UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

STUDIES ON THE INTERNATIONAL ECONOMICS OF INFORMATION TECHNOLOGY

A DISSERTATION

SUBMITTED TO THE GRADUTE FACULTY

in partial fulfillment of the requirements for the

degree of

Doctor of Philosophy

By
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Norman, Oklahoma
2007

STUDIES ON THE INTERNATIONAL ECONOMICS OF INFORMATION TECHNOLOGY

A DISSERTATION APPROVED FOR THE
GRADUATE COLLEGE

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Acknowledgements

This dissertation is dedicated to my parents, Sabri Erturk and Ulku Erturk. They brought me up well as an only child, and always encouraged me to continue my studies further. Several years ago, I used to view the Ph.D. as an ultimate station but I now realize that it is only a beginning for those who want to join the world of academic scholars and advanced research.

My sincere appreciation goes to all members of the dissertation committee for their guidance and positive approach. It has been nice to work with such professors with great experience and distinction. I also appreciate the friendly assistance that I received from various university administrators and staff. Finally, my thanks go to all other individuals I am acquainted with, who have motivated me through their positive comments.

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Abstract

This dissertation is a collection of three separate studies, which synergistically demonstrate how information technology (with emphases on the Internet and software) contributes to increases in economic productivity and economic development in general. The three studies also highlight how the quality and quantity of human capital influence a country's ability to benefit from computer technology and the Internet.

The computer is an example of a general purpose technology, a leap of innovation that affects entire economies and causes drastic advancement. Specifically, the Internet works as a virtual large-scale international community of economic integration, and contributes to economic development around the world. The Internet has reduced the cost of communication, increased the amount of communication and information worldwide, and thereby increased commerce for a variety of goods and services. In the dissertation, the economic roles of innovation and technology are discussed in detail with specific examples from the field of computer technology.

The first study statistically analyzes the relationship between computer technology use and economic productivity using international data. At the end of this first study, the findings show a positive relationship between computer technology and productivity. In the second study, free Linux software is examined as an example of how computer technology may benefit less developed countries in the future. Here the level of human capital is determined to be a key factor that influences the ability of people in a country to adopt software technology. In the third study, international software outsourcing is discussed in order to illustrate how human capital plays an important role in national economic development. In addition, the potential benefits of outsourcing for both the developed and the less developed countries are underscored.

CHAPTER 1

The Internet and Economic Productivity

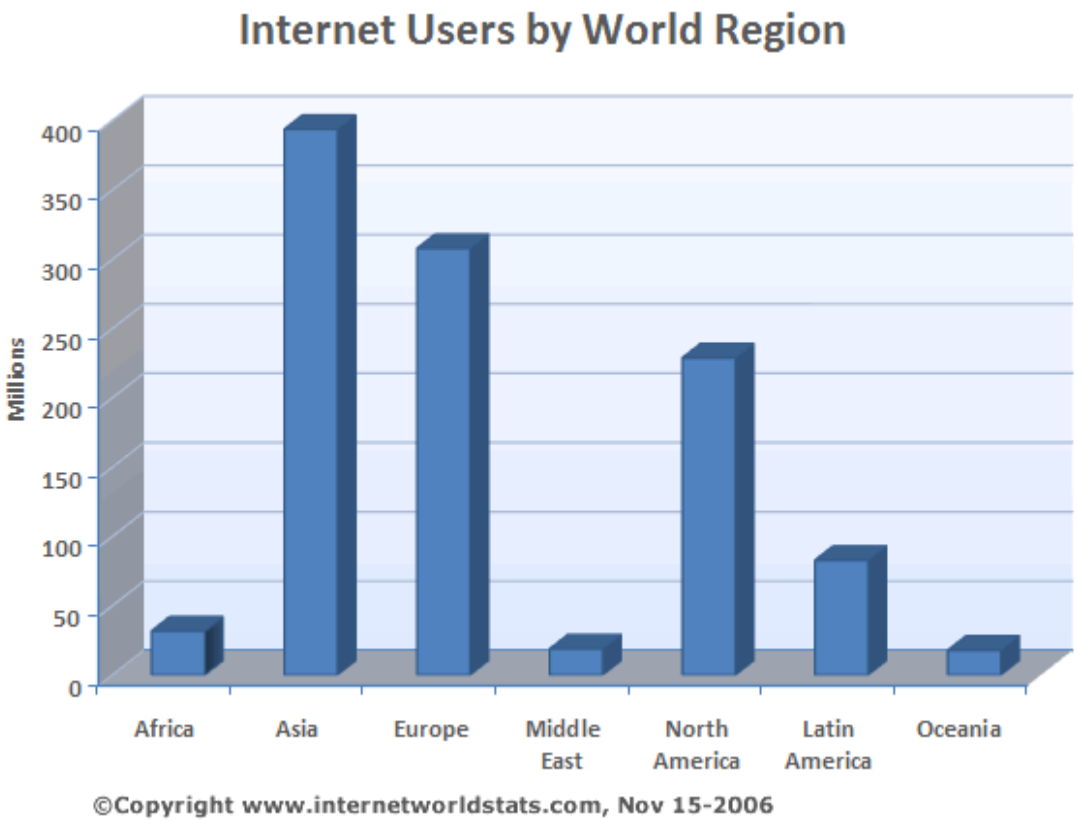
1.1 Introduction

1.1.1 The Global Digital Divide

Ever since the World Wide Web started making the Internet accessible to a tremendous number of people, the Internet has been regarded as one of the historical technology breakthroughs that had great economic impact such as the locomotive, the automobile, the telephone, the television, etc. Although the Internet is regarded as a potential source of economic benefits, there are currently relatively few studies that attempt to explain how the economic benefits take place and most of these previous studies focus on a small group of developed countries.Therefore one of the puposes of this study is to analyze this phenomena within a larger and economically asymmetric world sample, including countries from different continents and regional organizations.

From the consumption perspective, Internet usage is a sign of prosperity, especially on the part of wealthier countries. The “digital divide” has been a source of concern not only within individual economies but also between countries at an international level. Figure 1.1 on the next page compares the current Internet usage between different continents. People in some parts of the world enjoy this luxury and employ its tools to a greater extent than people in other parts of the world. This is part of a general economic asymmetry between the developed parts of the world and those that are developing.

Figure 1.1: Internet Users by World Region

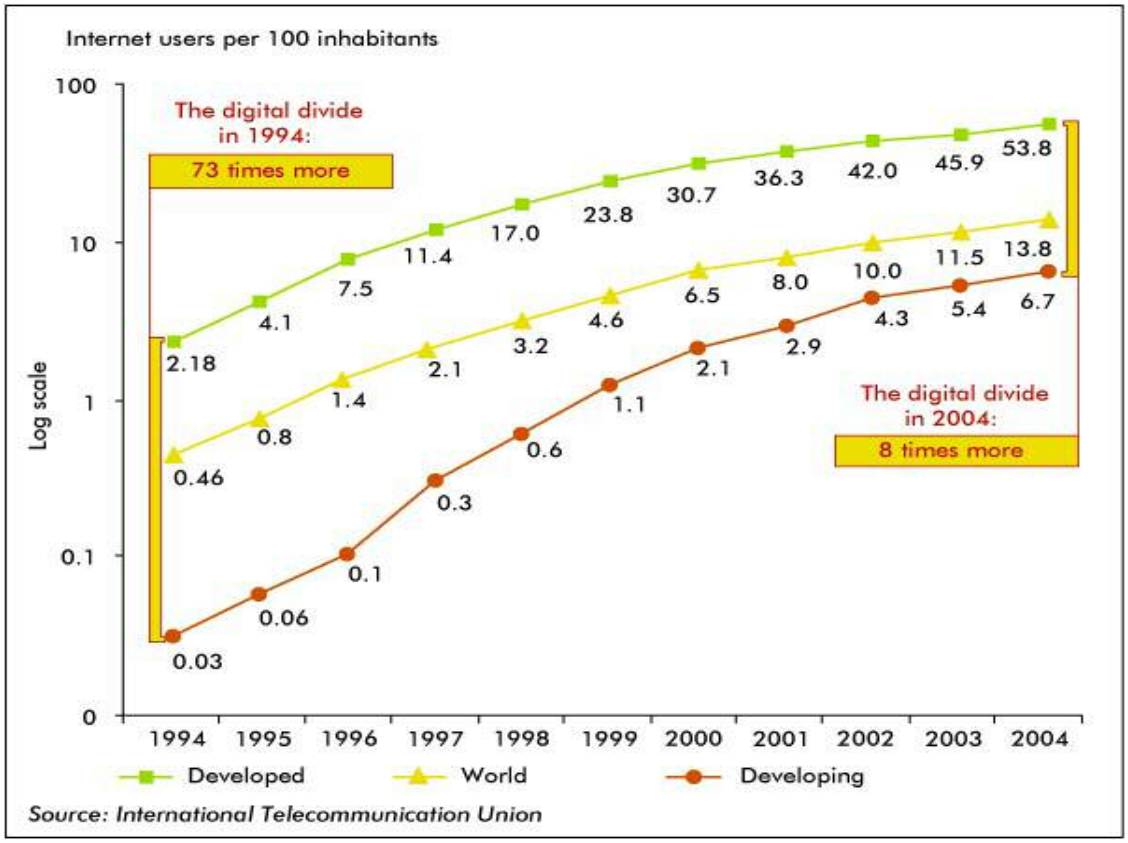


Aside from labor, natural resources and capital, technology also plays an important role in the efforts of many developing countries in catching up with the more developed ones. Figure 1.2 on the next page shows the growth of the Internet since 1994 for developed and less developed countries.

The Internet is a strategic venue. As early as 1995, Frank Odasz stated: "the nations that first establish a high degree of citizen tele-literacy may well become the new global economic leaders. Thus, successful implementation of the economic potential of networking must emphasize the development of these skills." Quite often, having personal practice with computers and personal experience online seems more valuable than learning how to use computers through formal instructional training.

Countries with more computers and Internet users per capita have an advantage because they have more people who can learn on their own time and resources. Therefore efforts in this regard need to be made as early as possible. Even in conservative countries, the Internet is inevitably viewed as a priority. Recently, in February 2007, the newly inaugurated president of Turkmenistan called for the reorganization of the education system and greater Internet access (Agence France-Presse, 2007). In return, the Internet can help alleviate some of the problems of the developing world through commercial and government transaction cost savings as well as increased communication and education.

Figure 1.2: The Growth of the Internet and the Closing Digital Divide



According to a group of articles in the German publication *Nord-Sued Aktuell* ("Internet in Entwicklungslaendern: Chance oder Chimaere?," 2000), the Internet is a potential source of confusion or even disaster for some developing countries because it seems frivolous or too early in the context of other more basic human needs that are not still satisfied for many people in developing countries. In another European study, the Norwegian author Stokke (2005) argues that adopting foreign technology in general is inappropriate for low income countries. Part of this pessimism is due to the common underlying notion that technology is not cost-effective for potential users in such countries because it is expensive for them and they typically do not conduct business at a large enough scale to take advantage of it. Another reason is due to domestic and international barriers that make it difficult for such countries to import equipment and knowledge. The author concludes that technology adoption is most profitable for middle-income countries, which have the potential and the capability to use it.

According to Haarapanta and Virta from the United Nations University in Helsinki, Finland (2006), high debt is another reason why some developing countries cannot afford to buy the latest technologies because they may be liquidity constrained. But the authors have also discovered that these highly indebted countries have nevertheless been able to improve the efficiency and utility of their old equipment. It is possible to counter the pessimistic arguments and, at the same time, derive important lessons from them.

In the case of less developed countries, governments, organizations, and businesses must implement computer technology *not for high-end applications or for entertainment* but in order to assist in addressing basic human issues of nutrition, construction, health, and education. Computers have a higher potential benefit to a larger group of people with different uses because they are *general purpose technology*. Last, the Internet itself is a way to alleviate domestic and international barriers to trade and knowledge.

Innovation entrepreneurship is recognized in economics literature as a potential factor in economic growth. In one study (Tang & Koveos, 2004) there is a mild correlation between innovation entrepreneurship and economic growth (growth in the Gross Domestic Product [GDP]) in the case of middle (relatively low) income countries. In that study, innovation entrepreneurship was expressed as an index/score for each country. It was a weighted average of the responses to survey questions and the hard data. An additional characteristic of successful economies is their integration in world trade and their ability to export. According to Paul Romer (1993), the value of knowledge and technology increases with the increase in the size of the market. It is only natural to think that the Internet is a great illustration of this far-sighted point.

The global mindset (Nummela, Saarenketo & Puumalainen, 2004) is positively correlated with the orientation toward exporting and with successful exporting outcomes. This concept also shares some logic with innovation entrepreneurship. In a later study carried out by two of the same authors in cooperation with two new authors (Jantunen, Saarenketo, Puumalainen, & Kylaheiko, 2005), it is demonstrated that people and companies with higher entrepreneurial orientations have a potential competitive advantage, can take better advantage of organizational and technological capabilities, can expect a better international

performance. In that study, the concept of entrepreneurial orientation was defined as innovativeness, pro-activeness, and risk taking. Innovation and entrepreneurship, positive factors for all economies, may be increased through various means, one of which is the Internet. An analysis of some of the available international data may show is a strong correlation between the rate of Internet use in a country and that country's innovation entrepreneurship score. On the other hand, both of these variables also correlate strongly with per capita income. As discussed later in this study, wealthier countries have more Internet users and depend more on innovations.

The realization of the importance of innovation in economic development goes back in time. The work of Joseph Schumpeter (1883-1950) influenced many future theoretical studies in this area. "Innovations have ever since been appreciated as a core concept in Schumpeterian economics (Witt, 2002)." According to Schumpeter: "Change [that is endogenously generated] within the economy is brought about by the innovative activities of entrepreneurs, the only agents who are capable of carrying out new combinations of resources and transforming organizational forms." New ideas and knowledge are at the core of innovations, examples of which are new goods, new markets, new methods of production, new source of materials, and new types of organizations. The Internet seems to incorporate all of these examples (new goods, markets, new production methods, and new organizations), even including the concept of a new source of raw materials when one considers data and information as raw materials for many goods and services.

