score of 0.152 and was significant at \( p = 0.009 \). Some of
the other tests for spatial dependence in the linear models are highly significant. The Lagrange
Multiplier (lag) tests the null hypothesis of the lack of the missing spatial lag dependent variable
(\( H_0: \rho = 0 \)) against the alternative hypothesis of the presence of the missing spatial lag dependent
variable (\( H_1: \rho \neq 0 \)). The Lagrange Multiplier (error) tests the null hypothesis of the lack of error
dependence (\( H_0: \lambda = 0 \)) against the alternative hypothesis of the presence of error dependence
(\( H_1: \lambda \neq 0 \)). Table 4.4 shows that the simple Lagrange multiplier for the missing spatial lag
dependent variable (LM lag) is significant (\( p = 0.002 \)), while the simple Lagrange multiplier for
error dependence (LM error) is significant (\( p = 0.057 \)).

On the one hand, Robust LM (lag) tests \( H_0: \rho = 0 \) in the possible presence of the nuisance
dependence (i.e., \( \lambda \neq 0 \)). On the other, the Robust LM (error) tests \( H_0: \lambda = 0 \) in the possible
presence of the spatial lag dependence (i.e., \( \rho \neq 0 \)). Theoretically, both the robust tests are carried
out under the joint null hypothesis for the constrained model. Table 4.4 shows that the Robust
LM (lag) is significant (\( p = 0.01 \)), while the Robust LM (error) is insignificant (\( p = 0.4 \)). The
significance of the Robust LM (lag) test implies that when the error dependence is present (i.e., \( \lambda
\neq 0 \)), the spatial lag dependence is still significant. However, the Robust LM (error) specification
is not robust in the presence of the spatial lag. Thus, the spatial lag (SAR) model is the robust
model (Refer to decision tree in Figure 4.9).
Table 4.4. Diagnostics for spatial dependence (Internet cafés per 100,000 inhabitants)

<table>
<thead>
<tr>
<th>Test</th>
<th>MI/DF</th>
<th>Value</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moran's I (error)</td>
<td>0.152</td>
<td>2.618</td>
<td>0.009</td>
</tr>
<tr>
<td>Lagrange Multiplier (lag)</td>
<td>1</td>
<td>9.611</td>
<td>0.002</td>
</tr>
<tr>
<td>Robust LM (lag)</td>
<td>1</td>
<td>6.697</td>
<td>0.010</td>
</tr>
<tr>
<td>Lagrange Multiplier (error)</td>
<td>1</td>
<td>3.622</td>
<td>0.057</td>
</tr>
<tr>
<td>Robust LM (error)</td>
<td>1</td>
<td>0.709</td>
<td>0.400</td>
</tr>
<tr>
<td>Lagrange Multiplier (SARMA)</td>
<td>2</td>
<td>10.320</td>
<td>0.006</td>
</tr>
</tbody>
</table>

Table 4.5 shows the regression diagnostics results using the Queen Contiguity. In addition to the Jarque-Bera test for non-normality of errors, which is highly significant, the table also shows that the two tests of heteroscedasticity (i.e., the Breusch-Pagan test and the Koenker-Bassett) are also highly significant. Since the multicollinearity condition of number was within the recommended 30 upper threshold, multicollinearity was found not to be a problem (Anselin 2005).

Because of the presence of significant spatial dependence in Cafés_Den, the research proceeded to analyze the digital divide determinants by employing a spatial autoregressive (SAR) model. This was done to address the hypothesis that spatial factors (i.e., spatial lag) influence local inequalities. In other words, the SAR model tested the null hypothesis (H₀) of spatial independence versus the alternative hypothesis (H₁) of spatial dependence in the measure for ICT adoption and use. In theory, spatial lag arises where the estimated ICT index (i.e.,
number of Internet cafés) is influenced by both explanatory variables in the same location and by other variables in the neighboring districts (Anselin 1995).

Generically, the spatial autoregressive regression model (SAR) takes the form

$$Y = \rho W Y + X \beta + \epsilon$$

In the above equation, $Y$ represents Cafés_Den and is a 66x1 matrix representing the dependent variables in the 66 districts. The parameter $X$ is a 66x15 matrix with 1s in the first column and the rest of the entries representing the explanatory variables in the 66 districts. Parameter $\rho$ reflects spatial dependence in the research data, while parameter $W$ represents a weight matrix constructed using the concept of Queen Contiguity between districts (i.e., districts with borders that touch). The weight matrix $W$ is a 66x66 matrix that has 0s on the main diagonal, rows that contain 0s in positions associated with non-contiguous districts and is row-standardized. Parameter $\beta$ is a 15x1 vector of coefficients: the first entry is a constant coefficient, while the rest of the entries are beta coefficients that reflect the influence of the various explanatory variables in the SAR model. Parameter $\epsilon$ denotes a specific vector of random disturbances and is a 66x1 matrix. Thus, the following functional form was employed in the research in the spatial regression model.

$$\text{Cafes}_\text{Den} = \rho WCafes\_Den + \beta_0 + \beta_1 Tre\_Den + \beta_2 Rat\_Urb\_Pop + \beta_3 Rat\_Wor\_Agr + \beta_4 Urb\_Poor + \beta_5 Con\_Nat\_Pov + \beta_6 HH\_Inc\_Wag + \beta_7 Enr\_pri + \beta_8 Enr\_Sec + \beta_9 Lit\_Level + \beta_{10} HH\_Elec + \beta_{11} Rat\_UrbElec + \beta_{12} Rat\_Y\_Pop + \beta_{13} Rdisk\_Sqk + \beta_{14} HqDist\_Mt + \epsilon$$

To decide which spatial regression model would be appropriate for Tel_Den and Cafés_Den, respectively, the research followed the steps shown in Figure 4.9. The figure shows two distinct steps used to analyze or model Tel_Den and Cafés_Den. Accordingly, two separate chapters will be devoted to that purpose. The results of the research data analysis and related
discussions for the lnTel_Den are presented in Chapter V, while the modeling and presentation of results and related discussion for the Cafés_Den are presented in Chapter VI.
Figure 4.9. Spatial regression decision

Source: Adapted from Anselin 2005
Notes: ・・・ Cafés_Den decision path  ➔  lnTel_Den decision path
CHAPTER V: SPATIAL DIGITAL DIVIDE IN TELEPHONE DIFFUSION

This chapter presents the results and discussion of the number of telephone connections per 100,000 inhabitants in Kenya; that is, teledensity (Tel_Den) with a log transformation (lnTel_Den), which was used to measure the “old” digital divide. The research employed GeoDa as an analytical tool to carry out spatial regression analysis on the created geodatabase (Anselin 2003). Tel_Den was modeled using classical OLS in GeoDa since Tel_Den returned insignificant global spatial autocorrelation. This chapter has three sections. These sections correspond with the analysis of descriptive, concentration, and spatial regression modeling results of Tel_Den and the related discussions, respectively.

A. Descriptive Results and Related Discussions

Descriptive results elaborate on the chloropleth maps of Tel_Den. The value of the chloropleth maps is that they allow single variables to be mapped, which are needed to show spatial differences among districts. In this way, regional variations of the various variables are examined.

Tel_Den distribution is shown in Figure 5.1. In the figure, Nairobi, the central Kenya districts, and the coastal districts occupy the upper percentiles. An examination of the box-plot (see Figure 4.4) reveals that Nairobi, Mombasa (coastal Kenya), and Nyeri (central Kenya) districts have higher values vis-à-vis other districts. This is possible since these districts contain Nairobi (the national capital), Mombasa (the second largest and the major port city), and Nakuru (one of the eight provincial capitals), respectively.
Figure 5.1. Percentile map for Kenya's teledensity
In Table 5.1, descriptive statistics and the correlation matrix for all the model variables are given. There are both positive and negative relationships among the model variables. The table shows that the average number of telephone connections (Tel_Den) in a given district is 654 for every 100,000 Kenyans. In particular, the disparity among districts is wide, as noted by the minimum average of 15 and the maximum (19,576) number of telephone connections for every 100,000 Kenyans. These minimum and maximum values correspond to Gucha and Nairobi districts, respectively.