The countries where the most innovative activities take place (including the sophisticated use of the Internet for science and commerce) may *not* be the fastest growing countries; developing countries are usually growing faster although relatively smaller portions of their national resources are dedicated to innovation and technology. According to a study by Kelly Morgan and Anya Hagerman (1999), the regions of the USA, where more technological and innovative activities occur, grew slower than those regions, where such innovative activities were relatively scarce but unskilled inexpensive labor was available to produce the emerging goods. Therefore, in the statistical analysis later in this study, the comparisons need to be made between somewhat similar countries and also take into account other factors. Since the past literature is still unclear on the issue of the innovative technology (Internet) as contributing to overall economic growth, this study sets out to clarify the relationship between Internet use and economic benefits.

1.1.2 Technology, Human Capital and Economic Development

Computer technology can be used in schools, libraries, and continuing education to develop human capital resources. Educating young people using computers delivers more than just content to them. Using a computer (just like reading a book) has intrinsic value; it can in and of itself help stimulate and develop a person's intellectual faculties. Human capital is considered to be a major source of social-economic development (Huang, 1997). This theory is supported also by economic facts. For example, it is assumed that rich countries possess a higher quality of human capital on the average in comparison with poor countries. Likewise, according to Huang's study (1997), the countries that have grown fast since the 1960's (for example countries in East Asia) are those that invested more in human capital than the other less developed countries which relatively fell behind.

Shortage of human capital has been suggested as one of the obstacles to growth and development in Africa (Nandwa, 2004). The education level of a population influences its ability to absorb information and new technology. This is clearly relevant to the same population's economic productivity and development. In addition, when advanced education and technical skills are not widely available throughout the population, this situation also results in socio-economic inequalities (which are also a negative indicator for economic development). Certain basic technological i.e. computer skills are best introduced at the high school or secondary school level. For this reason, in developed countries, young people are taught basic computer usage and the Internet as teenagers (those skills that will get them around for the rest of their lives and which they can build upon in their free time).

A recent study (Sab, 2000) shows that the secondary school enrolment rate is strongly associated with income and growth. Another study (Hu, 1999) emphasizes the importance of "research and development" aspect of human capital in economic production, growth, and development. Currently, most research and development is managed using computers. All the information needed for research as well as all the information that results from the research is maintained by computers and distributed with the help of computers (i.e. electronically published and distributed using the Internet). Computer technology has also impacted entrepreneurs (Chen, 1996). With the advance of technology, the work force experiences pressure to acquire more human capital in order to prepare themselves for future jobs. According to Mookmanee (2005), workers will find it worthwhile to invest in education if the marginal cost is not too high. In one of the statistical models of that study (featuring 11 high-income OECD countries), Mookmanee (2005) showed that public subsidies of education can help increase the education level and thereby the productivity of the

workforce. In return, with a more prepared work force market, entrepreneurs look to opportunities in the service and technology sectors where computer systems are used as opposed to physical production such as agriculture and manufacturing. If more and more people in less developed countries acquire technology skills, this will enable their potential employers (including their governments) to offer more business and work alternatives. This will then help these economies grow.

1.1.3 Significance of the Research

This study is intended to provide significant information to anyone in the public, private, or education sectors who may be interested in understanding or solving development and technology issues in their countries or around the world. The significance manifests itself in two directions: (a) leaders who read this study will be able to make more informed practical decisions in regards to this topic, and (b) the research will contribute to the theoretical knowledge about this topic. Other interesting aspects of this study are the predominant use of high quality sources accessed through the Internet, and the use of the latest computer software during its own preparation.

Both the developed and the developing countries may benefit from innovations and ventures that take advantage of the Internet. They also may benefit from the extra consumer information and market competition that the Internet can help develop. These aspects can lead to good effects in the economy. Business leadership across the world also needs to look for new and more efficient uses for technologies such as the Internet. This study, in combination with the other two studies in this dissertation, also provides data and insight that could prove useful to businesses who market computer technology across the world.

Initial development of the Internet infrastructure and non-commercial Internet services require public leadership and favorable government initiatives. The developed countries contain many examples of this (one of which is the role of the U.S. government and military in inventing the concept and building the earlier computer networks). The development of policies and initiatives are currently under way in developing countries as part of their effort to catch up with developed countries in terms of economic development and quality of life.

An enlightened leadership style is needed to carry out policies that do not hinder the spread of the Internet (Global Internet Policy Initiative, 2004). This seems, from one point of view, to be laissez-faire: allow more freedom of expression, allow more competition, and not introduce Internet-specific laws or taxes. This is the case in countries where the Internet has flourished the most, and increased regulation correlates negatively with higher Internet penetration and low access charges (Global Internet Policy Initiative, 2004).

Secondly, this research will build on some of the previous studies cited in this dissertation. Previous studies, especially those done in late 1990s or early part of this decade, are quite often limited to a small sample of countries because they suffer from a lack of international data being available at the time. Therefore this study will broaden the international perspective. At the same time, since this is a current topic, this study intends to cement previous knowledge with more up-to-date facts. This study, in combination with the other two studies in this dissertation, is intended to be a well-rounded (and not dry) source in presenting many interesting and useful facts about computer technology and the Internet.

1.2 Literature Review

1.2.1 The Internet as an Innovative and Dynamic Technology

An important innovative technology in recent years has been computer technology. It has contributed to economic expansion in many countries. Computers and computer networks have replaced manual labor and cut costs for many companies. They have increased the information that is available to companies' managers in making accurate and competitive decisions. Computer networks that make up the Internet have opened up new markets to many companies for marketing and selling their goods and services. Networks have also made communication faster and cheaper between companies that are related to one another as suppliers and vendors. As a result, computers have cut transaction costs in many economic activities. Computer technology (including both electronic hardware components and software programs) in most countries is a large industry of its own. It provides employment and profits for many employees and entrepreneurs.

1.2.2 Innovation, Technology, and Economic Growth

The absorption rate of emerging technologies influences a country's economic growth. Technology brings about the ability to produce more with the same amount of natural resources, labor, and capital. Some countries may respond to technological progress faster and start gaining from it earlier. Despite the different timing, all countries will eventually take advantage of it to the full extent (Altig & Rupert, 1999). One of the important elements of the adoption of computer technology currently is the breadth of Internet use. According to a Federal Reserve Bank of Cleveland commentary (Altig & Rupert, 1999) which compared some developed countries, there is a positive relationship between increases in Internet use (as a proxy for computer technology) and GDP growth.

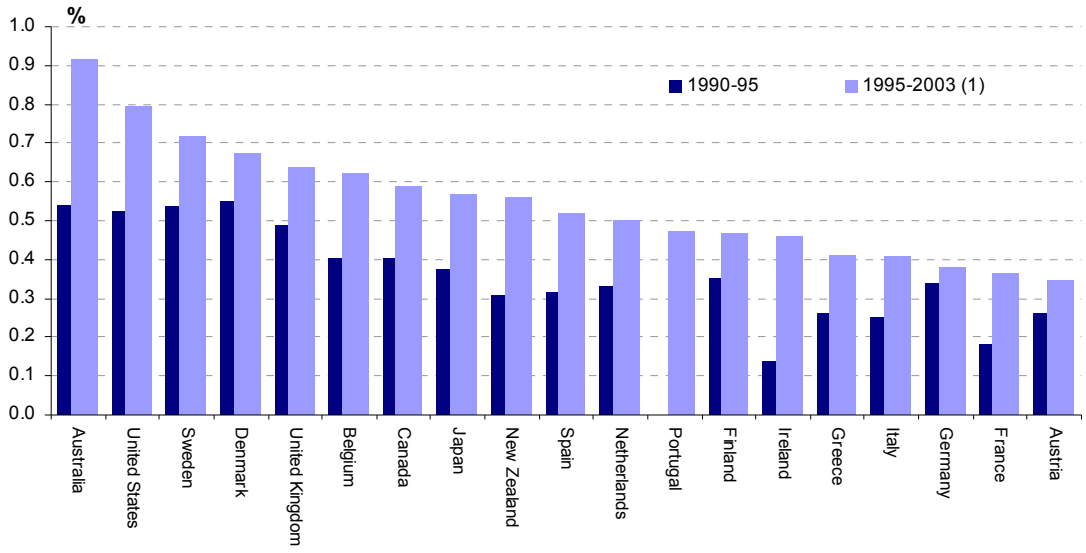
The conclusion of the same report was that greater computer and Internet use contributed to the faster growth of the United States between 1988 and 1998 in comparison with Europe and Japan during the same period. It also predicted that, with increasing computer technology penetration in Europe and Japan after 1998, the technology gap would be closed. These observations suggest that less developed countries can catch up in terms of using computer technology in the future and then they too will realize benefits from it.

Another study, published recently by three scholars from the Massachusetts Institute of Technology and Boston University, examined the technology and productivity relationship at the micro-economic level by analyzing a sample of individual workers and their workplace activities (Aral, Brynjolfsson, & Van Alstyne, 2006). In that study, they found that IT use is positively correlated with non-linear work productivity and the ability to multi-task work activities.

Litan and Rivlin (as cited in Madden & Coble-Neal, 2002) have stated in 2001 that e-commerce has the potential for the US economy to produce a total annual cost saving of about 1-2 percent, which over 5 years translates into an annual contribution to productivity growth of 0.2-0.4 percent. This kind of projected growth is dependent on the quality of the underlying telecommunication infrastructure. Other economies also have the potential to gain similar benefits – although each country to a different degree. That is why the Information and Communications Technology (ICT) infrastructure is a high priority for many governments and international development agencies.

The OECD (Organisation for Economic Co-operation and Development) currently prepares similar statistics regarding the impact of ICT investment on the economic growth of its member countries. Below is a graph that shows the organization's most recent findings.

Figure 1.3: Contributions of ICT Investment to GDP Growth, in Percentage Points



(1) 1995-2002 for Australia, France, Japan, New Zealand and Spain.

Source: OECD, Productivity Database, 2005. Available online: http://www.oecd.org/statistics/productivity

In the Madden and Coble-Neal study mentioned above (2002), information diffusion and market integration have been recognized as important underlying mechanisms behind the increase in productivity and economic growth. Together with better market integration, the authors validated the importance of ICT products and services exports (using data from Asia and the Pacific region) by showing that telecommunications exports have a positive inelastic impact on economic growth.

1.2.3. The Literature on the Internet and Economics

A study conducted by the Center for Research in Electronic Commerce - University of Texas at Austin (2004) categorized the Internet economy in the United States in four layers along with their growth in employment and revenues: (a) the physical Internet telecommunications infrastructure, (b) the Internet networking software programs, (c) Internet service companies, and (d) e-commerce companies that do transaction electronically. Overall, the revenues of the Internet economy grew 156% in just two years between 1998 and 2000 (Center for Research in Electronic Commerce - University of Texas at Austin, 2004). In the first half of 2000, the Internet economy supported 600,000 new jobs, going up to roughly 3 million by late 2000. These jobs are not only in information technology but also to a greater extent in sales, marketing, operations, manufacturing, accounting, and finance. The Internet economy in the United States is also highly productive; the revenue per employee increased 11.5% overall in the first 6 months of 2000 (Center for Research in Electronic Commerce - University of Texas at Austin, 2004). These computer technologies can be used to increase productivity also in the various sectors of less developed countries.

The state of the Internet in various countries has been compared in order to understand what they have achieved. In one such study, China has been examined in detail along six dimensions: pervasiveness of the technology, geographic dispersion of the technology, sector absorption of the technology, computer network infrastructure, organizational infrastructure, and sophistication of use (Press, 2003). China has many Internet users in absolute numbers (pervasiveness), and the proportion of the population that uses it is also high when compared with other less developed countries. The four sectors examined in regards to Internet absorption

were: commercial, education, government, and health. China has made progress in these sectors (although the health sector is still missing some computer technology).

China leads less developed countries in 'network (connectivity) infrastructure.' The 'sophistication of use' focuses on how much the computer technology and the Internet alter the lives and work of individuals and organizations (for example generating greater efficiency and utilizing more innovations). In this category, China is making progress. As a result of the above framework, it seems that the Chinese have become more successful than many other less developed countries in the area of the Internet in general. China's success in this area appears to be due to the broad economic reforms undertaken in the late 1980s and 1990s. Industrial policy in China focused on infrastructure and high technology, and a national decision made the Internet a priority. The Information and Communications Technology expenditures as percent of GDP is more in China than in some other less developed countries (International Telecommunications Union, 2004). In addition, the Purchasing Power Parity Gross Domestic Product per capita in China is also higher than some other less developed countries (World Bank, 2004).

1.2.4 Economic Development Literature

The Solow neoclassical growth model used technology as one of the factors that explain long-term growth (Todaro & Smith, 2005). In addition, the Solow model allows for the substitution between labor and capital. This idea also emphasizes the importance of technology in general because technology and know-how can make this possible. In the Romer model of economic growth, some of the spillovers of investment and industry are technological advances. Paul Romer (as cited in Ein-Dor, Myers, & Raman, 2004) suggests that technology and knowledge are a third factor of production in addition to the classic factors – labor and capital. Entrepreneurship

results in new uses of technology (in order to survive and make profit). Technology has also been interpreted and expressed in various economic models as "increases in the efficiency of capital use and labor use" (Hughes, 1996). In any national or global economic predictions, technological change needs to be taken into consideration.

Economic development involves catching up with developed countries in advanced areas as well. As mentioned before, Frank Odasz (1995) stated: "the nations that first establish a high degree of citizen tele-literacy may well become the new global economic leaders. Thus, successful implementation of the economic potential of networking must emphasize the development of these skills." Therefore the Internet may help alleviate some of the problems of the developing world through commercial and government transaction cost savings as well as increased communication and education. One of the advantages of less developed countries today versus western societies in previous decades is their ability to borrow technology without having to create it from nothing. According to the International Monetary Fund (IMF), the current information technology revolution embodied by computer technology and the Internet is similar to developments in history such as the industrial revolution textiles production, steam power, railroads in the nineteenth century, electricity, and automobiles in the twentieth century (2001). Computer technology has been regarded as both a potential source of economic benefits, and a measure of prosperity for a country. Technologies, which have been critiqued and refined in developed countries, are also going to be useful to people of less developed countries to bring about greater efficiency and information.

As mentioned before, computer technology can also be used in schools, libraries, and continuing education to develop human capital resources. As Ein-Dor et al. (2004) stated appropriately in their study, "new information technologies are tools for releasing the creative potential and knowledge embodied in people."

The realization of the importance of human capital in economic development goes back in time. Gary Becker (1992) described how human capital is just like other capital in the sense that it creates more outputs and income, and how investments in human capital (education, training, medical care, etc.) are similar to other physical and financial investments. Becker's original book on human capital was published in 1975. In his 1992 paper at the annual meeting of the National Association of Business economists, Becker also cited Edward Denison's 1985 study, which estimated that increased schooling of the average worker in the United States between 1929 and 1982 explains one-fourth of the rise in per capita income during that period. Becker (1992) judged the high number of women in the workforce and especially their participation in technical professions as one of the relative strengths of the US economy. Another example he provided was Japan, which lacks natural resources but experienced an economic miracle as a result of investments in technology and human capital.

Becker (1992) argued that, if countries were to become wealthier only due to their natural resources and physical capital, then they would eventually experience diminishing returns to these factors and their economic growth would come to an end. Therefore they must invest in education, especially elementary and secondary education, because early developed intellectual strengths determine one's ability to absorb advanced education and training in the future. Becker (1992) also mentioned

that population control is integral to the quality of human capital because families with fewer children are able to invest more in their children's education and training.

According to Neves Sequeira (2003), currently the middle income countries are investing proportionally more in technological human capital than the richest countries. Understandably they try to reach the level of wealth in the richest countries; more investment in human capital is one of the ways that may help them catch up. A reason for the relative decline in human capital investment in the richest countries may be that they can afford to import human capital from elsewhere and therefore are not limited to their own domestic resources. There may be many ways in which the wealthiest countries take advantage of human capital from outside sources, for example, by attracting qualified immigrants from other countries or by outsourcing work to other countries. This phenomenon is also partly something that Becker (1992) foresaw and appreciated: the United States (as well as other developed countries) must actively seek high quality human capital from other countries to fulfill the needs of their economies.

Linghui Tang wrote a study in 2004 which examined the differences in Internet diffusion across countries based on data collected by the International Telecommunications Union (Tang, 2004). In the statistical model of the study, the number of Internet hosts per 10,000 inhabitants as the dependent variable was to be predicted through the following independent variables: GDP per capita, the level of telecom infrastructure, the adult illiteracy rate (negative coefficient), the number of years the country has had a private operator, whether or not the country has an autonomous telecom regulatory organization, whether or not the country is English-speaking, and the country's telephone subscription rate. In addition, Tang (2004) discusses the circumstances in Africa that inhibit the diffusion of the Internet. These

include: low income, low education, poor infrastructure, the lack of effective reforms, and lack of effective privatization (which then results in a lack of competition and inhibits the necessary reductions in Internet access prices). One of the important recommendations of the study is for the relatively poor African countries to cooperate with each other by sharing their infrastructures and know-how. Nevertheless, Internet usage is still growing at a faster rate in Africa than in developed countries, and Africa is slowly catching up. At the present rates, it may take up to fifteen years for Africa to catch up with North America and Western Europe in terms of Internet usage (see the Appendix).

There are already efforts in Africa in actively promoting the Internet, not just by national governments, but by international large and small non-profit organizations. The United Nations Development Programme (UNDP) together with Accenture and the Markle Foundation (2007) has outlined ways in which information and communication technologies are to be used in poor countries in the fields of health, education, and overall human development and economic progress. Once the infrastructure is in place, the Internet is capable of reaching large numbers of people including the least privileged ones. According to the UNDP, projects are underway to use the Internet to support medical, education, and new business endeavors in local communities in Africa and Asia.

Kabissa is an example of a smaller organization that aims to increase the use of computer information and communication technologies (i.e. Internet) throughout Africa to support the work of humanitarian, environmental, and activist individuals and organizations (http://www.kabissa.org). The individuals and organizations supported by Kabissa are very diverse: doctors, women's organizations, organizations which help provide clean water, etc. Kabissa is supported by some big international organizations, national governments, and by charity contributions. These charitable contributions come from all over the world, and can be in the form of money (the author of this dissertation has personally contributed a small amount to this organization) or in the form of computer equipments and software programs. Kabissa pursues three programs: (a) providing affordable Internet services to African organizations including web site hosting, email, online newsletters and discussion groups, (b) training African organizations and people to use the Internet and computers in their work and activities, and (c) strengthening the ties between all of the organizations that work with Kabissa by planning activities for cooperation, and distributing information between all of these organizations.

1.3 Methodology

1.3.1 Computer Technology / Internet Use & Economic Productivity

The hypothesis of this study is that greater use of computer technology contributes positively to economic productivity. A regression analysis on a large sample of countries is performed in order to look at the relationship between the use of computer / Internet technology and economic productivity.

In this process, there is a need to control the impact of certain factors such as geography, political system, social values, etc. Therefore this study also analyzes the same hypothesis for different groups of countries. Each group includes countries in the same geography, which have somewhat similar social systems due to their history and proximity, and have access to similar resources due to significant amounts of trade amongst themselves. The groups are as follows: (a) Europe, (b) the Americas (North America and South America), (c) Asia, Oceania, and Africa, and (d) the low income countries of Africa and Asia. Each group also contains countries that have somewhat similar size service and manufacturing sectors (the most likely sectors to be impacted by computer information technology as opposed to agriculture). It may also be expected that those groups of countries with the larger service and manufacturing sectors are impacted more positively.

Another part of the methodology used is to look at and compare a span of years rather than just a single year. This makes sense because a single year might be affected by unique or temporary events, and because some of the impact of greater computer technology may be realized in the following year(s) rather than the same year. Therefore this study covers the years 1999 through 2003. The older studies on this topic did not cover these years.

In addition, 1999 is an appropriate year to start since Africa is also a part of this study. Much of the Internet infrastructure (i.e. ground stations) in Africa began their first operations as late as 1996-1998 (USAID, 2007).

1.3.2 Definitions

These definitions are from the World Bank (2006) unless otherwise noted.

1. GDP (Gross Domestic Product): the total final output of goods and services produced by the country's economy within the country's territory.
2. Hosts: Internet server computers that control network communications or administer online databases and Internet services.
3. Information and communications technology expenditures: tangible spending on IT products purchased by businesses, households, governments, and education institutions plus intangible spending on internally customized software and capital depreciation plus spending on telecommunications and other office equipment.
4. Innovation entrepreneurship: the creative capacity for enhancements within established businesses as defined by Tang & Koveos (2004). Based on the World Economic Forum's (Schwab, Lopez-Claros, & Porter, 2007) survey questions and hard data: (a) quality of research institutions in your country, (b) how much do companies in your country spend on research and development, (c) university / industry research collaboration, (d) government procurement of technology products, (e) availability of scientists / engineers, (f) intellectual property protection, (g) innovation capacity, (h) US utility patents granted per million of country's population.
5. Internet users: people with access to the global Internet computer network.

6. Personal computers (PC's): self-contained computers designed to be used by an individual.

1.3.3 Variables

To test the hypothesis (the positive impact of computer / Internet use on economic productivity), this study uses a concise model inspired by the ideas of Paul Romer (as cited in Pohjola, 2000) and Matti Pohjola (2000). The model uses regression analysis to predict changes in economic (labor) productivity (Y) through the three factors of production: technology (x_1), physical capital (x_2), and labor (x_3). This shows the importance of technology (computer/Internet) in the presence of other important economic factors. Here is an explanation of the variables.

1. Changes in productivity (Y): Measured as changes in GDP per worker.
2. Changes in Internet use (x_1): An important element of the adoption of computer technology is the breadth of Internet use. As a statistical indicator, it is measured accurately around the world. It can be treated as a proxy for a country's strength in computer and information technology; a correlation of 92.5% between Internet use and computer ownership in a data set of 171 countries (see the Appendix) supports this assumption. As an extension, it is assumed that the use of computer technology parallels a country's advances in and use of technology in general.
3. Capital investment (x_2): Measured as a country's average share of investments out of overall GDP (between 1999 and 2003).
4. Labor (x_3): Measured as the percentage of country's economically active (or working age) population out of its total population. Higher figures for a country may denote more efficient labor markets and greater labor related investments.

1.4 Data

1.4.1 International Measurements of Computer & Internet Use

The following sources provide data on many countries:

1. Center for International Comparisons at the University of Pennsylvania (2006). Real GDP per worker in $, and investment as percentage of real GDP.
2. International Labour Office (2007). Total and economically active population figures.
3. International Telecommunications Union (2006). Internet hosts per 10,000 inhabitants, Internet users per 100 inhabitants, and personal computers per 100 inhabitants.
4. Internet World Stats (2006). Current Internet usage in various countries.
5. World Bank (2006). World Development Indicators Section 1.1: Size of the Economy. Gross national income per capita.
6. World Bank (2006). World Development Indicators Section 2.1: Population Dynamics. Working age (15-64) population as percent of total.
7. World Bank (2006). World Development Indicators Section 2.3: Employment by Economic Activity. The percentage shares of the three sectors (Agriculture, Manufacturing, and Services) in a country's total labor.
8. World Bank (2006). World Development Indicators Section 5.11: The Information Age. Supplementary data such as ICT expenditure figures as % of GDP, computers in education, and number of secure Internet servers (hosts).

1.4.2 Sample

This study targeted many countries of diverse economic and geographic backgrounds. The sample was aimed to include almost all of the members of the following important international and regional economic organizations: (a) **G8** (Group of Eight), (b) **OECD** (Organisation for Economic Co-operation and Development), (c) **EU** (European Union - including candidate countries), (d) **MERCOSUR** (South American Regional Trade Agreement – including associate members), (e) **APEC** (Asia-Pacific Economic Cooperation), and (f) **EAEC**, Eurasian Economic Community). Several potential countries could not be included because detailed historical and recent data are not available.

In addition to the international organizations listed above, the sample contains a few of the highest populated countries of **ACD** (Asia Cooperation Dialogue), as well as a few of the lowest income countries in Asia for which data are available. Finally, the sample contains as many countries as possible from the **AU** (African Union). These include the high population countries, and other African countries for which data are available to ensure that the sample is geographically evenly distributed, and three countries from the region of North Africa and Middle East.

The final sample used in the regression analysis is made up of 64 countries. These include 23 high-income, 24 middle-income, and 17 low-income countries. See the Appendix for the sample data used for the multiple regression analysis. The income classes are based on the most recently available World Bank (2006) data for the year 2004. High income countries have an annual Gross national income (GNI) per capita of $10,066 or more (World Bank, 2006). Middle income countries have an annual GNI per capita between $2,237 and $10,065. Low-income countries have an annual GNI per capita of less than $2,237.

1.4.3 The Data and the Requirements for Regression

Before the results are calculated and presented, the data must be examined for suitability to be used in a statistical regression analysis.

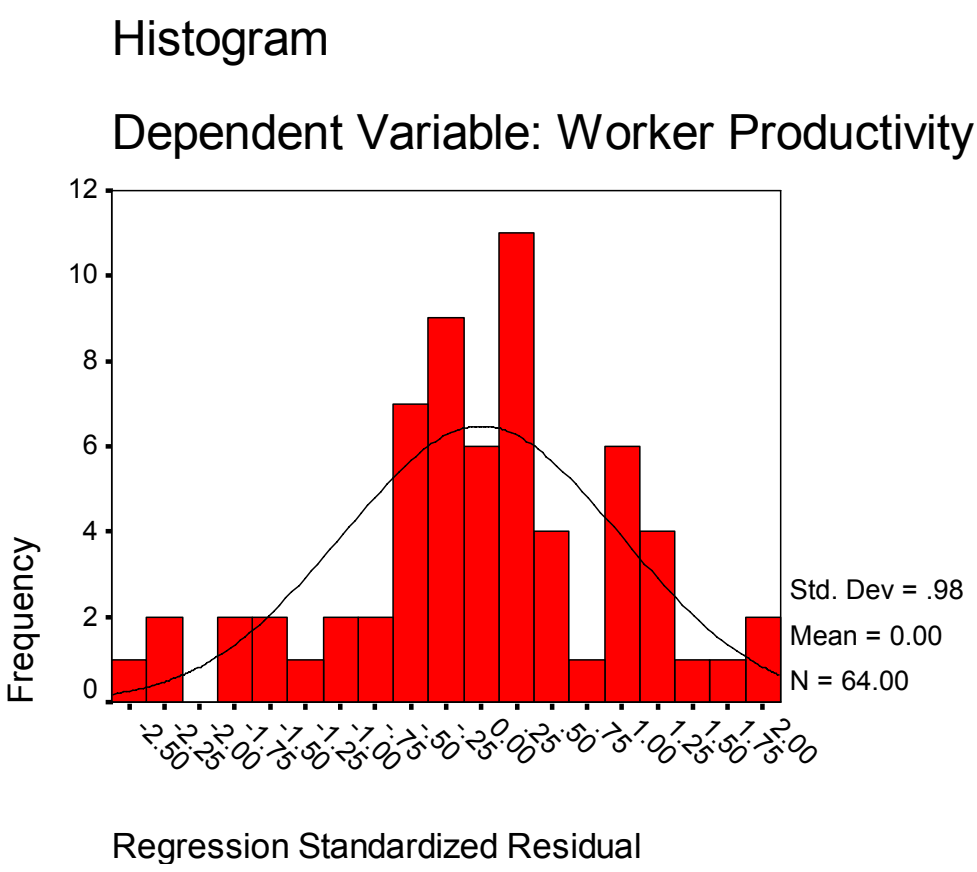
First, the sample data need to follow a normal distribution for the dependent variable and the independent variables. Two aspects have been looked at in order to examine normality: the skewness of the distribution, and the kurtosis of the distribution. In the table at the top of the next page, the calculated skewness and kurtosis of the sample data for all of the variables and the sub-groups of data (when regression is conducted on a group of countries e.g. a continent, region, or income class) re reported.