Except for the correlation coefficients between teledensity, and (a) the ratio of the urban population to the total district population (Rat_Urb_Pop), and (b) the contribution to the national poverty (Con_Nat_Pov), the signs of the correlation coefficients with the rest of the explanatory variables are as hypothesized in Table 4.1. By using the absolute size of the district urban population (vis-à-vis Rat_Urb_Pop), the coefficient sign between district urban population and Tel_Den is positive.

In Table 5.1, four correlation coefficient values are more than 0.6. The correlation coefficient between the ratio of the urban population (Rat_Urb_Pop) and primary enrollment (Enr_Pri) is -0.612. When the absolute size of the district urban population is used, the correlation sign is positive (i.e., 0.318). The correlation coefficient between the percentage of household income from wage employment (HH_Inc_Wag) and the percentage of households with electricity connections (HH_Elec) is positive (0.618). The level of adult literacy (Lit_Level) has a negative correlation coefficient (-0.631) with the distance of the district headquarters from a major urban area (HQdist_Mt), implying that people with higher literacy levels live in urban areas. Overall, the correlation coefficient values among the explanatory variables do not strongly point toward a possibility of multicollinearity in the modeling procedures.
### Table 5.1. Statistical properties of the model variables and correlation matrix

<table>
<thead>
<tr>
<th>Variable</th>
<th>Cafés_Den</th>
<th>Tel_Den</th>
<th>Rat_Y_Pop</th>
<th>Rat_Urb_Pop</th>
<th>Urb_Poor</th>
<th>Con_Nat_Pov</th>
<th>HH_Inc_Wag</th>
<th>Enr_Pri</th>
<th>Enr_Sec</th>
<th>Lit_Level</th>
<th>HH_Elec</th>
<th>RDist_SqK</th>
<th>HqDist_Mt</th>
<th>Rat_Wor_Agr</th>
<th>Rat_UrbElec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>0</td>
<td>14.8</td>
<td>0.121</td>
<td>0.004</td>
<td>0.000</td>
<td>0.150</td>
<td>0.000</td>
<td>4779</td>
<td>1299</td>
<td>3.000</td>
<td>0.400</td>
<td>0.001</td>
<td>0.000</td>
<td>0.068</td>
<td>0.053</td>
</tr>
<tr>
<td>Max</td>
<td>41.15</td>
<td>19,575.65</td>
<td>1.473</td>
<td>0.184</td>
<td>76.600</td>
<td>7.500</td>
<td>81.000</td>
<td>374,347</td>
<td>120,370</td>
<td>94.250</td>
<td>61.000</td>
<td>1.757</td>
<td>727.000</td>
<td>1.002</td>
<td>1.000</td>
</tr>
<tr>
<td>Mean</td>
<td>2.86</td>
<td>653.97</td>
<td>0.332</td>
<td>0.036</td>
<td>42.997</td>
<td>1.442</td>
<td>17.185</td>
<td>119,328</td>
<td>21,932</td>
<td>59.881</td>
<td>8.868</td>
<td>0.470</td>
<td>116.652</td>
<td>0.479</td>
<td>0.044</td>
</tr>
<tr>
<td>Std. dev.</td>
<td>5.88</td>
<td>2,412.18</td>
<td>0.024</td>
<td>0.004</td>
<td>2.438</td>
<td>0.170</td>
<td>2.027</td>
<td>9,836</td>
<td>2,556</td>
<td>2.771</td>
<td>1.358</td>
<td>0.046</td>
<td>17.391</td>
<td>0.030</td>
<td>0.234</td>
</tr>
<tr>
<td>N</td>
<td>66</td>
<td>66</td>
<td>66</td>
<td>66</td>
<td>66</td>
<td>66</td>
<td>66</td>
<td>66</td>
<td>66</td>
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<td>66</td>
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<td>66</td>
<td>66</td>
<td>66</td>
</tr>
</tbody>
</table>

### Table 5.1. Continued…

<table>
<thead>
<tr>
<th>Variable</th>
<th>HH_Elec</th>
<th>RDist_SqK</th>
<th>HqDist_Mt</th>
<th>Rat_Wor_Agr</th>
<th>Rat_UrbElec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>0.400</td>
<td>0.001</td>
<td>0.000</td>
<td>0.068</td>
<td>0.053</td>
</tr>
<tr>
<td>Max</td>
<td>61.000</td>
<td>1.757</td>
<td>727.000</td>
<td>1.002</td>
<td>1.000</td>
</tr>
<tr>
<td>Mean</td>
<td>8.868</td>
<td>0.286</td>
<td>116.652</td>
<td>0.479</td>
<td>0.044</td>
</tr>
<tr>
<td>Std. dev.</td>
<td>1.358</td>
<td>0.046</td>
<td>17.391</td>
<td>0.030</td>
<td>0.234</td>
</tr>
<tr>
<td>N</td>
<td>66</td>
<td>66</td>
<td>66</td>
<td>66</td>
<td>66</td>
</tr>
</tbody>
</table>
B. Concentration Analysis

This section reports on concentration analysis for the number of telephone connections. Concentration analysis estimates the extent of the digital divide by describing the distribution of the respective variable quantitatively. Figures 5.2 and 5.3 show the Lorenz curve, in cumulative percentages, for the number of telephone connections for all the districts and for all the districts excluding Nairobi, respectively. The inclusion of Nairobi in the construction of the Lorenz curve widens the disparities.

The calculation of the respective Gini coefficient, an inequality index defined as the ratio of the area between the line of equality (45-degree line) and the Lorenz curve to the area enclosed by the entire equality line, confirms the results in Figures 5.2 and 5.3. In theory, a Gini coefficient of zero means perfect equality while a value of 100 means maximum inequality. The Gini coefficients for all districts and for all districts excluding Nairobi are 95.5% and 70.87%, respectively. Thus, and not surprisingly, the Nairobi district has a higher concentration of the number of the telephone connections.

Figure 5.2. Lorenz curve for Tel_Den in Kenyan districts.
The research also calculated the Herfindahl-Hirschman Index (HHI). By definition, the HHI characterizes the distribution of a variable of interest by measuring its degree of concentration across units. The normalized values lie between zero and one, with zero indicating maximum equality and one indicating maximum imbalance (i.e., inequality) (Owen, Ryan, and Weatherston 2007). The HHI calculation yielded the following results. With respect to the number of telephone connections, when all the districts are included, the HHI is 0.67 (i.e., 67%), but when Nairobi is excluded, the index is considerably reduced to 0.07 (i.e., 7%). This means that with Nairobi being the dominant district, the HHI shows a higher concentration of the number of telephone connections within it. In this research, the calculation of concentration indices aimed to give a “snapshot,” or show the static extent of the digital divide. If time series data were available then the analysis could have been used to monitor evolution (i.e., dynamic analysis).