Here it must also be noted that none of the data have been logarithmically transformed in order to create normality. The values for all of the variables except for changes in Technology (Internet) use are exactly as they have been retrieved from databases and reports. Their values range between 0 and +1 or 100% (usually the maximum values are around 40% or 0.4). The original values in the population sample for changes in Internet use range from 6% to 8800% (33.55% to 1265% in the study sample). These have been rescaled (by subtracting a constant, dividing by a constant, and square rooting) in order to fit the same range as the other variables. The skewness and kurtosis of the sample data shows that they are normally distributed for all of the variables. For the sub-groups of data, the distributions are also acceptable in terms of normality because they fall within the range of ± 1 skewness and ± 3 kurtosis. In addition, the histogram (Figure 1.4 on the next page) shows a normal distribution for the dependent variable Productivity.

Table 1.1: Normality Measurements for Productivity and Independent Variables

		Productivity	Technology (Internet)	Physical capital	Labor
World	*Skewness*	-0.02	0.65	-0.12	-0.62
	Kurtosis	1.21	0.23	-0.87	0.84
**********					
Europe	*Skewness*	0.98	0.43	-0.90	0.04
	Kurtosis	0.61	-0.28	0.39	-0.29
The Americas	*Skewness*	-0.68	-0.68	0.52	0.19
	Kurtosis	-0.64	-1.04	-0.87	-1.38
Asia, Oceania, & Africa	*Skewness*	0.84	0.72	0.74	0.31
	Kurtosis	2.25	-0.44	-0.68	-0.52
Low income: Africa & Asia	*Skewness*	-0.27	0.44	0.88	0.11
	Kurtosis	-0.59	-1.07	-0.10	0.05

Figure 1.4: Histogram, Worker Productivity



Second, the independent variables should not be highly correlated with each other or be almost identical to each other. In other words, they should not be multi-collinear. This has been examined in two ways: (a) by calculating the correlation between each of the independent variables, and (b) by calculating the Variance Inflation Factor (VIF) for each of the independent variables. These can be seen in the table below. The conclusion here is that there is not a substantial risk of multi-collinearity (VIF's < 5).

Table 1.2: Tests for Multi-Collinearity for Variables Predicting Productivity

Correlation Scores between the Independent Variables

	Technology (Internet)	Physical capital	Labor
Technology (Internet)	x	-0.49	-0.29
Physical capital	-0.49	X	+0.63
Labor	-0.29	+0.63	X

Variance Inflation Factors for the Independent Variables

Technology (Internet)	1.317891
Physical capital	1.658058
Labor	2.004231

Third, the relationship between the independent variables and the dependent variable needs to be linear. Similarly, the relationship between the actual values of the dependent variable and predicted values of the dependent variable will also be linear. Furthermore, the residuals values (difference between the actual values of the dependent variable Y and predicted values of the dependent variable Y) sum up to zero so that if these residuals were to be regressed to the predicted Y values, there should not be a significant relationship. At the same time, if these were put on a scatter plot, there should be no graphic pattern emerging.

The calculations show: (a) the residuals are normally distributed, (b) the predicted Y values are normally distributed, and (c) there is no relationship between the residuals and the predicted Y values (R^2 and F very close to zero). See the Appendix for a graph of the residuals.

Last, the sample data must meet the homoscedasticity assumption. The variability in the values for one variable needs to be roughly the same at all values of the other variable. This has been examined in two ways: (a) by using a scatter plot, and (b) by calculating a Breusch-Pagan test. In the scatter plot, homosecdastic data would be expected to be oval shaped, sloped, and with most of the X values concentrated around the mean of the Y values (in this case graphed along the x-axis). A scatter plot is shown in the Appendix of this study, which follows this assumption. In addition, a Breusch-Pagan test has been done. The result of this confirms the homoscedasticity of the sample data.

1.5 Results

1.5.1 Summary

After using statistical tools to calculate a linear model equation that best suits the data values for the one dependent value (Y) and the three independent values (x_1, x_2, and x_3), the following equation arises.

Equation: $Y = -0.37 + 0.65x_1 + 0.27x_2 + 0.64x_3$

The coefficients of all of the independent values are positive (0.65, 0.27, and 0.64 respectively). Thus, for the diverse sample of 64 countries between 1999 and 2003, Internet technology (x_1), labor (x_2), and physical capital (x_3) all have a positive relationship with economic productivity. This is also true for the standardized beta coefficients. The beta coefficients indicate which independent variable has a greater impact on the dependent variable.

The F value for this regression is 6.893032; and the associated P value is 0.000459 at the significance level 5%. This P value is less than 0.05, which supports the alternate hypothesis that the three independent values have an effect on the independent value. See the Appendix for the complete data that were used in the regression analysis.

Table 1.3: Descriptive and Regression Statistics for Productivity

General Description	World	Europe	The Americas	Asia, Oceania, & Africa	Low Income: Africa & Asia
Sample Size	64	29	13	22	12
Average Service & Manufacturing	84.9%	90.2%	89.9%	68.7%	38.7%
Number of High-Income Countries	23	17	2	4	0
Number of Middle-Income Countries	24	12	7	5	0
Number of Low-Income Countries	17	0	4	13	12
Average Increase in Worker Productivity	7.7%	11.9%	-3.8%	6.7%	7.4%

Regression	World	Europe	The Americas	Asia, Oceania, & Africa	Low Income: Africa & Asia
R square for the Model Equation with 4 variables	+ 0.26	+ 0.49	+ 0.53	+ 0.46	+ 0.28
Coefficient of Increase in Internet Use	+ 0.65	+ 0.47	+ 0.51	+ 0.60	+ 0.57
Coefficient of Physical Capital Investments	+ 0.27	- 0.70	+ 1.13	+ 0.39	+ 0.37
Coefficient of Labor Resources	+ 0.64	+ 0.19	+ 0.51	+ 0.28	+ 0.06
Beta Coefficient of Increase in Internet Use	+ 0.46	+ 0.35	+ 0.36	+ 0.59	+ 0.59
Beta Coefficient of Physical Capital Investments	+ 0.20	- 0.42	+ 0.68	+ 0.43	+ 0.20
Beta Coefficient of Labor Resources	+ 0.32	+ 0.05	+ 0.20	+ 0.24	+ 0.03
F	6.892	8.109	3.332	5.042	1.041
P	0.000	0.001	0.070	0.010	0.425

1.5.2 Europe

European countries make up the first group. This is the largest sub-sample with 29 countries (all of which are high or middle income). This is also the group with the greatest average service and manufacturing sectors. For this group, the regression results show an R square value of 49%. This means that the changes in the independent variables of the model explain a good portion of the variation in the independent variable.

Equation: $Y = +0.10 + 0.47x_1 - 0.70x_2 + 0.19x_3$

Table 1.4: Sample Countries and Values for Productivity and Internet Users – Europe

1999-2003	Δ worker productivity (y)	Δ Internet Users (x_1)	Organization	Income
Austria	5.89%	99.04%	EU	High
Belgium	6.42%	181.42%	EU	High
Bulgaria	19.98%	183.75%	EU	Middle
Croatia	13.73%	418.57%	EU	Middle
Czech R.	10.67%	346.26%	EU	Middle
Denmark	6.02%	50.20%	EU	High
Estonia	22.30%	220.19%	EU	Middle
Finland	12.18%	52.00%	EU	High
France	6.61%	296.72%	G8	High
Germany	3.94%	92.12%	G8	High
Greece	15.64%	112.46%	EU	High
Hungary	19.79%	301.35%	EU	Middle
Ireland	18.58%	189.22%	EU	High
Italy	5.17%	176.36%	G8	High
Latvia	25.64%	209.53%	EU	Middle
Lithuania	26.01%	624.46%	EU	Middle
Netherlands	3.31%	33.55%	EU	High
Norway	4.89%	40.88%	OECD	High
Poland	8.72%	328.78%	EU	Middle
Portugal	2.82%	70.20%	EU	High
Romania	15.95%	588.43%	EU	Middle
Russia	34.77%	713.73%	G8	Middle
Slovak R.	12.70%	371.77%	EU	Middle
Slovenia	12.83%	218.70%	EU	High
Spain	8.72%	225.71%	EU	High
Sweden	7.85%	52.28%	EU	High
Switzerland	2.99%	118.27%	OECD	High
Turkey	0.56%	277.58%	OECD	Middle
UK	9.24%	175.20%	G8	High

1.5.3 The Americas

The second group includes the Americas (both North America and South America). Here the sample is made up of 13 high, middle, and low income countries. Many of these countries (especially in South America) actually experienced decreases in economic productivity within the time period covered by this study. From 1999 and 2004, South America experienced an economic crisis (Free World Academy, 2005). On the other hand, this group is mostly made up of fairly developed and industrialized middle-income economies. The regression results for the model show an R square value of 53%. This result confirms the hypothesis for this group. All of the coefficients for the independent variables are positive numbers, which makes this a suitable model. The effect of technology (Internet) is strong and in the positive direction. Therefore, even in a period of economic crisis and investment risk, investments in information technology continued and provided good results.

Equation: $Y = -0.52 + 0.51x_1 + 1.13x_2 + 0.51x_3$

Table 1.5: Sample Countries and Values for Productivity and Internet Users – The Americas

1999-2003	Δ worker productivity (y)	Δ Internet Users (x_1)	Organization	Income
Argentina	-15.80%	262.42%	MERCOSUR	Middle
Bolivia	1.03%	258.16%	MERCOSUR	Low
Brazil	1.99%	386.27%	MERCOSUR	Middle
Canada	8.34%	53.62%	G8	High
Chile	5.39%	531.25%	APEC	Middle
Colombia	-2.34%	340.00%	MERCOSUR	Low
Ecuador	-4.50%	437.04%	MERCOSUR	Low
Mexico	-1.36%	539.57%	OECD	Middle
Paraguay	-9.20%	445.95%	MERCOSUR	Low
Peru	-0.16%	424.75%	APEC	Middle
Uruguay	-20.57%	58.61%	MERCOSUR	Middle
USA	3.74%	52.07%	G8	High
Venezuela	-16.41%	162.37%	MERCOSUR	Middle

1.5.4 Asia, Oceania, and Africa

The third group includes Asia, Oceania (Australia and New Zealand), and Africa for a total of 22 countries. It includes countries from different backgrounds, high-income, middle-income, and low-income. The regression and the correlation analyses make this group also a good fit for the model and for the hypothesis. The regression fit for the model is an R square of 46%. All of the coefficients for the independent variables are positive numbers, which makes this a suitable model.

Equation: $Y = -0.20 + 0.60x_1 + 0.39x_2 + 0.28x_3$

Table 1.6: Sample Countries and Values for Productivity and Internet Users – Asia, Oceania, and Africa

1999-2003	Δ worker productivity (y)	Δ Internet Users (x_1)	Organization	Income
Australia	8.34%	92.09%	OECD	High
China	34.17%	778.57%	ACD	Low
India	13.22%	525.00%	ACD	Low
Indonesia	10.60%	754.55%	APEC	Low
Japan	3.09%	126.02%	G8	High
Malaysia	8.86%	168.90%	APEC	Middle
Nepal	4.27%	162.50%	ACD	Low
New Zealand	9.29%	84.25%	OECD	High
Philippines	0.33%	237.67%	APEC	Low
S. Korea	17.83%	156.92%	OECD	High
Thailand	13.60%	346.26%	APEC	Middle
Burkina Faso	20.45%	550.00%	AU	Low
Cameroon	11.60%	342.86%	AU	Low
Egypt	2.45%	1265.63%	AU	Low
Madagascar	-6.46%	150.00%	AU	Low
Mauritania	-2.99%	266.67%	AU	Low
Nigeria	14.97%	1120.00%	AU	Low
Oman	-0.55%	301.92%	ACD	Middle
South Africa	10.71%	75.50%	AU	Middle
Tanzania	10.72%	871.43%	AU	Low
Tunisia	6.09%	301.26%	AU	Middle
Uganda	9.39%	327.27%	AU	Low

1.5.5 Low Income Countries from Africa and Asia

The last group includes 12 low income countries from Africa and Asia. Whereas the previous groups analyzed earlier were formed on geographic bases and were diverse in income, this one has been formed on the basis of income and development. It would be interesting to also look at a homogenous group and how the model works for low income countries. This does not include all African countries because not all African countries are low income. Not all of the world's very low income countries are in Africa either; some of them are in Asia and have been included in this group. Here, on the average, the service and manufacturing sectors make up 39% of their economies while the remainder consists of agriculture and subsistence. Their economies are likely not to be affected as much by factors such as computer information technology, which increase productivity in advanced industries and services. An overall positive relationship between increases in computer technology and increases in productivity may be expected but this may be somewhat weaker. Thus the regression results show an R square of 28% for the model; nevertheless it is fair for the hypothesis. All of the coefficients for the independent variables are positive numbers, which makes this a suitable model.

Equation: $Y = -0.11 + 0.57x_1 + 0.37x_2 + 0.06x_3$

Table 1.7: Countries and Values – Low Income Countries from Africa and Asia

1999-2003	Δ worker productivity (y)	Δ Internet Users (x_1)	Organization	Income
Burkina Faso	20.45%	550.00%	AU	Low
Cameroon	11.60%	342.86%	AU	Low
Egypt	2.45%	1265.63%	AU	Low
India	13.22%	525.00%	ACD	Low
Indonesia	10.60%	754.55%	APEC	Low
Madagascar	-6.46%	150.00%	AU	Low
Mauritania	-2.99%	266.67%	AU	Low
Nepal	4.27%	162.50%	ACD	Low
Nigeria	14.97%	1120.00%	AU	Low
Philippines	0.33%	237.67%	APEC	Low
Tanzania	10.72%	871.43%	AU	Low
Uganda	9.39%	327.27%	AU	Low

1.5.6 Limitations of the Research

One of the limitations of this study is the concise nature of the statistical model, which uses a relatively small number of independent variables. There are many other potential variables that may explain changes in economic productivity. Those were not considered in this study because the purpose of the study is not to attempt to create a statistical model that completely explains economic productivity. On a side note, creating an undisputable statistical model that explains economic productivity is a difficult endeavor since economics is not a physical science, and involves many difficult or unquantifiable social and human factors that may influence economic outcomes. The purpose of the study rather is to support the hypothesis that computer technology plays a positive role in increasing economic productivity. Thus a practical model was created that would meet the requirements of regression analysis, and would explain a sufficient portion of the variance in economic productivity. This parsimonious model in turn helps support the hypothesis of the study. However, the author of this study has also investigated a larger model. Due to data availablity constraints, a larger model with five dependent variables could only be constructed on a sample of 43 upper-middle and high income countries. This model yields a greater R^2 and is discussed in the Appendix of this study. In any case, if the reader is looking for an in-depth discussion and formulation of economic productivity itself, they would be advised to turn to other studies that are solely focused on that issue.