Figure 5.3. Lorenz curve for Tel_Den in Kenyan districts excluding Nairobi district.
C. Spatial Regression Analysis

1. Local Spatial Autocorrelation

In the Moran’s I scatter plot, the four quadrants represent different types of spatial autocorrelation (relative to the mean): high-high and low-low for positive spatial autocorrelation; low-high and high-low for negative spatial autocorrelation (Anselin 2005). The former two are associated with the right upper and left lower quadrants, respectively. These quadrants represent spatial clusters where similar values (i.e., high and high as well as low and low) neighbor each other. The low-high and high-low are associated with the upper left and lower right quadrants, respectively. These represent the spatial autocorrelation of dissimilar values. With the exception of one extreme data point to the right of the centered mean (i.e., Nairobi, arrow pointed), most of the other data values are close to the mean in the Moran’s I scatter plot. This explains the insignificance of the Moran’s I as observed in Figure 4.2, where the slope of the scatter plot has been enclosed by the random envelopes.

To elaborate on the Moran’s I as discussed above, the use of cluster and significance maps are useful (Anselin 1995). In Figure 5.4, the red color represents spatial clusters where districts with a high teledensity are surrounded by districts with similarly high teledensity. These districts are Nairobi and the abutting Kiambu. In the same figure, the light blue colors represent districts with lower teledensity surrounded by districts with higher teledensity. The dark blue colors represent districts with low teledensity surrounded by districts with similarly low teledensity. Surprisingly, the coastal region (where Mombasa, the second largest and major port city is located) did not show any clustering.

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75 See Figure 4.1 in Chapter IV.
Figure 5.4. LISA cluster map for Kenya’s teledensity
Figure 5.5. LISA significance map for Kenya’s teledensity
In Figure 5.5, significance levels related to the above spatial clustering (seen in Figure 5.4) are shown. In the figure, the hatched green indicates significance at \( p = 0.01 \), while the light green areas indicate significance at \( p = 0.05 \). Thus, spatial clustering is around Kiambu (abutting Nairobi) and the low-high observations are Thika and Kajiado districts. Further sensitivity analysis at a higher number of permutations confirms the stability of the preceding results (Anselin, Syabri, and Kho 2006).

2. *Ordinary Least Squares (OLS)*

   **a. Model Results**

   Given that the diagnostic tests for spatial dependence led to insignificant Moran’s \( I \), the research proceeds to estimate the model using *classic* OLS in GeoDa. However, to correct for asymmetric error term distribution, the research uses lnTel_Den (Chatterjee and Hadi 2000). Log transformation in this research was used to correct the skewed error distribution.\(^{76}\) Using the OLS functional model of the transformed dependent variable, re-stated below, regression results are shown in Table 5.2.

\[
\text{lnTel\_Den} = \beta_0 + \beta_1\text{Rat\_Y\_Pop} + \beta_2\text{Rat\_Urb\_Pop} + \beta_3\text{Rat\_Wor\_Agr} + \\
\beta_4\text{Urb\_Poor} + \beta_5\text{Con\_Nat\_Pov} + \beta_6\text{HH\_Inc\_Wag} + \beta_7\text{Enr\_pri} + \\
\beta_8\text{Enr\_Sec} + \beta_9\text{Lit\_Level} + \beta_{10}\text{HH\_Elec} + \beta_{11}\text{Rat\_UrbElec} + \beta_{12}\text{Rdisk\_Sqk} + \\
\beta_{13}\text{HqDist\_Mt} + \epsilon
\]

\(^{76}\) See Table 4.3, where Jarque-Bera test for normality of errors shows insignificant results after log-transformation of teledensity.
### Table 5.2. OLS results for the log of teledensity

<table>
<thead>
<tr>
<th>Variables</th>
<th>β Coefficients</th>
<th>t-values</th>
<th>p-values</th>
<th>% change in Tel_Den with one-unit change in the explanatory variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>4.521&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.820</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>Rat_Urb_Pop</td>
<td>2.130</td>
<td>2.390</td>
<td>0.021</td>
<td>213.0**</td>
</tr>
<tr>
<td>Rat_Wor_Agr</td>
<td>-0.002</td>
<td>-0.370</td>
<td>0.713</td>
<td>-0.2</td>
</tr>
<tr>
<td>Urb_Poor</td>
<td>0.0005</td>
<td>0.076</td>
<td>0.940</td>
<td>0.0</td>
</tr>
<tr>
<td>Con_Nat_Pov</td>
<td>-0.338</td>
<td>-1.960</td>
<td>0.055</td>
<td>-33.8*</td>
</tr>
<tr>
<td>HH_Inc_Wag</td>
<td>0.006</td>
<td>0.620</td>
<td>0.538</td>
<td>0.6</td>
</tr>
<tr>
<td>Enr_Pri</td>
<td>0.000</td>
<td>0.940</td>
<td>0.351</td>
<td>0.0</td>
</tr>
<tr>
<td>Enr_Sec</td>
<td>0.000</td>
<td>0.398</td>
<td>0.692</td>
<td>0.0</td>
</tr>
<tr>
<td>Lit_Level</td>
<td>-0.007</td>
<td>-1.036</td>
<td>0.305</td>
<td>-0.7</td>
</tr>
<tr>
<td>HH_Elec</td>
<td>0.069</td>
<td>4.324</td>
<td>0.000</td>
<td>6.9***</td>
</tr>
<tr>
<td>Rat_UrbElec</td>
<td>0.368</td>
<td>0.623</td>
<td>0.536</td>
<td>36.8</td>
</tr>
<tr>
<td>Rat_Y_Pop</td>
<td>0.995</td>
<td>1.310</td>
<td>0.196</td>
<td>99.5</td>
</tr>
<tr>
<td>Rdist_Sqk</td>
<td>-0.715</td>
<td>-1.356</td>
<td>0.181</td>
<td>-71.5</td>
</tr>
<tr>
<td>HqDist_Mt</td>
<td>-0.001</td>
<td>-0.462</td>
<td>0.646</td>
<td>-0.1</td>
</tr>
<tr>
<td>R²</td>
<td>0.612</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: *, **, and *** indicate significant explanatory variables at 10%, 5%, and 1%, respectively. Only these three explanatory variables are interpreted as significant determinants of telephone diffusion.

<sup>a</sup> The anti-log of the constant provides that the model intercept is equal to 91,185 telephone connections.

### b. Determinants of Telephone Diffusion

Several variables, broadly defined as socio-economic, infrastructural, and geographical, were hypothesized as influencing telephone diffusion. The results of the OLS estimation show that only three of the thirteen explanatory variables used in the modeling exercise were statistically significant in explaining telephone diffusion. The R-squared value of 0.612 means that the model variables explain about 61% of the variation in telephone diffusion. Since we are dealing with a log-linear model, interpretation is achieved by estimating that a one-unit change in the explanatory variable is equivalent to a \((100 \times \beta)\)% change in the dependent variable. This
estimation yields the percentage changes in the dependent variable (in this research, Tel_Den) as a result of one-unit changes in the explanatory variables (see Table 5.2).\(^{77}\)

In Table 5.2, the *ratio of the urban population* (Rat_Urb_Pop) as a measure of the degree of urbanization had a positive (2.13) and statistically significant (*p* = 0.021) β coefficient. Translated, the results show that a 1% increase in urban population leads to a 213% increase in the number of telephone connections per 100,000 inhabitants. Thus, a higher degree of urbanization has a greater influence on telephone diffusion.\(^{78}\)

The *percentage of households with electricity* (HH_Elec) had a β coefficient of 0.069 that was highly significant (*p* = 0.00). The results mean that a 1% increase in the *percentage of households with electricity connections* (HH_Elec) translates to a 6.9% increase in the number of telephone connections per 100,000 inhabitants in a given district. Figure 5.6 shows the percentile map for the percentage distribution of household electricity connections (HH_Elec). In the figure, the regions around Nairobi and along the main westward corridor\(^{79}\) and the coastal district of Mombasa have a higher percentage of households with electricity connections than the rest of the country. A recent study shows that Kenya’s cities (i.e., Nairobi, Mombasa, Nakuru, Eldoret, and Kisumu) are connected to the national electricity grid. Apart from the Mt. Kenya region, these cities and other major urban areas have higher electricity penetration rates in their hinterlands (i.e., the percentage of households with a grid connection) than other regions of the country.\(^{80}\)

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\(^{77}\) The other alternative interpretation of the model results is to take an exponential (i.e., anti-log to base e) of the β coefficients. For more information, see UCLA: Academic Technology Services, Statistical Consulting Group (Accessed May 6, 2010).


\(^{79}\) This corresponds, roughly, to the corridor running alongside the Kenya-Uganda railway and part of the Cape Town (South Africa)-Cairo (Egypt) Great North road. This corridor links Kenya’s Mombasa port city and Uganda through Nairobi.

\(^{80}\) See Parshall, et al. (2009).
Figure 5.6. Percentile map for the percentage of households with electricity connections in Kenyan districts.
Another measure of electricity – the ratio of urban centers with electricity to the total number of urban centers in the same district (Rat_UrbElec) – did not emerge as a significant determinant of telephone diffusion. Rat_UrbElec supplemented household electricity connections (HH_Elec) that is available for firms and other institutions at the district level.\textsuperscript{81}

The first measure of the level of economic well-being in the district – contribution to the national poverty (Con_Nat_Pov) – had a negative (-0.338) and statistically significant ($p = 0.055$) $\beta$ coefficient. Translated, this means that if the districts’ contribution to the national poverty increases by 1%, then the number of telephone connections per 100,000 inhabitants will decrease by 33.8%. The other measure of the level of economic well-being in the district – the ratio of urban poor (Urb_Poor) – turned out to be a non-determinant of telephone diffusion.

In this research, the district’s contribution to national poverty (Con_Nat_Pov) and its share of the urban poor (Urb_Poor) were used to measure the relative position of the district’s level of economic well-being nationally and the extent of urban poverty within the district, respectively. Understanding these two phenomena is important in prescribing appropriate national and regional policies.

The model results also show that the rest of the variables representing the district industrial structure (i.e., the ratio of workers in agriculture, Rat_Wor_Agr, and the average household incomes from wage employment, HH_Inc_Wag) and the youth population (i.e., the share of the population between 15 and 29 years of age, Rat_Y_Pop) emerged as non-determinants of telephone diffusion. Other proxies for human capital (i.e., primary enrollment, secondary enrollment, tertiary enrollment, etc.) were also included in the model but did not emerge as significant determinants of telephone diffusion.

\textsuperscript{81} To the author’s knowledge, this is the first time Rat_UrbElec has been used in spatial regression analysis. Its use in this context was to supplement HH_Elec as that electricity available to firms and other institutions. Its inclusion was necessary since the penetration rate of household electricity was low and because electricity consumption data by firms and other institutions were not available. Parshall, et al. note that with the major urban areas (see Figure 5.1) and the Mt. Kenya region having penetration rates of about 30%, most of the rest of the country has low penetration rates of about 10% or less (2009). In fact, much of the north and east of the country is arid and has no power grid lines.
Enr_Pri, secondary enrollment, Enr_Sec, and literacy levels, Lit_Level) and geographical connectivity (i.e., length of all-weather roads per square kilometer in the district, RDist_SqK and distance from the district headquarters to the nearest major urban area, HqDist_Mt) also emerged as non-determinants of telephone diffusion. These results are contrary to past studies.\(^{82}\)

**D. Summary**

This chapter has analyzed and presented descriptive, concentration, and spatial modeling results of teledensity – Tel_Den. Descriptive results include the elaboration of chloropleth mapping. The percentile map for teledensity shows an uneven distribution of this variable across districts. Descriptive statistics have also shown the existence of very large disparities among districts with respect to this “old” digital divide measure.

Concentration analysis achieved through the Lorenz curves, Gini coefficients, and the Herfindahl-Hirschman Indices (HHI) further confirmed the existence of the spatial “old” digital divide in Kenya. The Gini coefficients for the number of telephone connections for all districts and all districts excluding Nairobi are 95.5% and 70.87%, respectively. Both the Gini coefficients show large disparities.\(^{83}\) The Herfindahl-Hirschman Index (HHI) is 0.67 (i.e., 67%) overall, but when Nairobi is excluded the index is significantly reduced to 0.07 (i.e., 7%). These results further show the high concentration of the number of telephone connections in Nairobi.

The results showed non-significant spatial dependence in the number of telephone connections. Ordinary least squares analysis in GeoDa has shown the determinants of Kenya’s “old” digital divide. These variables are the ratio of the district urban population (Rat_Urb_Pop), the district contribution to the national poverty (Con_Nat_Pov), and the percentage of

\(^{83}\) See Figures 5.2 and 5.3.
households with electricity connections (HH_Elec). The next chapter will present the results and
discussion of Cafés_Den, a measure for the “new” digital divide.
CHAPTER VI: SPATIAL DIGITAL DIVIDE IN INTERNET DIFFUSION

This chapter presents the results and discussion of the number of Internet cafés per 100,000 inhabitants (i.e., Cafés_Den), a measure of the “new” digital divide. As noted in the last chapter, the research employed GeoDa as an analytical tool to carry out spatial regression analysis on the created geodatabase (Anselin 2003). Cafés_Den was modeled using a spatial autoregressive model (SAR) that incorporated spatial autocorrelation in it. This chapter presents the analysis of descriptive, concentration, and spatial regression modeling results of Cafés_Den and the related discussions, respectively.

A. Descriptive Results and Related Discussions

Descriptive results elaborate on the chloropleth maps of Cafés_Den. Chloropleth mapping shows the spatial differences of the variable among districts. Figure 6.1 indicates that Nairobi and its environ has a spatial cluster of high values of the number of Internet cafés per 100,000 inhabitants (Cafés_Den). That is, Nairobi and the two abutting districts of Thika and Kiambu have the three highest values.

In Table 5.1, in the previous chapter, the descriptive results for the number of Internet cafés per 100,000 inhabitants (Cafés_Den) are alarming: for every 100,000 Kenyans, there are on average only three Internet cafés in a given district. This disparity ranges from a minimum of zero in eight districts to the maximum of 41 Internet cafés per 100,000 inhabitants in the Nairobi district. The signs of the correlation coefficients between Cafés_Den and most of the explanatory variables are as hypothesized in Table 4.1. Only two explanatory variables, that is, the ratio of urban population (Rat_Urb_Pop) and contribution to the national poverty (Con_Nat_Pov), had negative and positive correlation coefficients sign, respectively.
Figure 6.1. Percentile map for the number of Internet cafés per 100,000 inhabitants in Kenyan districts.
However, for the district’s Rat_Urb_Pop, the coefficient sign is positive when the absolute size of the district’s urban population is used instead.

**B. Concentration Analysis**

This section reports on the concentration analysis for the number of Internet cafés. Concentration analysis results for the number of Internet cafés are as shown in Figures 6.2 and 6.3 below. The Gini coefficients for Figures 6.2 and 6.3 are 85.38% and 78.84%, respectively. This shows that Nairobi’s proportion in the “old” digital divide is larger than in the “new” digital divide. The Herfindahl-Hirschman Index (HHI) calculation for Cafés_Den yielded values of 0.18 (i.e., 18%) and 0.13 (i.e., 13%), for all districts and for all districts excluding Nairobi, respectively.

![Figure 6.2. Lorenz curve for Cafés_Den in Kenyan districts.](image-url)
Figure 6.3. Lorenz curve for Cafés_Den in Kenyan districts excluding Nairobi district.