The second limitation of this study has to do with the sample although there is limited choice in this aspect. The countries were not sampled randomly. Many countries still do not have data available for certain variables. In some cases, the lack of data may be a result of the relatively low priority that computer technology has in those countries. Even though the study used most of the countries that had data available, there is still be a small selection bias in the sampling. For example countries

in political conflict or war zones and countries that do not have an association with a regional international organization(s) have been avoided. These countries and their use of information technology may be distorted by certain overriding political factors, which may make them unsuitable for being analyzed together with other countries. Some very small countries have also been excluded for reasons of research convenience. It seems more fruitful to analyze large economies than small ones because the findings may be potentially interesting to a greater number of people. Even with a sample of 64 countries, the study covers a great majority of the world's population. It is also thought that small countries can make an unfair influence in a statistical model because, even though they have a much smaller population, they would be considered a subject equal to other larger countries. Such injustice (due to subjects with unequal population sizes) still exists in the sample and model of this study but it is relatively less. In the question of sampling, more attention needs to be placed on external validity here. Since the counties were not randomly sampled, the conclusions of this study should normally be applied only to the countries included in this study.

Another limitation of this study is the span of years 1999 through 2003. This is a short span of years compared to some of the other studies in the field of economics. The main reason for this is that the Internet is a relatively young technology, and data in this field do not go far back in time. Although Internet data after 2003 are available, the macro-economic data for the other economic independent variables are not yet available for the most recent years. Therefore the time span 1999-2003 is a compromise as a result of the new technology, and the available data. The conclusions of this study would have been much stronger if the study had covered a very long time span.

1.5.7 Recommendations for Future Research

In the future, five, ten, or more years from now, researchers will be able to do new studies in this area again with data available from a longer span of time. Therefore a natural recommendation for future research is to study a longer historical period. The advantage of time will also provide the future researcher with a much better chance to expand the sample size as well. Over time, more countries (especially developing countries) will be able to collect and offer the relevant statistical figures.

This may be regarded as one of the pioneering studies in this area. Therefore future researchers have the potential to make many improvements. Aside from increasing the sample and the time span, they could add other new variables or use different measures for the existing variables. That way, they could build different or more accurate models.

Aside from statistical analysis, future studies will have a greater volume of literature available for review, and can analyze new social and technological developments in the developing world. They may do more detailed case studies. Certain specific communication and computer technologies have been getting more popular around the world since 1999-2003. A possibility for further research may be to concentrate on the impact of mobile communication technologies, for example. Nevertheless, in general, in order to continue where this research leaves off, the focus in future studies should still remain on understanding how technology contributes to the well-being of people around the world.

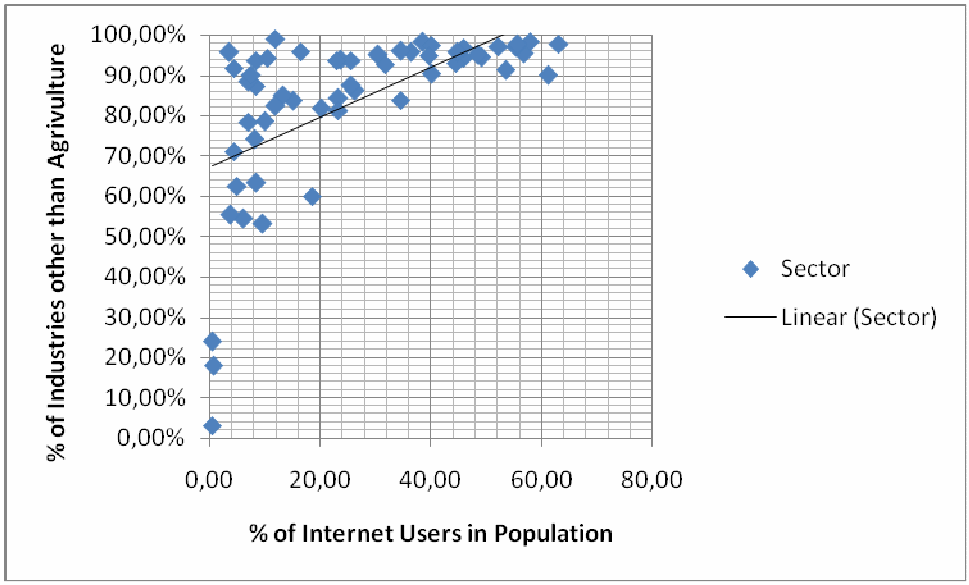
1.6 Conclusion

1.6.1 Sectors of the Economy

An important point to be considered is the sector composition of an economy (the relative size of the agriculture, manufacturing, and service sectors). Theoretically, each sector has the potential to grow and experience increased productivity. The share of each sector in a country's economy does not predetermine that country's potential as long as there is a demand for the larger sectors and those sectors can also help the other sectors.

For the purposes of this study, one might expect that information technology plays a much more important role in countries with large manufacturing and service sectors. Caselli and Coleman (2001) also had a similar inclination: "human capital is less conducive to computer adoption in countries with a relatively large share of agriculture." In the same study, Caselli and Coleman's statistical analysis supports a production complementation between human capital and computers rather than a consumption complementation. This means that computers might be most effective in parts of the economy where they can be easily used together with other production tools and inputs. The Figure 1.5 on the next page illustrates using International Labour Office (2007) and World Bank (2006) data that countries with a larger share of non-agriculture industries tend to have more Internet users.

Figure 1.5: Scatter Plot: % of Non-Agriculture Industries and % of Internet Use



According to the OECD (2006), the parts of the economy that contains businesses with the most Internet penetration are manufacturing, construction, wholesale / retail, hotels and restaurants, transport, storage / communication, real estate / renting, education, religious, community, social and personal services. The results of this study support these ideas because the statistical model fits more industrialized countries better (i.e. in Europe, North America, high income countries of Asia, and Oceania as opposed to Africa and the low income countries of Asia).

1.6.2 General Conclusions

The social and economic importance of computer technology and the Internet (although potentially great everywhere) varies among different countries. According to the Global Competitiveness Report of the World Economic Forum (Schwab et al., 2007), certain economies (with high incomes per capita) are driven by innovation and technology since their basic infrastructure is there and their markets are already efficient (see the Appendix for supplemental data which illustrate this point). Other middle income countries also devote much of their resources toward using and

creating technology (if not as much as high-income high technology group). On the other hand, in low income countries, the growth sectors are those related to the infrastructures, and meeting nutrition, health, and construction needs.

There are many factors that make up and influence the annual growth of GDP figures for different countries, technology being one of them. In order for a country to take economic advantage of this technology on a mass-scale, it is better for the current usage levels to be above a certain threshold. Technology alone cannot predict economic growth but, when combined with other factors, it plays an important role and it can be a good indicator of economic performance for different countries. The findings reviewed in the Results section supported this hypothesis. It does not always make much sense to collectively analyze and compare countries that are politically, geographically, economically, and socially diverse. All of these diversities have an impact on the economy. One of the ways to simplify the impact of all these intangible diverse points is to compare countries in the same world geographic region. Therefore such an approach was followed in this study.

Countries in the same or approximate region tend to have similar economies and social systems in general. In general, the statistical models fit separate groups better than they fit the whole world sample. The reason for this is that in each region certain factors of production play relatively more important roles. Countries in the same group tend to have parallels whereas the trends of some countries can easily statistically cancel out the contribution of other countries into the predictive model. This did not happen much when regression analysis was applied to each group. Thus the model almost always predicted approximately 50% of the variation in economic productivity.

As the literature review showed, human capital is an IT-enhancing complementary factor within the industries and services, and enhances and amplifies the effects of investments in computer information technology (Pohjola, 2000). At the end of this first study, the main point to be carried on to the following studies is that, **information technology** and the greater **knowledge** resulting from information technology, facilitate the production and distribution of goods and services, and thereby enhance economic productivity. The following two studies explore the direct relationship between human capital and technology in greater detail with specific examples.

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Appendix

Appendix 1.1: Africa and Internet catch-up calculation

	Annual increase in # of users	Current usage % of population	Estimated minimum # of years to reach 100%
Africa	35.75%	3.60%	11 years *
Europe	11.90%	38.60%	8.5 years

*Not considering population growth – it might take longer in parallel with the population growth in Africa.

Appendix 1.2: Data used to validate Internet as a proxy for computer technology

ITU Data for 2004		Correlation = 92.5%
	Internet Users 100 inhab.	Computers 100 inhab.
Albania	2.35	1.17
Algeria	4.63	0.9
Angola	1.22	0.19
Argentina	16.1	8.37
Armenia	4.96	6.61
Australia	65.28	68.9
Austria	47.52	57.63
Azerbaijan	4.88	1.78
Bahrain	21.34	16.9
Bangladesh	0.22	1.19
Barbados	55.35	12.55
Belgium	40.21	34.72
Belize	13.41	13.51
Benin	1.38	0.41
Bermuda	60.99	53.61
Bhutan	2.56	1.41
Bolivia	4.44	2.33
Botswana	3.39	4.52
Brazil	11.96	10.52
Brunei Darussalam	15.3	8.47
Bulgaria	15.9	5.94
Burkina Faso	0.4	0.21
Burundi	0.35	0.48
Cambodia	0.28	0.26
Cameroon	1.02	0.98
Canada	62.36	69.82
Cape Verde	5.35	10.27
Central African Rep.	0.23	0.28
Chad	0.4	0.17
Chile	27.9	13.87
China	7.23	4.08

Colombia	8.53	3.88
Comoros	1.01	0.63
Congo	0.94	0.45
Costa Rica	23.54	21.89
Côte d'Ivoire	0.95	1.55
Croatia	30.07	19.07
Cuba	1.33	2.67
Cyprus	36.93	30.86
Czech Republic	49.97	24
Denmark	50.36	65.48
Djibouti	1.32	3.09
Dominica	28.75	18.23
Ecuador	4.73	5.49
Egypt	5.57	3.29
El Salvador	8.88	4.54
Equatorial Guinea	0.99	1.38
Eritrea	1.18	0.36
Estonia	50.18	46.44
Ethiopia	0.16	0.31
Fiji	7.2	5.19
Finland	63	48.22
France	39.27	49.64
French Guiana	20.77	18.03
French Polynesia	18.15	10.08
Gabon	2.96	2.96
Gambia	3.35	1.57
Georgia	3.89	4.25
Germany	42.67	54.54
Ghana	1.72	0.52
Greece	17.62	8.88
Grenada	18.64	15.65
Guadeloupe	17.83	20.32
Guatemala	5.97	1.82
Guinea	0.59	0.56
Guyana	19.33	3.6
Honduras	3.18	1.57
Hong Kong, China	50.32	60.55
Hungary	26.74	14.62
Iceland	77	47.1
India	3.24	1.21
Indonesia	5.04	1.36
Iran (I.R.)	7.88	10.53
Iraq	0.14	0.83
Ireland	29.63	49.74
Israel	46.63	73.4
Italy	46.84	31.1
Jamaica	39.87	6.2
Japan	50.2	54.15
Jordan	11.22	5.34
Kenya	3.22	0.95
Kiribati	2.35	1.18
Korea (Rep.)	65.68	54.49
Kuwait	23.5	17.63
Kyrgyzstan	5.16	1.71

Lao P.D.R.	0.36	0.38
Latvia	35.43	21.92
Lebanon	16.9	11.27
Libya	3.62	2.34
Lithuania	28.09	15.47
Luxembourg	59	62.09
Macao, China	32.24	29.01
Madagascar	0.5	0.5
Malawi	0.37	0.16
Malaysia	38.62	19.16
Maldives	5.79	10.98
Mali	0.45	0.38
Malta	27.91	15.3
Marshall Islands	3.51	8.77
Martinique	27.09	20.76
Mauritania	0.47	1.41
Mauritius	14.6	16.22
Mexico	13.38	10.68
Moldova	9.52	2.63
Mongolia	7.6	11.86
Morocco	11.71	2.07
Mozambique	0.73	0.59
Myanmar	0.12	0.6
Namibia	3.73	10.94
Nepal	0.48	0.47
Netherlands	61.63	68.47
New Zealand	58.91	48.23
Nicaragua	2.2	3.52
Niger	0.19	0.07
Nigeria	1.39	0.68
Norway	38.97	57.2
Oman	9.67	4.66
Palestine	4.34	4.59
Panama	6.2	4.1
Papua New Guinea	2.91	6.29
Paraguay	3.32	5.92
Peru	11.61	8.29
Philippines	5.32	4.46
Poland	23.35	19.1
Portugal	28.03	13.32
Qatar	22.18	17.88
Réunion	26.08	36.31
Romania	20.76	11.3
Russia	12.86	10.42
Samoa	3.33	0.67
Saudi Arabia	6.62	35.39
Senegal	4.66	2.34
Serbia	18.61	4.77
Seychelles	250.28	187.71
Singapore	57.87	62.2
Slovak Republic	42.27	29.58
Slovenia	47.96	35.54
Solomon Islands	0.61	4.07
Somalia	1.08	0.63

South Africa	7.55	7.92
Spain	33.18	25.36
Sri Lanka	1.44	2.72
St. Kitts and Nevis	24.28	26.07
St. Lucia	34.49	16.3
St. Vincent and the Grenadines	6.61	13.22
Sudan	3.3	1.76
Swaziland	3.32	3.32
Sweden	75.46	76.14
Switzerland	47.2	82.33
Syria	4.39	3.29
Taiwan, China	53.81	52.78
Tanzania	0.89	0.74
TFYR Macedonia	7.83	6.89
Thailand	10.95	5.83
Togo	4.41	3.41
Tonga	3.01	5.01
Trinidad & Tobago	12.24	7.9
Tunisia	8.37	4.73
Turkey	14.15	5.13
Uganda	0.72	0.43
Ukraine	7.98	2.82
United Arab Emirates	28.91	19.84
United Kingdom	62.88	60.02
United States	63	76.22
Uruguay	20.98	13.27
Vanuatu	3.52	1.41
Venezuela	8.84	8.19
Viet Nam	7.63	1.26
Yemen	0.87	1.45
Zambia	2.01	0.98
Zimbabwe	6.9	8.41

Appendix 1.3: The parallels between income and reliance on technology

Data retrieved and table created in 2004.