C. Spatial Regression Analysis

1. Local Spatial Autocorrelation

The Moran’s I scatter plot was also produced for the number of Internet cafés per 100,000 inhabitants. The same Moran’s I scatter plot shows that there are a number of data points in the high-high quadrant. In Figure 6.4, the districts in red represent spatial clusters where a high number of Internet cafés per 100,000 inhabitants are surrounded by districts with a similarly high number of Internet cafés per 100,000 inhabitants. These regions include Nairobi and its environs. In the same figure, the dark blue districts represent a low number of Internet cafés per 100,000 inhabitants surrounded by other districts with a low number of Internet cafés per 100,000 inhabitants. Here we see Turkana, Moyale, Isiolo, and Samburu districts, which surround the northern Kenya district of Marsabit. The light blue districts represent low-high spatial values, that is, districts with a low number of Internet cafés per 100,000 inhabitants surrounded by districts with a high number of Internet cafés per 100,000 inhabitants. For

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84 See Figure 4.6 in Chapter IV.
instance, Nyandarua district, with a low value, is surrounded by Nakuru district, which has a high value. These neighboring, but dissimilar, values can be easily identified in the table and the map through the “linking and brushing” query function in GeoDa.

In Figure 6.5, significance levels related to the above spatial autocorrelation are shown. In the figure, the districts in dark green indicate significance at $p = 0.001$, while the districts that are hatched green indicate significance at $p = 0.01$. The light green districts indicate significance at $p = 0.05$. Thus, spatial clustering around Nairobi and Kiambu is significant at $p = 0.001$, and the low-high observations in Nyandarua, Thika, Mwingi, and Kajiado districts are significant at $p = 0.01$. The other spatial clustering of similar values around the Nakuru district is significant at $p = 0.05$. Further sensitivity analysis at a higher number of permutations confirms the stability of the preceding results (Anselin, Syabri, and Kho 2006).
Figure 6.4. LISA Cluster map for Kenya’s Internet cafés per 100,000 inhabitants.
Figure 6.5. LISA Significance map for Kenya’s Internet cafés per 100,000 inhabitants.
2. Spatial Lag (SAR) Model

a. Model Results

Having proven the presence of significant spatial dependence, the research proceeds to re-estimate the model using the Maximum Likelihood approach since it allows spatial dependence to be controlled (Anselin and Bera 1998). The research uses a spatial autoregressive (SAR) model (re-stated below). Reasons for its choice were explained in Chapter 4 (see Figure 4.9).

\[
Cafes\_Den = \rho WCafes\_Den + \beta_0 + \beta_1 Tel\_Den + \beta_2 Rat\_Urb\_Pop + \beta_3 Rat\_Wor\_Agr + \beta_4 Urb\_Poor + \beta_5 Con\_Nat\_Pov + \beta_6 HH\_Inc\_Wag + \beta_7 Enr\_pri + \beta_8 Enr\_Sec + \beta_9 Lit\_Level + \beta_{10} HH\_Elec + \beta_{11} Rat\_UrbElec + \beta_{12} Rat\_Y\_Pop + \beta_{13} Rdisk\_Sqk + \beta_{14} HqDist\_Mt + \epsilon
\]

Table 6.1. SAR model results for Cafés\_Den

<table>
<thead>
<tr>
<th>Variables</th>
<th>(\beta) coefficients</th>
<th>Total impacts</th>
<th>(t)-values</th>
<th>(p)-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-1.609</td>
<td></td>
<td>-0.692</td>
<td>0.489</td>
</tr>
<tr>
<td>Tel_Den</td>
<td>-0.001</td>
<td>-0.002</td>
<td>-3.0256</td>
<td>0.001</td>
</tr>
<tr>
<td>Rat_Urb_Pop</td>
<td>-0.693</td>
<td>-1.490</td>
<td>-0.216</td>
<td>0.829</td>
</tr>
<tr>
<td>Rat_Wor_Agr</td>
<td>-0.045</td>
<td>-0.097</td>
<td>-2.228</td>
<td>0.026**</td>
</tr>
<tr>
<td>Urb_Poor</td>
<td>-0.016</td>
<td>-0.034</td>
<td>0.652</td>
<td>0.514</td>
</tr>
<tr>
<td>Con_Nat_Pov</td>
<td>-0.405</td>
<td>-0.871</td>
<td>-0.648</td>
<td>0.517</td>
</tr>
<tr>
<td>HH_Inc_Wag</td>
<td>0.091</td>
<td>0.196</td>
<td>2.667</td>
<td>0.008***</td>
</tr>
<tr>
<td>Enr_Pri</td>
<td>-0.000</td>
<td>-0.000</td>
<td>-0.404</td>
<td>0.686</td>
</tr>
<tr>
<td>Enr_Sec</td>
<td>0.000</td>
<td>0.000</td>
<td>0.200</td>
<td>0.841</td>
</tr>
<tr>
<td>Lit_Level</td>
<td>0.027</td>
<td>0.058</td>
<td>1.049</td>
<td>0.294</td>
</tr>
<tr>
<td>HH_Elec</td>
<td>0.193</td>
<td>0.415</td>
<td>3.107</td>
<td>0.002***</td>
</tr>
<tr>
<td>Rat_UrbElec</td>
<td>2.509</td>
<td>5.396</td>
<td>1.204</td>
<td>0.229</td>
</tr>
<tr>
<td>Rat_Y_Pop</td>
<td>-3.758</td>
<td>-8.082</td>
<td>-1.400</td>
<td>0.162</td>
</tr>
<tr>
<td>RDist_Sqk</td>
<td>6.043</td>
<td>12.996</td>
<td>3.203</td>
<td>0.001***</td>
</tr>
<tr>
<td>HqDist_Mt</td>
<td>0.010</td>
<td>0.022</td>
<td>2.298</td>
<td>0.021**</td>
</tr>
<tr>
<td>Rho ((\rho))</td>
<td>0.535</td>
<td>5.036</td>
<td>0.000</td>
<td>0.000***</td>
</tr>
<tr>
<td>Log-likelihood</td>
<td>-171.673</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: ** and *** indicate significant explanatory variables at 5% and 1%, respectively.
In Table 6.1, the rho (ρ) score of 0.535, which measures the average influence on observations by their neighboring observations in the SAR model, is highly significant. And, with the score being positive and moderately strong, the general model fit is improved. The significant rho (ρ) means that, on average, the number of Internet cafés in neighboring districts contribute 0.535 to the value of the number of Internet cafés in a given district.

**b. Determinants of Internet Diffusion**

It was hypothesized that several variables, broadly defined as socio-economic, infrastructural, and geographical, explain Internet diffusion. The model results in Table 6.1, show that six of the fourteen explanatory variables emerged as statistically significant predictors of Internet diffusion (as measured by the number of Internet cafés).

The significant explanatory variables included the following. The ratio of workers in agriculture to the total population (Rat_Wor_Agr) and the distance of the district headquarters to the nearest major urban area (HqDist_Mt) were moderately significant at the 95% level with \( p \)-values of 0.026 and 0.021, respectively. The rest of the variables – households’ income from wage employment (HH_Inc_Wag), percentage of households in the district with electricity connections (HH_Elec), teledensity (Tel_Den), and the length of all-weather roads per square kilometers in the district (RDist_SqK) – were highly significant at the 99% level (\( p < 0.01 \)).

Since we are dealing with a linear-linear model, the interpretation of the significant \( \beta \) coefficients is straightforward. However, in dealing with an SAR model, a one-unit change (decrease or increase) in the explanatory variables leads to a corresponding change (decrease or increase) in the dependent variable (in this research, Cafés_Den) in a given district (a direct impact) and its neighboring districts (an indirect impact). Both the direct and indirect impacts
constitute the total impacts of a one-unit change in the explanatory variable. According to LeSage and Pace, the total impact of one-unit changes in the $\beta$ coefficients, when using a row-standardized weight matrix, can be obtained by the simple form $(1 - \rho)^{-1} \beta_r$, where $\rho = 0.535$ (from Table 6.1). The parameter $\beta$ represents the $\beta$ coefficients with $r = 1, 2, \ldots 14$. The implementation results of the above simple form are as shown in the “total impacts” column of Table 6.1.\(^85\)

The two measures – *average household incomes from wage employment* (HH_Inc_Wag) and *district’s workers in agriculture* (Rat_Wor_Agr) – for industrial structure emerged as determinants of Internet diffusion in Kenya. HH_Inc_Wag had a positive (0.091) and a highly significant $\beta$ coefficient ($p = 0.008$). This means that, if average household income from wage employment were to increase by 1%, the number of Internet cafés per 100,000 inhabitants in a given district and its neighbors would increase by about 0.196 Internet cafés as total impacts. This is confirmed by the cluster of Nairobi, Kiambu, and Thika districts, which command high average household income from wage employment and a high number of Internet cafés per 100,000 inhabitants.

Rat_Wor_Agr had a negative (-0.045) and significant ($p = 0.026$) $\beta$ coefficient. The significant result means that if the ratio of workers in agriculture were to decrease by 1%, the number of Internet cafés per 100,000 inhabitants in a given district and its neighbors would increase by about 0.097 as total impacts. Existing literature seems to support these findings.\(^86\)

The *ratio of the labor force to total population* as measure of industrial structure was excluded because of multicollinearity. The use of average household income from wage employment was deemed a more appropriate replacement. In addition, the ratio of workers in

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\(^85\) See LeSage and Pace 2009, chapter 2. Note also that this research used a row-standardized weight matrix, $W$.

agriculture (Rat_Wor_Agr) supplemented the preceding and was used because it had more explanatory power than the average household incomes from agriculture.

The percentage of households with electricity connections in the district (HH_Elec) had a positive (0.193) and significant ($p = 0.002$) $\beta$ coefficient. These results mean that if the percentage of households with electricity connections in the district (HH_Elec) were to increase by 1%, this would lead to an increase in the number of Internet cafés per 100,000 inhabitants by 0.415 Internet cafés in a given district and neighboring districts as total impacts.

Teledensity (defined as the number of telephone connections per 100,000 inhabitants in this research) emerged as a determinant of Internet diffusion. However, compared to past studies, the results of the SAR model were negative (-0.001) and highly significant ($p < 0.01$). The model results show that if telephone connections per 100,000 inhabitants were to increase by 1,000, then Internet cafés per 100,000 inhabitants would decrease by two.

The unexpected results in this research can be explained by the following. First, the diagnostics for spatial dependence showed that the numbers of Internet cafés per 100,000 inhabitants (Cafés_Den) are significantly clustered while teledensity (Tel_Den) is insignificantly clustered. This implies that, except for a few districts, many districts have dissimilar values. Second, the unexpected results could also have arisen since the levels of penetration of the two measures of the digital divide differ. That is, the number of telephone connections, being an old technology, has a higher penetration rate (i.e., regionally) than the Internet. However, given that other means of accessing the Internet (e.g., modems and Wireless Application Protocol (WAP) enabled cell phones) may overtake the conventional fixed telephone line, it is right to suggest

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87 See Bonaccarsi, Piscitello, and Rossi (2005).
that the expected relationship may break down completely when the Internet penetration rate increases over time.

The length of all-weather roads per square kilometers in the district (RDist_SqK), a measure of the level of regional connectivity in the district, had a positive (6.027) and highly significant ($p = 0.001$) $\beta$ coefficient. These results mean that on average an increase in the length of all-weather roads per square kilometer causes the number of Internet cafés in a given district and its neighbors to increase by approximately thirteen.

Similarly, the distance from the district’s headquarters to the nearest major urban area (HqDist_Mt) emerged as a determinant of Internet diffusion. The results show a positive (0.01) and significant ($p = 0.021$) $\beta$ coefficient. The positive coefficient is contrary to the expectation of a negative coefficient. The positive $\beta$ coefficient and significant results mean that an increase in the distance from the district’s headquarter to the nearest major urban area by one kilometer leads to an increase in the number of Internet cafés per 100,000 inhabitants by 0.022.

Despite the negative relationship between HqDist_Mt and Cafés_Den as shown by the scatter plot (Figure 6.6), the unexpected coefficient could be a result of the influence of some of the explanatory variables. Attempts to control for any of the model explanatory variables did not yield the expected negative coefficient. This means that other variables not included in the model could be responsible. After all, Baliamuone-Lutz remarks that in some cases the empirical evidence of the impact of variables, particularly in developing countries, is ambiguous or more in support of their insignificance (2003).

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88 See Bonaccorsi, Piscitello, and Rossi (2005) and Grubesic (2002).
89 See Madden and Coble-Neal (2003).
D. Summary

This chapter has analyzed and presented descriptive, concentration, and spatial modeling results for Cafés_Den. Descriptive results, in the form of chloropleth mapping, have shown the regional variations in the number of Internet cafés – a measure for the “new” digital divide. Additionally, concentration analysis using the Lorenz curves, Gini coefficients, and the Herfindahl-Hirschman Indices (HHI) further confirms the spatial disparities in the “new” digital divide in Kenya. The Gini coefficients for the number of Internet cafés of 85.38% and 78.84% for all districts and all districts excluding Nairobi, respectively, confirm the above results. The Herfindahl-Hirschman Index (HHI) calculation indicates that for the number of Internet cafés the values are 18% and 13% for all districts and all districts excluding Nairobi, respectively.

The spatial modeling results showed significant spatial dependence in the number of Internet cafés. The rho (ρ) score of 0.535 measures the average influence on a given district’s number of Internet cafés by its neighboring districts’ number of Internet cafés in the SAR model. Spatial analysis has shown the significant determinants of Internet diffusion. These variables are the ratio of workers in agriculture to the total population (Rat_Wor_Agr), the distance of the

Figure 6.6. Scatter plot for Cafés_Den and HqDist_Mt in Kenyan districts.
district headquarters to the nearest major urban area (HqDist_Mt), and the percentage of households’ income from wage employment (HH_Inc_Wag). Others are the percentage of households in the district with electricity connections (HH_Elec), teledensity (Tel_Den), and the length of all-weather roads per square kilometer in the district (RDist_SqK). The next chapter will present the research conclusions, recommendations, and implications for future research.
CHAPTER VII: CONCLUSIONS AND FUTURE RESEARCH

This chapter concludes the research by stressing that the pattern of the digital divide and its contributing factors mirror the existing level of economic development disparities. The chapter also highlights recommendations and implications for future research.

A. Conclusions

This research investigated Kenya’s intra-national digital divide. It was guided by the argument that past infrastructure investments led to inequalities in economic development and further that the same could persist or grow worse in Kenya and other developing countries, given the present ICT-dominated New Economy.

The literature illustrated that regional development, which began in earnest in Third World countries following the Second World War, owes its origin to the presence of substantial economic growth and the persisting presence of spatial and regional disparities. The literature also showed that various scholars have used several theories – theories of regional economic convergence, theories of regional economic divergence, and structural theories of regional economic development – to explain how regions grow. In turn, various governments and other players have relied on several theories as guiding instruments for addressing regional development disparities. These efforts were aimed at bridging regional disparities by employing factors of production in view of comparative advantage, generating economies of scale because of an expanded market, providing stimuli for investment, and better utilization of economic resources and enjoyment of multiplier effects. Notwithstanding the preceding efforts, a large body of literature shows the continued presence of spatial and regional development disparities in many developing countries. Reasons such as population and land pressures, inadequate
physical infrastructure, poor information gathering and dissemination, and limited markets for products are to blame (Kenya, 1991, cited in Goonerante and Obudho 1997, 91).