IE = Innovation index 2002
U = Users per 1000 inhabitants 2002
U-r = Users-figures rescaled
PCI = Per capita GNI 2002 ($)

	IE	U	U-r	PCI
ARGENTINA	2.94	112	1.67	6,960
AUSTRALIA	3.96	482	3.89	19,770
AUSTRIA	3.87	409	3.45	23,940
BELGIUM	4.00	328	2.97	23,340
BRAZIL	2.25	82	1.49	3,060
BULGARIA	2.59	81	1.49	1,560
CANADA	4.45	513	4.08	21,340
CHILE	2.79	238	2.43	4,350
COLOMBIA	2.28	46	1.28	1,910
CZECH REPUBLIC	2.57	256	2.54	5,270
DENMARK	4.26	513	4.08	31,090
FINLAND	5.71	509	4.05	23,940
FRANCE	3.92	314	2.88	22,690
GERMANY	4.36	412	3.47	23,700
GREECE	3.02	155	1.93	11,780
IRELAND	3.48	271	2.63	23,060
ITALY	3.33	352	3.11	19,470
JAPAN	5.49	449	3.69	35,990
KOREA, SOUTH	4.69	552	4.31	9,400
MALAYSIA	2.66	320	2.92	3,640
MEXICO	2.25	98	1.59	5,540
NETHERLANDS	4.04	506	4.04	24,040
NEW ZEALAND	4.02	484	3.90	12,380
NORWAY	4.23	346	3.08	35,530
PHILIPPINES	2.41	44	1.26	1,050
POLAND	3.20	230	2.38	4,240
PORTUGAL	2.98	194	2.16	10,670
ROMANIA	2.30	83	1.50	1,710
RUSSIA	3.36	41	1.25	1,750
SINGAPORE	4.04	504	4.02	24,740
SLOVAK REPUBLIC	2.58	160	1.96	3,700
SLOVENIA	3.51	376	3.26	9,780
SOUTH AFRICA	2.27	68	1.41	2,900
SPAIN	3.46	156	1.94	14,860
SWEDEN	5.52	573	4.44	25,400
SWITZERLAND	4.65	351	3.11	36,970
THAILAND	2.76	78	1.47	1,970
TURKEY	2.01	73	1.44	2,540
UNITED KINGDOM	4.11	423	3.54	24,230
UNITED STATES	6.44	551	4.31	34,870

Examining the data above using stem-and-leaf diagrams helps reveal how certain economies (as incomes get higher) can afford technology more easily, and are also driven more by innovation and technology since their basic infrastructures and efficient markets are in place (so they have high innovation indices).

STEM & LEAF DIAGRAMS

NOTE THE VERY SIMILAR DISTRIBUTIONS FOR THESE VARIABLES.

IE = Innovation index 2003 (LIKERT 1=min & 7=max)

1															
2	01	25	25	27	28	30	41	57	58	59	66	76	79	94	98
3	02	20	33	36	46	48	51	87	92	96					
4	00	02	04	04	11	23	26	36	45	65	69				
5	49	52	71												
6	44														

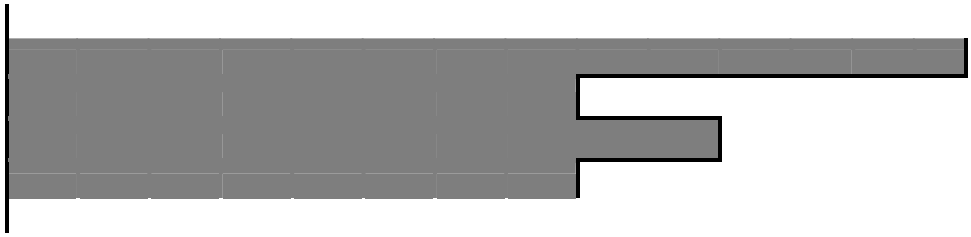
PCI = Per capita GNI in US$ 2002

<1000															
<6000	1050	1560	1710	1750	1910	1970	2540	2900	3060	3640	3700	4240	4350	5270	5540
<20000	6960	9400	9780	10670	11780	12380	14860	19470	19770						
<30000	21340	22690	23060	23340	23700	23940	23940	24040	24230	24740	25400				
>30000	31090	34870	35530	35990	36970										

U-r = Users per 1000 inhabitants 2002 - rescaled (1=min & 7=max)

0														
1	25	26	28	41	44	47	49	49	50	59	67	93	94	96
2	16	38	43	54	63	88	92	97						
3	08	11	11	26	45	47	54	69	89	90				
4	02	04	05	08	08	31	31	41						
5														

The pattern for all of the three variables above resembles the shape below:



Appendix 1.4: Data for Chapter 1 regression analysis

1999-2003	Δ worker productivity (y)	Δ Internet Users (x_1)	x_1 (rescaled)	Δ Capital (x_2)	Labor (x_3)
Argentina	-15.80%	262.42%	18.58%	12.65%	63.10%
Australia	8.34%	92.09%	4.75%	26.49%	67.50%
Austria	5.89%	99.04%	5.32%	23.65%	67.80%
Belgium	6.42%	181.42%	12.00%	22.77%	65.60%
Bolivia	1.03%	258.16%	18.23%	8.83%	57.00%
Brazil	1.99%	386.27%	28.63%	14.93%	65.90%
Bulgaria	19.98%	183.75%	12.19%	9.06%	69.20%
Burkina Faso	20.45%	550.00%	41.92%	10.00%	49.80%
Cameroon	11.60%	342.86%	25.10%	4.34%	54.70%
Canada	8.34%	53.62%	1.63%	25.11%	69.10%
Chile	5.39%	531.25%	40.40%	20.33%	66.60%
China	34.17%	778.57%	60.47%	29.02%	70.50%
Colombia	-2.34%	340.00%	24.87%	9.09%	63.60%
Croatia	13.73%	418.57%	31.25%	16.86%	67.20%
Czech R.	10.67%	346.26%	25.38%	20.73%	71.00%
Denmark	6.02%	50.20%	1.35%	23.51%	66.30%
Ecuador	-4.50%	437.04%	32.75%	16.16%	61.50%
Egypt	2.45%	1265.63%	100.00%	4.92%	61.40%
Estonia	22.30%	220.19%	15.15%	16.10%	68.10%
Finland	12.18%	52.00%	1.50%	22.75%	66.80%
France	6.61%	296.72%	21.36%	23.56%	66.80%
Germany	3.94%	92.12%	4.75%	21.46%	67.20%
Greece	15.64%	112.46%	6.41%	24.60%	67.60%
Hungary	19.79%	301.35%	21.74%	21.88%	68.90%
India	13.22%	525.00%	39.89%	11.56%	62.30%
Indonesia	10.60%	754.55%	58.52%	10.90%	66.00%
Ireland	18.58%	189.22%	12.64%	22.34%	68.70%
Italy	5.17%	176.36%	11.59%	21.96%	66.30%
Japan	3.09%	126.02%	7.51%	28.82%	66.70%
Latvia	25.64%	209.53%	14.28%	16.01%	68.10%
Lithuania	26.01%	624.46%	47.96%	13.60%	67.40%
Madagascar	-6.46%	150.00%	9.45%	4.71%	52.70%
Malaysia	8.86%	168.90%	10.99%	18.67%	62.80%
Mauritania	-2.99%	266.67%	18.92%	7.35%	53.50%
Mexico	-1.36%	539.57%	41.07%	19.28%	63.20%
Nepal	4.27%	162.50%	10.47%	17.62%	56.90%
Netherlands	3.31%	33.55%	0.00%	21.44%	67.70%
New Zealand	9.29%	84.25%	4.12%	22.84%	66.10%
Nigeria	14.97%	1120.00%	88.18%	4.59%	52.50%
Norway	4.89%	40.88%	0.60%	21.95%	65.30%
Oman	-0.55%	301.92%	21.78%	7.00%	62.70%
Paraguay	-9.20%	445.95%	33.47%	9.31%	58.30%
Peru	-0.16%	424.75%	31.75%	16.06%	62.10%
Philippines	0.33%	237.67%	16.57%	12.99%	60.50%
Poland	8.72%	328.78%	23.96%	20.13%	70.30%
Portugal	2.82%	70.20%	2.97%	24.89%	67.20%
Romania	15.95%	588.43%	45.04%	11.16%	69.50%
Russia	34.77%	713.73%	55.21%	8.37%	70.70%
S. Korea	17.83%	156.92%	10.01%	33.81%	71.90%
Slovak R.	12.70%	371.77%	27.45%	19.29%	71.10%
Slovenia	12.83%	218.70%	15.03%	27.69%	70.40%
South Africa	10.71%	75.50%	3.40%	7.81%	63.10%

1999-2003	Δ worker productivity (y)	Δ Internet Users (x_1)	x_1 (rescaled)	Δ Capital (x_2)	Labor (x_3)
Spain	8.72%	225.71%	15.60%	26.28%	69.20%
Sweden	7.85%	52.28%	1.52%	20.06%	65.10%
Switzerland	2.99%	118.27%	6.88%	27.02%	67.60%
Tanzania	10.72%	871.43%	68.01%	3.81%	53.90%
Thailand	13.60%	346.26%	25.38%	20.63%	69.00%
Tunisia	6.09%	301.26%	21.73%	12.78%	67.10%
Turkey	0.56%	277.58%	19.81%	16.38%	65.10%
Uganda	9.39%	327.27%	23.84%	3.32%	47.10%
UK	9.24%	175.20%	11.50%	19.49%	65.90%
Uruguay	-20.57%	58.61%	2.03%	11.25%	62.40%
USA	3.74%	52.07%	1.50%	22.92%	66.80%
Venezuela	-16.41%	162.37%	10.46%	11.57%	63.40%

Appendix 1.5: Five-Variable Model for Predicting Productivity

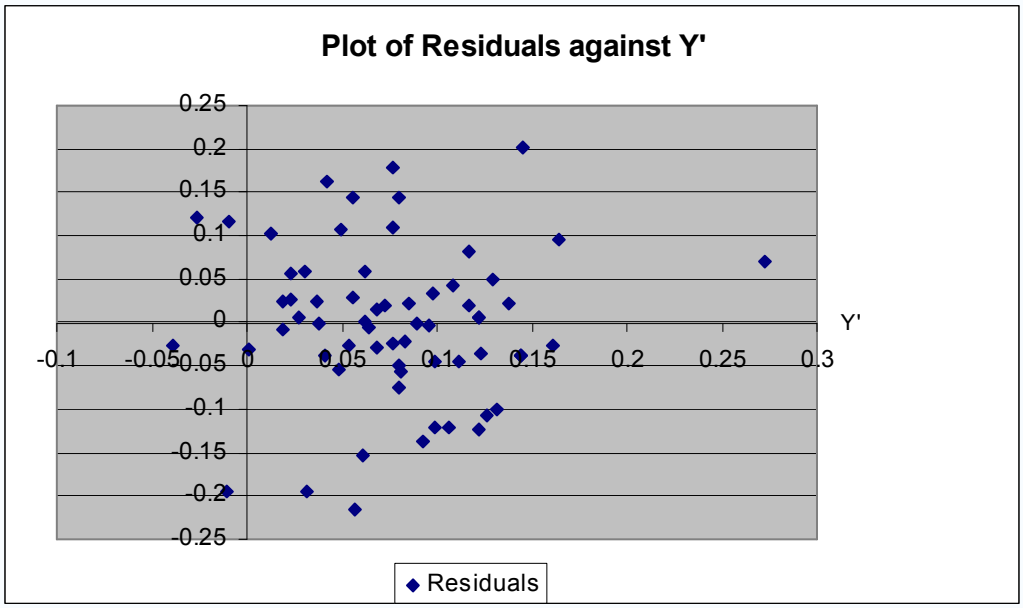
$R^2 = 0.50$, N=43

	Unstandardized Coefficients		Standardized Coefficients
Variable	B	Std. Error	Beta
(Constant)	-0.657	0.234	
Technology	0.529	0.224	0.318
Physical Capital	0.006	0.227	0.033
Labor Rate	0.936	0.528	0.241
Export Rate	0.160	0.091	0.241
Human Capital	0.178	0.070	0.378