Kenya’s experiences with implementing regional development date back to the early years of independence, when the country faced widespread uneven development mainly in the form of poverty, illiteracy, and disease. Importantly, during the colonial period the colonial government relied on A. W. Lewis’ structural transformation model, which emphasized selective infrastructural investments. This policy focus optimized the extraction of resources for onward transmission to Britain, the colonizing country. It is not surprising therefore that at independence, Kenya’s economy was characterized by core-periphery dualism, the predominance of foreign capital, the dominance of agriculture, the limited development of industry and heavy reliance on exporting primary products, and imports of capital and manufactured consumer goods.

Responding to the prevailing state of uneven development, the newly independent Kenyan government relied on Sessional papers and later five-year development plans as development tools. In particular, growth pole theory was adopted as an official approach to guide regional development policy. Among other things, the growth pole theory necessitated triggering supply-side development forces through the investment of physical infrastructure in regional growth and service centers. The aim of such efforts was to concentrate resources in high potential regions with the expectation that over time the accrued benefits would trickle down to other regions, thus balancing regional development. Nevertheless, after several years of implementation, Kenya’s disparities among regions and communities persist.

In terms of information and communication technologies (i.e., old and new), the existing literature showed that these technologies have played crucial roles in economic development at the national and at the regional levels. At both levels, ICTs are useful in reducing information
asymmetry, lowering transaction costs, and enhancing competition so consumers have a wider choice of merchandise and prices. ICTs also enable developing countries to leapfrog and enjoy faster growth and a larger share of the world’s development due to their inherent features. In the past, African countries have used ICTs to disseminate information and messages aimed at improving agricultural production, health, education, and national security in particular, and aimed at creating a conducive environment for national development in general (Schramm 1964).

Specific to regional development at the country level, a central focus of this research, ICTs have the potential to democratize political participation and policy formulation, reduce regional, rural-urban, and gender imbalances and redefine the parameters of development thinking and practice. This is achieved by reducing the barriers of time and distance from major markets, reducing information asymmetry, improving governance, and increasing the technology transfer between the urban and rural areas.

Literature on the development of ICTs and the digital divide in Africa and in Kenya confirms low development of both old and new ICTs across the African continent. Similarly, the literature shows observable regional disparities in ICT development across the continent. This scenario, coupled with the rise of economic globalization and accelerated international competition, places Africa (in general) and Kenya (in particular) in a precarious position. Specific to Kenya’s regional disparities, Nairobi and other major urban regions are pitted against rural areas with respect to old and new ICTs. Thus, faced with the reality that access to and use of ICTs between regions and people is one of the obstacles that stands in the way of bridging regional development disparities, this research proceeded to study Kenya’s intra-national digital divide. The research addressed the following three research questions:
• What is the extent of the intra-national digital divide in Kenya?
• What are the factors that determine the intra-national digital divide in Kenya?
• How can the intra-national digital divide be substantiated using regional-level data?

The results of descriptive, concentration, and spatial analyses showed an existing spatial intra-national digital divide in telephone and Internet diffusion. The results of concentration analyses (i.e., for all districts and all districts excluding Nairobi) indicate that Nairobi is dominant in its share of both the number of telephone connections and the number of Internet cafés. Nevertheless, Nairobi’s share is greater in the former than in the latter.

Spatial analyses showed several variables – broadly, socio-economic, infrastructural, and geographical – as significant determinants of the intra-national digital divide in Kenya. For the “old” digital divide (measured by the number of telephone connections), the ratio of district urban population (Rat_Urb_Pop), the district’s contribution to national poverty (Con_Nat_Pov), and the percentage of households with electricity connections (HH_Elec) emerged as significant determinants. For the “new” digital divide (measured by the number of Internet cafés), the following emerged as significant determinants: the ratio of workers in agriculture to the total population (Rat_Wor_Agr), the distance of the district headquarters to the nearest major urban area (HqDist_Mt), and the percentage of households’ income from wage employment (HH_Inc_Wag). Others determinants include the percentage of households in the district with electricity connections (HH_Elec), the number of telephone connections per 100,000 inhabitants (Tel_Den), and the length of all-weather roads per square kilometers in the district (RDist_SqK).

In addition, the spatial analyses indicated significant spatial dependence (or autocorrelation) in the “new” digital divide (i.e., Internet diffusion) and lack of it in the “old” digital divide (i.e., telephone diffusion). With caution, this research concludes that the lack of
significant spatial dependence in the number of telephone connections, an “old” digital divide, could mean that in the future the spread of the number of Internet cafés, a “new” digital divide, may also exhibit spatial independence. If this happens, then it suggests that spatial dependence in the digital divide is a temporal phenomenon; that is, with an increase in the density of technology use, the spatial dependence will become insignificant.

Unsurprisingly, the research results revealed that the extent of existing ICT adoption and use in the country, as represented by telephone and Internet diffusion, mirrors that of existing economic development. Concisely, the districts that are more urbanized, more educated, and more endowed with ICT-related backbone infrastructure, together with their neighbors, exhibit more developed telephone and Internet diffusion.

Accordingly, the contribution of this research to the existing literature is as follows. First, the research has focused on the intra-national or regional digital divide. Aside from being a little-explored study area, this research is the first of its kind to employ spatial analysis in a developing country. It employed the conventional measures used in the existing literature as well as new ones. For instance, the research uses the ratio of urban areas with electricity as a measure of electricity available for firms and other institutions for the first time. This is appropriate since electricity penetration rates in developing countries are generally low. As such, the findings in this research provide benchmarks for future studies not only in Kenya but also in other developing countries with comparable economic structures in the New Economy.

Second, the findings will permit policymakers and development experts to speculate on what approaches and policies Kenya and other developing countries with comparable economic profiles will require to narrow the existing intra-national digital divide in the future. This is possible since the spatial analysis used in the research provides simple quantitative descriptions
of existing patterns of the extent and determinants of the intra-national digital divide. The procedure used (i.e., spatial analysis) is useful in modeling other variables not identified in the spatial models in this research.

Third, empirical findings here corroborate some robust findings in the existing literature with respect to the variables that are thought to influence the digital divide. Model variables that corroborate their influence on the digital divide broadly include socio-economic, infrastructural, and geographical variables. It became apparent from the research that spatial contiguity is very important for diffusion flow across districts. Related to the preceding is the fact that “peripherality” is still an obstacle to the adoption and use of ICTs in Kenya.

B. Implications for Future Research

The research was limited by a lack of available data that could have provided more precise descriptions of the variables. For instance, the number of Internet users per district would have been a more precise measure for Internet diffusion than the number of Internet cafés. Other more precise variables include cell phone usage, the percentage of college-educated residents, and the average years of schooling attained. The first variable represents telephone diffusion, while the last two represent the level of education in the country.

The research also underscores that instead of using the average household incomes from wage employment as a measure for the district’s industrial structure, other measures like its median equivalent would have been more appropriate. It would be interesting to consider the preceding and other more precise measures (e.g., security and ethnicity) in future research.
C. Recommendations for Policy

From the above section, it can be concluded that the presence of the digital divide means that deliberate demand- and supply-side policy prescriptions aimed at enabling lagging regions to increase their ICT adoption and use are needed for ICT-related development to lead to regional development convergence. Recent efforts, for instance, observed in the massive investments in the undersea fiber optic cables by public-private partnerships is an example of supply-side policy option. Demand-side policies would include subsidies that allow ICT consumers incur less costs in accessing and using ICTs. Policy makers need to pay attention to the significant determinants of Kenya’s intra-national digital divide. Further to this, by incorporating spatial dependence in the model exercise, the research is informative and robust in guiding policy formulation.