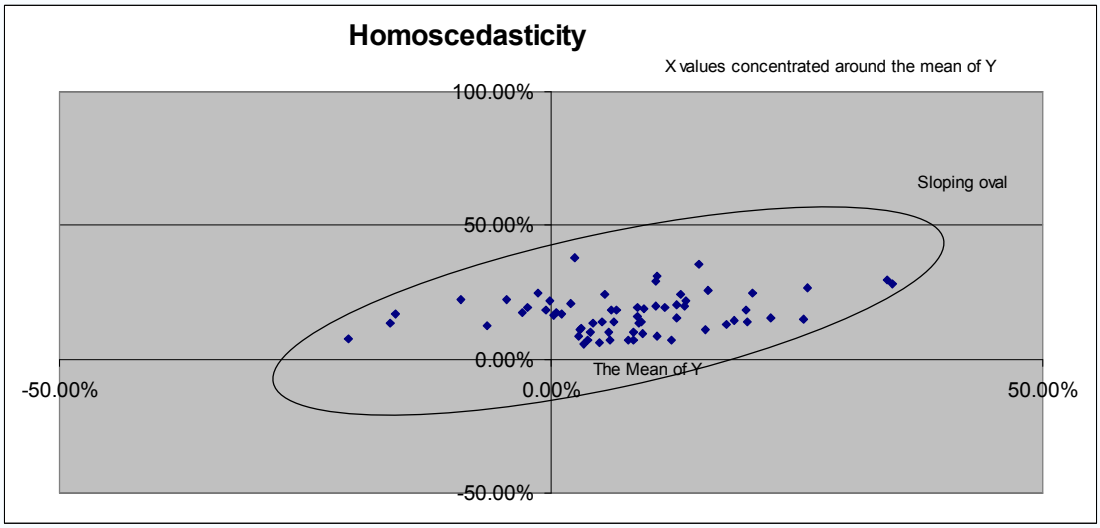
Appendix 1.6: Sample Data for the Five-Variable Model for Predicting Productivity

	x_1	x_2	x_3	X_4	x_5	Y
Argentina	17,06%	12,65%	43,56%	46,26%	58,57%	-15,80%
Australia	9,88%	26,49%	46,59%	43,75%	67,21%	8,34%
Austria	10,27%	23,65%	46,80%	69,50%	77,98%	5,89%
Belgium	14,11%	22,77%	42,90%	90,99%	67,31%	6,42%
Brazil	20,77%	14,93%	49,50%	38,77%	25,51%	1,99%
Bulgaria	14,20%	9,06%	47,77%	73,54%	78,56%	19,98%
Canada	7,34%	25,11%	47,70%	64,38%	82,31%	8,34%
Croatia	21,64%	16,86%	46,39%	68,53%	77,47%	13,73%
Czech R.	19,65%	20,73%	50,90%	79,03%	90,06%	10,67%
Denmark	7,07%	23,51%	45,77%	68,21%	77,68%	6,02%
Ecuador	22,12%	16,16%	42,45%	50,66%	24,79%	-4,50%
Estonia	15,59%	16,10%	47,01%	88,05%	88,40%	22,30%
Finland	7,22%	22,75%	49,90%	61,91%	75,06%	12,18%
France	18,16%	23,56%	46,11%	51,90%	72,24%	6,61%
Germany	9,88%	21,46%	48,70%	59,50%	82,63%	3,94%
Greece	10,99%	24,60%	43,30%	46,04%	58,05%	15,64%
Hungary	18,31%	21,88%	47,56%	81,38%	81,89%	19,79%
Ireland	14,42%	22,34%	45,10%	96,06%	65,61%	18,58%
Italy	13,90%	21,96%	45,77%	50,78%	52,19%	5,17%
Japan	11,67%	28,82%	53,50%	33,66%	36,86%	3,09%
Latvia	15,19%	16,01%	47,01%	64,43%	83,69%	25,64%
Lithuania	26,49%	13,60%	50,30%	71,65%	85,76%	26,01%
Mexico	24,61%	19,28%	40,70%	52,34%	28,55%	-1,36%
Netherlands	5,58%	21,44%	46,73%	80,56%	69,19%	3,31%
New Zealand	9,42%	22,84%	49,30%	56,69%	77,61%	9,29%
Norway	6,28%	21,95%	45,07%	65,12%	85,91%	4,89%
Oman	18,32%	7,00%	43,28%	75,38%	38,73%	-0,55%
Peru	21,80%	16,06%	47,40%	40,55%	30,72%	-0,16%
Poland	19,14%	20,13%	48,53%	54,49%	85,30%	8,72%
Portugal	8,53%	24,89%	46,39%	53,20%	21,92%	2,82%
Romania	25,71%	11,16%	47,97%	58,72%	67,31%	15,95%
Russia	28,34%	8,37%	47,70%	59,79%	91,56%	34,77%
S. Korea	13,08%	33,81%	49,63%	60,83%	67,75%	17,83%
Slovak R.	20,37%	19,29%	47,40%	86,18%	90,09%	12,70%
Slovenia	15,53%	27,69%	48,60%	75,32%	79,93%	12,83%
South Africa	8,87%	7,81%	43,56%	54,95%	45,04%	10,71%
Spain	15,79%	26,28%	43,90%	52,34%	46,41%	8,72%
Sweden	7,24%	20,06%	44,94%	66,66%	80,63%	7,85%
Switzerland	11,28%	27,02%	46,66%	66,39%	83,30%	2,99%
Turkey	17,55%	16,38%	44,94%	54,87%	30,83%	0,56%
UK	13,85%	19,49%	49,90%	51,36%	82,65%	9,24%
Uruguay	7,72%	11,25%	43,07%	47,04%	45,13%	-20,57%
USA	7,22%	22,92%	46,11%	31,35%	89,78%	3,74%

Appendix 1.7: Residuals



Appendix 1.8: Homoscedasticity



CHAPTER 2

Free Computer Software and International Technology Transfer

2.1 Introduction

2.1.1 Computer Software

Computer technology has contributed to economic expansion in many countries. Computers have increased the information that is available to organizational managers in making accurate and competitive decisions. Computer networks that make up the Internet have opened up new markets to many companies for marketing and selling their goods and services to consumers. Computer networks have also made communication faster and cheaper between companies that are related to one another as suppliers and vendors. As a result, computers have cut transaction costs in many economic activities. Computer technology (including both electronic hardware and software programs) in many countries is a large industry of its own. It provides employment and profits for many employees and entrepreneurs.

In a global environment of economic asymmetries, computer technology can help alleviate some of the problems of the less developed countries by saving commercial and government transaction costs and by increasing communication. Less developed countries today have an advantage because they have the ability to borrow a proven technology without having to reinvent it. Computer technology is beneficial to schools, libraries, and continuing education to help develop a nation's human capital resources.

In contrast to the physical hardware components, computer software are the programs that enable a computer to perform specific tasks including application software (such as a word processor), and system software such as an operating system, which enables other software to run properly, by interfacing with hardware and with other software (http://en.wikipedia.org/wiki/Software).

Computer software is not only an economic commodity; it is part of the economic production function. For example, the Solow neoclassical economic growth model entails technology as one of the factors explaining long-term economic growth (Todaro & Smith, 2005). It is also a means for innovation within any given industry that uses computers (Jorgenson & Wessner, 2006). Analyzing software from an economic perspective is complex: the effectiveness of a specific software program both depends on and influences the effectiveness of (a) the computer hardware, (b) other software, and (c) the human users.

2.1.2 Free Linux Software

The most popular operating system software in the world is Microsoft Windows. As of March 2007, Microsoft Windows is estimated to account for 86.6% of the operating system software in computers around the world. In comparison, Linux is a small competitor, estimated to represent 3.4% of the operating system software around the world (http://www.w3schools.com/browsers/browsers_stats.asp).

Linux is one of the most prominent examples of free computer operating system software, unlike proprietary computer operating systems such as Microsoft Windows (http://en.wikipedia.org/wiki/Linux). All of Linux's underlying code is available for anyone to use, modify, and redistribute freely. Initially, Linux was primarily developed and used by individual enthusiasts on personal computers. Since

then, Linux has gained the support of major corporations such as IBM, Sun Microsystems, Hewlett-Packard, and Novell for use in network server computers. It is slowly gaining popularity in the desktop market. It is used in a variety of other systems ranging from supercomputers to mobile phones. Another currently popular operating system, Apple Mac OS X, was built upon a core system (named 'Darwin') that is similar to Linux. This has allowed compatibility between Apple's computer systems and Linux application software; thus Linux software has found another niche market. Linux's advantages include its security, reliability, low cost, and freedom from vendor lock-in.

2.1.3 Economic Benefits of Software Technology Transfer

Linux is a software technology that could be of great benefit to computer users in the less developed countries due to its free of charge availability. The purposes of this study include understanding what kind of economic and social asymmetries affect the distribution of this technology in different parts of the world, and understanding what may be further done in order to promote its further distribution.

Open-source software such as Linux (together with the physical computer equipment) can help inter-government agencies, national bodies, and nongovernmental organizations distribute humanitarian information more economically to schools and hospitals, which in turn can more easily tackle community and health problems (Witten, 2006). The remaining less developed countries, which have not yet adopted it, may be inspired by some of their less developed counterparts that have already adopted the cost-effective Linux. Even in high income countries such as France, government agencies are switching to Linux (Guillemin, 2006). Just by virtue of being an alternative to Microsoft Windows, Linux

has forced Microsoft to lower the prices of its software in some of the less developed regions of the world (http://www.tmcnet.com/usubmit/2006/05/05/1639555.htm).

Linux is used by an increasing number of people in less developed countries. Yet an analysis of the data shows that Linux users tend to be concentrated heavily in wealthier European countries rather than in less developed countries.

2.2 Literature Review

2.2.1 Human Capital and Software Use

According to a former Peace Corps volunteer who wrote on this subject, despite such great potential advantages, computer technology has not affected Africa so much because it is expensive and not common (Harmon, 2003). Human capital resources on the average are not developed sufficiently in Africa in order to use computer technology. In response to a question on the role of open source software in Africa, Gerald Ilukwe, the general manager of Microsoft Nigeria, said that cost is not important (Marson, 2005). “You can give people free software, but they won't have the expertise to use it.” Using computers in general requires some education and practical experience. But using the Linux operating system software and installing Linux system and application software may often require more knowledge and skill than Microsoft Windows software. This is mainly because many versions of Linux provide the user with greater exposure to as well as greater control over advanced features that are normally simplified and concealed from the Microsoft Windows user. Lack of prior computer education and training is one of the main obstacles around the world that keeps Linux from becoming a massively popular software product.

2.2.2 The National IT Sector as Software User

To further understand in which parts of the world Linux is more popular, it is a good idea to understand how free software (such as Linux as well as the many application software programs that runs on the Linux platform) is created. Some free software is created because there are computer programmers who really enjoy programming in itself. This is similar to the way some artists do their work: motivated primarily by creativity and recognition by others in their professions (Jorgenson & Wessner, 2006). There are also individual programmers who dislike or envy large companies that manufacture proprietary software. Recent research and measurements show that free software has equally good quality programming code (Jorgenson & Wessner, 2006). Free software can be a good training ground; the same free software developers can later also create expensive commercial products, or continue to provide the software free of charge but make money through consulting, support, and providing additional components. Additionally, according to Dr. Hal Varian (as cited in Jorgenson & Wessner, 2006), the many of the users of free software / Linux are programmers and systems developers rather than basic home users. Since the Information Technology (IT) sector is a much smaller component of the economies of less developed countries, this insight explains the other reason why Linux users are relatively fewer in less developed / low income countries.

2.2.3 Economic Networking and Software Choice

Due to Microsoft's extensive licensing agreements with many computer vendors, Windows presently comes pre-installed on most computers, making it the default choice for most of the market around the world. For some consumers, Windows is the only valid option for a computing environment, or it is mandated by their workplace; additionally, an unfamiliarity with other operating systems results in a lack of desire to switch to other operating systems. Finally, the large base of proprietary software available exclusively for the Windows family of operating systems has become a large reason for the popularity of Windows, at least partly because many users do not realize that there are free, open source, and portable alternatives available. In recent years, many companies have been started with the sole intention of releasing Windows software; the fact that there is already a large customer base in place is reason enough for such companies to spend their resources solely on Windows software development. As a result, the fact that many companies are supporting Windows exclusively is a self-reinforcing reason for customers to choose Windows (http://en.wikipedia.org/wiki/Microsoft_windows).

For those computers users in less developed countries who have a choice on operating system software and who have the ability to obtain Linux, the fact that Microsoft software has more users in developed countries and the resulting economic networking benefits make Microsoft Windows still a more appealing choice. With Microsoft Windows, they can more easily associate with users in developed countries, and they can integrate themselves more easily with the worldwide business and academic community through Microsoft office software that runs on Windows.

2.2.4 Costs of Switching between Software Products

According to studies conducted by Dr. Hal Varian and Carl Shapiro (as cited in Jorgenson & Wessner, 2006), switching costs from one operating system software to another is the most influential factor for technical staff and managers in making decisions on adopting a new operating system. If a user or an organization in a less developed country has a machine with Microsoft Windows on it, then adopting Linux requires switching costs. These may not necessarily involve financial costs; nevertheless costs in terms of time, learning, and effort could still keep users from switching.

It can be argued that users in high income countries may naturally better absorb the financial costs of switching from one type of operating system software to another. It may also be expected that individuals in high income countries deal with allocating time and effort more easily (as a hobby) because individuals in less developed countries are more likely to be preoccupied in their lives with other personal safety, health, and economic issues that affect their communities or countries.

2.2.5 Consumer Attitudes: Complex vs. Standard Software

There are also major companies in the U.S.A. and Europe that utilize and modify free software. Free software gives them more freedom to customize their own computer systems to better meet their business needs. The freedom and the diversity of having different versions of a product spur innovation and continuous enhancement (Jorgenson & Wessner, 2006).

On the other hand, the same freedom to modify and create different versions of Linux has become another one of its major obstacles in becoming a standard and massively popular operating system. Different branches of Linux have arisen. This has caused compatibility issues within the Linux community itself. It has also presented an additional risk for those users and organizations that may switch from Windows to Linux. This diverse and splintered state of Linux causes potential users to also have to consider and to do research as to which type of Linux is better. The answer to this question may even change over time because different types of Linux get updated and enhanced in different paces and different ways. If, in the future, they would prefer another type of Linux than the one they have implemented, then they would again need to spend time and effort to make another switch.

2.3 Ideas and Data

2.3.1 Human Capital

In general, computer technology has not penetrated less-developed countries as much as developed countries. It is normal that consumers, companies, and governments in low income countries do not use as much computer technology as high income countries. Even though there is free software, a potential user still needs to have a computer or access to a publicly owned computer to be able to use that free software. Initially, unless it is donated and delivered directly to them, they also need to have access to a distribution channel where they can obtain Linux, such as the Internet, an electronics store, a computer hobby club, a book store, etc. All of these prerequisites either cost money or usually require the user to be in an urban or suburban setting. Using simple economic reasoning, it may be expected that those individuals who own computers in low income countries use relatively more Linux software versus Microsoft Windows because Linux is a cheaper substitute. However, research in this area suggests a different fact: in comparison with high income countries, low income countries have a relatively smaller proportion of Linux users versus Microsoft Windows users.