The research emphasizes that policy formulation should incorporate how the Internet’s distributive power, for instance, can be leveraged to encourage the decentralization of economic and social activities in Kenya. In any case, as a general-purpose technology, the Internet can compensate for the spatial barriers brought on by geographical distance, reduce information asymmetry and transaction costs, and increase network externalities. In addition, the Internet has potential to lead to greater decentralization and non-hierarchical patterns. If policies are formulated and implemented as will be suggested later, then this research argues that the Internet activity currently exhibited in urban areas will eventually spread to more rural or peripheral areas over time. This needs to be boosted, however, by policy formulation and guidance that encourage pervasive ICT diffusion in the long run by paying attention to several factors that may stand in the way.

Some of the significant determinants of Kenya’s intra-national digital divide alluded to above have been identified in the research. First, spatial analysis suggests that peripherality is
still an obstacle to ICT adoption and use. Both measures of geographical connectivity – the distance of the district headquarter to the nearest major urban area (HqDist_Mt) and the length of all-weather roads per square kilometers in the district (RDist_SqK) – emerged as significant determinants of the “new” digital divide (measured by the number of Internet cafés). Thus, it is valid to argue that if geographical connectivity between districts and urban centers is improved, then ICT diffusion will also improve at the national level. In other words, inter- and intra-district connectivity need to be important parts of any effort towards bringing convergence in ICT development.

Second, the research results show that the effect of electricity penetration is important in influencing the “new” digital divide (measured by the number of Internet cafés) and the “old” digital divide (measured by the number of telephone connections). This means that policy makers should focus on how to address disparities related to electricity access connections.

Third, the results show that the level of economic well-being in the district (measured by district’s contribution to the national poverty) is a significant determinant of telephone diffusion. This means that policy prescription should incorporate a subsidy that makes the fixed line telephone accessible to many residents. Such a subsidy could in the form of the initial connection costs, which for long has been a hindrance to fixed line telephone diffusion.

Forth, research results show that the ratio of workers in agriculture (Rat_Wor_Agr) hinders Internet development. To change the negative contribution of this variable, the government can provide subsidies to the agricultural sector for the development of the Internet and other ICTs. These subsidies could be in support of digital villages and other public access fora (e.g., public libraries) in the rural areas where the majority of the residents are engaged in agricultural activities. By providing open access to the members of the public, digital villages
and other public access fora will strive to improve the integration of the Internet in rural areas. The latter could provide a catalytic role to rural and regional development.

In addition to the statistically significant factors that influence the adoption and use of new ICTs, other factors including the legal framework need to be addressed by government policies. If this is done, then the increase in adoption and use of the Internet in e-commerce, for instance, may be improved. This would enhance the private sector’s ability to take advantage of the inherent pervasive nature of new ICTs like the Internet. For instance, its use in one sector (e.g., e-commerce) could trigger a “multiplier effect” through the entire economy.

The research, by considering the demand and supply environments in which the level of ICT diffusion operates, has established that the former seems to have been the main driving force in the development of the present level of ICTs than the latter. This research argues that the dual role of demand and supply factors is a pre-requisite for the development of “threshold” levels of income, industrial structure, backbone infrastructure (e.g., telecommunication and electricity densities), and so on. In turn, critical “thresholds” of the preceding factors are pre-requisites for ICT development. Thus, any future policy formulation needs to mediate broadly both the demand-side and the supply-side environments as conceptualized in Figure 2.1. The role of the government in boosting supply-side efforts should be promotional in the sense of forging cooperative alliances with the other ICT players.

In closing, by establishing the inexcusable presence of the spatial digital divides as measured by the number of Internet cafés and the number of telephone connections in Kenya, this research confirms the digital divide as the current development dilemma that will deepen regional development divergence in the New Economy if it is not addressed in a coherent fashion. Thus, arguing on the premise that ICTs have a role in catalyzing development, the
preceding means that national and regional development disparities can be reinforced by the
divide in the access and use of the new technologies (e.g., the Internet) just as old technologies
have caused regional development disparities in the past.
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Appendix A. Diffusion model with van Dijk’s adaptation

Appendix B. Kenya Data Network’s fiber optic network coverage in Kenya
Source: www.kdn.co.ke
Appendix C. Significant milestones in Kenya’s early Internet development

1980s-1994
• 1980s IDRC funded East Africa Net
• 1989-90 USAID sponsored ERD-LAN networks at Ministry of Finance
• 1990 Health net covers Uganda, Tanzania, Zambia, Zimbabwe, and Kenya
• 1990-91 LEO technology applied
• 1992 duty on computers are reduced
• 1992 HealthNet
• 1992 Staff at Institute of Computer Science have e-mail access
• 1992-93 ARCC e-mail Fidonet
• 1993 Internet access is available
• 1994 Africa Online founded

1995
• Internet service unreliable
• ARCC inaugurates Internet access- with about 100 accounts
• East African Internet Association formed.
• ARCC receives funding from ODA for international dedicated line to provide Internet Services on a commercial basis.
• Form Net Africa founded and launches local bulletin board, and store and forward Internet e-mail service
• KPTC announces contract for building a Kenyan Internet Backbone

1996
• Local phone rates were reduced
• April 64 kbps link on-line
• Reliable Internet service achieved
• Africa Online and Form Net come on line with full Internet services
• EAIA forms Kenya Internet Services Ltd (KISL) to provide a hub for low cost shared access for ISPs and NGOs
• KPTC publishes RFP for provisioning a Kenya Internet Backbone to service approximately 40 ISPs and 50,000 users.

1997
• Early 10,000 users
• University of Nairobi Students acquire e-mail access
• May number of smaller ISPs comes on-line
• Indications are that the KPTC Internet Backbone order will soon be awarded.
• Late 15,000-50,000 users.

Appendix D. Regression diagnostics for Kenya’s teledensity

<table>
<thead>
<tr>
<th>Test on Normality of Errors</th>
<th>DF</th>
<th>Value</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jarque-Bera</td>
<td>2</td>
<td>398.664</td>
<td>0.000</td>
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</table>

**Diagnostics for Heteroscedasticity**

<table>
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<tr>
<th>Test</th>
<th>DF</th>
<th>Value</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breusch-Pagan test</td>
<td>13</td>
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<tr>
<td>Koenker-Bassett test</td>
<td>13</td>
<td>58.926</td>
<td>0.000</td>
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</table>

**Diagnostics for Spatial Dependence**

For Weight Matrix: `EDITED_QUEEN.GAL` (row-standardized weights)

<table>
<thead>
<tr>
<th>Test</th>
<th>MI/DF</th>
<th>Value</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moran's I (error)</td>
<td>-0.165</td>
<td>-1.685</td>
<td>0.092</td>
</tr>
<tr>
<td>Lagrange Multiplier (lag)</td>
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<td>3.164</td>
<td>0.075</td>
</tr>
<tr>
<td>Robust LM (lag)</td>
<td>1</td>
<td>0.101</td>
<td>0.750</td>
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<tr>
<td>Lagrange Multiplier (error)</td>
<td>1</td>
<td>4.163</td>
<td>0.041</td>
</tr>
<tr>
<td>Robust LM (error)</td>
<td>1</td>
<td>1.101</td>
<td>0.294</td>
</tr>
<tr>
<td>Lagrange Multiplier (SARMA)</td>
<td>2</td>
<td>4.264</td>
<td>0.119</td>
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