Upon review of the data on computer ownership and Linux usage, it is realized that Linux (free software) is used more in high income countries as opposed to low income countries. Apart from prices and income, there are other market and social factors that influence the decisions of their governments, private companies, and home users in favor of Microsoft software (some of which have been discussed in the Literature Review section of this study).

Above all, this study focuses on **human capital** as a key factor that influences the familiarity and capability of people within a country toward using computer software. Linux software in particular helps demonstrate this point because it has many features including advanced ones that require users to have certain computer knowledge and skills. Overall, raising the quality of human capital through better **education** is of critical importance whenever new computer technology is to be disseminated.

2.3.2 Research Significance, Limitations and Recommendations

This study is intended to provide information to leaders and professionals who are interested in understanding and solving economic development and technology transfer issues in the public, private, or education sectors. Even if their benefits are obvious, Linux and other free software technologies often need idealistic volunteers to promote them around the world. This study is an effort of this nature. Proprietary software technologies (e.g. Microsoft) are promoted by the companies that own and market them. On the other hand, Linux or similar technologies are supported and marketed partly by companies and partly by enthusiasts in the worldwide Linux community. The data and insight in the study may also be useful to private companies that produce and market their own Linux distributions.

It would be useful for future researchers to analyze free software technologies around the world, and how they may help technology transfer and economic development in general. While doing so, they may overcome some of the limitations of this study. Future researchers are advised to look at different sources of data, and alternative measurements for the distribution of Linux and other technologies in various countries. Some may also use methodologies other than statistical analysis, for example, they may do case studies on specific projects at a specific location.

2.3.3 Sources of Data

The following sources have provided the respective data for the statistics analyses:

1. Linux Counter Project (Alvestrand, 2007). Registered Linux users as of January 2, 2007
2. World Bank (2007). World Development Indicators Section 5.11: Information Age. Personal Computers per 1000 for the year 2003
3. World Economic Forum (Schwab, Lopez-Claros, & Porter, 2007). Higher education and training score for 2006-2007 (see the Appendix for an explanation of this score). Infrastructure score for 2006-2007 (see the Appendix for an explanation of this score).
4. International Monetary Fund (2007). Gross domestic product per capita 2006.

2.3.4 Exploratory Analysis of the Extreme Countries

In this section, a preliminary analysis is done using an Exploratory Data Analysis style. In the following sections of this study, correlation and regression analyses are done on a sample of 63 countries and the actual hypothesis of this study is stated and tested. One of the important aspects of the Exploratory Data Analysis is the attention given to outliers (Hartwig & Dearing, 1979). In this case, the first step is to take an exploratory look at the countries where there are the highest and lowest numbers of Linux users. The goal is to see, as stated earlier this study, whether Linux (free software) is used more in high income countries rather than in low income countries. Table 2.1 shows the fifteen countries with the highest concentration of Linux users (starting with the highest and continuing in descending order). Table 2.2 shows the fifteen countries with the lowest concentration of Linux users (starting with the lowest and continuing in ascending order).

Table 2.1: Countries with the highest % of Linux Users as of January 2, 2007

Country	Registered users per million population
Iceland	517
Finland	488
Estonia	407
Denmark	405
Norway	376
Sweden	264
Poland	208
Netherlands	202
Switzerland	183
Slovenia	183
New Zealand	181
Austria	175
Belgium	173
Spain	158
Hungary	157

Table 2.2: Countries with the lowest % of Linux Users as of January 2, 2007

Country	Registered users per million population
North Korea	0.04
Democratic Republic of Congo	0.06
Chad	0.12
Ethiopia	0.17
Niger	0.18
Somalia	0.22
Madagascar	0.24
Cambodia	0.30
Congo	0.32
Liberia	0.32
Burkina Faso	0.34
Haiti	0.36
Rwanda	0.38
Afghanistan	0.40
Turkmenistan	0.41

All of the countries with very high numbers of Linux users are European countries except New Zealand. All of the 15 countries with the smallest number of Linux users are low income, including 12 from Africa. This picture already suggests that there is positive relationship between wealth and the number of people in a country who use Linux. There are certain exceptions to this trend among both the high usage countries and the low usage countries. It is interesting to see a number of Eastern European countries (Estonia, Poland, Slovenia and Hungary) boasting more usage than most of the wealthier Western European and North American countries. In their case, it may be said that the skill and education levels of their computer enthusiasts are comparable to their Western counterparts, and they choose Linux logically on the basis of their relatively lower income and the fact that Linux is cheaper. On the other hand, even though Norway does have a great number of Linux users, the figure provided by the Linux Counter Project is assumed to be biased in favor of Norway because the project is based in Norway. Estonia is also an outlier with its high Linux figures. The Estonian government's information systems and web sites are Linux based, and it is possible to vote online in national elections. Among some low usage countries (such as North Korea and Afghanistan), due to the current political situation, the available data may not be accurate. Therefore, in those cases, it may be appropriate not to make attributions to low incomes or the lack of technology.

2.4 Findings

2.4.1 Sample

This study covers 63 countries, of diverse economic and geographic backgrounds. The sample includes all countries (with the exceptions noted in the following paragraph) that are members of the following important international and regional economic organizations: G8 (Group of Eight), OECD (Organisation for Economic Co-operation and Development), EU (European Union - including candidate countries), MERCOSUR (South American Regional Trade Agreement – including associate members), and APEC (Asia-Pacific Economic Cooperation).

The sample does not include three major Asian countries that are members of G8, OECD, or APEC: China, Japan, and Korea (the so-called "CJK" countries). The reason for this is simple and technical. "CJK" is a well known phenomenon in the field of computer communications. These countries use the Chinese alphabet, which only the newest versions of Unicode (a computer text character set) come close to fully covering (Sharma, 2006). The Linux Counter web site may not be a good tool to measure Linux usage in these countries because of compatibility issues. The users in these countries are not likely to fully contribute to this data collection web site. The opposite effect may be expected for Norway and Estonia (i.e. the collection web site may favor these countries for reasons discussed in the previous section on the extreme countries). Ireland is an outlier in the area of income according to figures from the International Monetary Fund (IMF). It has a very high GDP per capita but this comes in the background of a very high cost of living, which may raise questions. As a result, these three countries have also been excluded from the sample.

Last, the sample does contain the three highest populated countries of ACD (Asia Cooperation Dialogue), and the two lowest income countries in Asia for which data are available. Finally, the sample contains nine countries from the AU (African Union). These include the three highest populated countries, four other African countries for which data are available to ensure that the sample is geographically evenly distributed (that is four countries from Southern and Eastern Africa alongside four countries from Middle and Western Africa), and one country that represents the region of North Africa and Middle East.

The sample also has the characteristic of containing a wide range of countries from an income per capita perspective. Out of the 63 countries total, 21 are low-income/low middle-income, 21 upper middle-income, and 21 high-income. The income classes are based on the whole world sample data (180 countries) from the IMF. High income countries are above the 75th percentile (upper quartile), and have an annual GDP per capita higher than $11,500. Upper middle-income countries are above the 50th percentile (second quartile) and below the 75th percentile (upper quartile), and have an annual GDP per capita between $3,050 and $11,500. Low-income / low middle-income countries are below the 50th percentile (second quartile), and have an annual GDP per capita less than $3,050.

2.4.2 The Data and the Requirements for Regression

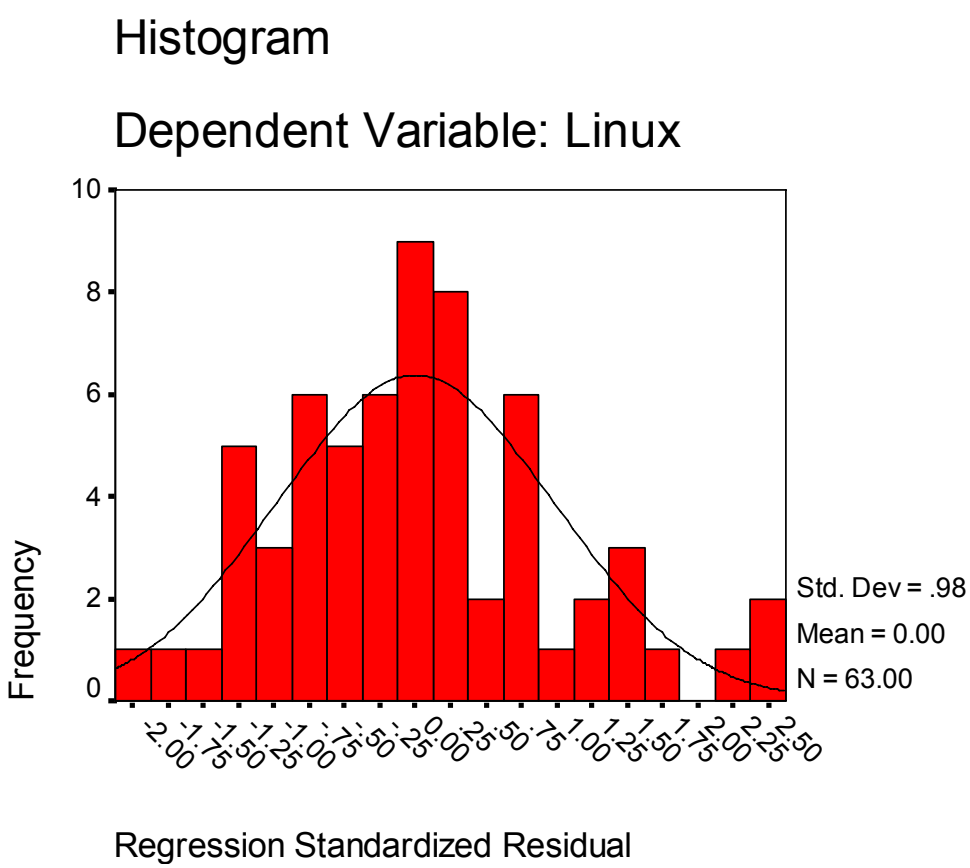
Before the results are calculated and presented, the data must be examined for suitability to be used in a statistical regression analysis. The sample data must follow a normal distribution for the dependent variable and the independent variables. Two aspects have been looked at in order to examine normality: the skewness of the distribution, and the kurtosis of the distribution. In Table 2.3 below, the calculated skewness and kurtosis of the sample data for all of the variables are reported. Figure 2.1 on the next page is a histogram for the dependent variable Linux use and shows a normal distribution.

Here it must also be noted that none of the data have been logarithmically transformed in order to create normality. The values for all of the variables except for the Linux use are exactly as they have been retrieved from databases and reports. The values for the Linux use (ranging from 0.12 to 488.41) registered users per million inhabitants have been square rooted so they now range between 0.35 and 22.10, and better parallel the values for the income variable. The skewness and kurtosis of the sample data show that the values for all of the variables are normally distributed as they fall within the range of ± 1 skewness and ± 3 kurtosis.

Table 2.3: Normality Measurements for Linux Users and Independent Variables

	Linux use	Income	Education	Infrastructure
Skewness	0.58	0.99	-0.27	0.27
Kurtosis	-0.17	-0.53	-0.78	-1.09

Figure 2.1: Histogram, Linux Users



The independent variables should also not be highly correlated with each other or be almost identical to each other. In other words, they should not be multi-collinear. This has been examined in two ways: (a) by calculating the correlation between each of the independent variables, and (b) by calculating the Variance Inflation Factor (VIF) for each of the independent variables. The correlation between Income and Education is 0.832. The VIF for the variables Income and Education is 3.24. Therefore there is some risk of multi-collinearity between the two independent variables although these variables are not identical. They measure two different concepts and their values come from two different sources. Due to the high correlation between Income and Education, in the sections on the hypothesis and the

results, this study will indicate which one of these has the higher zero order correlation and the higher partial correlation with the dependent variable.

2.4.3 Initial Statistics and Thoughts

The economic asymmetry between high income countries and low income countries has resulted in a digital divide. People in higher income countries have greater access to computer products and can afford them more easily. Organizations and companies in higher income countries also have greater markets, more financial resources, and more human resources in order to take advantage of these technologies. There is a strong positive relationship between income per capita in a country and the average number of computer users. The correlation between these two variables in the study sample of 63 countries is 0.937. Even in the case of Linux, there is a positive relationship between wealth and technology adoption. There is a strong positive relationship between income and the number of Linux users in a country. The correlation between these two variables is 0.798. Finally, there is a correlation between income and the number of Linux users per computer. The initial expectation due to a simple economic reasoning may be that since Linux is cheaper than proprietary systems such as Microsoft Windows - it would spread more widely in lower income countries, i.e. Linux users per computer would tend to be higher in lower income countries. This would have been a negative correlation between these two variables but this is not the case: there is a positive correlation of 0.13.

2.4.4 Hypothesis and Regression

The hypothesis of this study is: **Income** and **Human Capital / Education** are the two key factors that influence the **Use of Linux Software** in a given country.

The independent variables that have been tested in the regression analysis are: (a) Income (x_1), (b) Education (x_2), and (c) Infrastructure (x_3). Income (x_1) refers to the most recent GDP per capita for a given country. Education (x_2) refers to the most recent higher education and training score (reflecting both quantity and quality) for a given country. Infrastructure (x_3) refers to the most recent socre that measures the quality of the telephone, electricity, and transportation (air, land, and water) facilities all of which may impact the amount of technology transfer a country may achieve. There are many asymmetries and variations among the countries of the world in regards to these social and economic variables. Please see the Appendix for the full sample data that were used in the multiple regression analysis.

The regression analysis, involving the sample of 63 countries, confirms the hypothesis. A regression model with Income (x_1), Education (x_2), and Linux (Y) generates a coefficient of determination i.e. $R^2 = 0.73 / 1.00$. The equation for this model would be: $Y = -6.339 + 0.111x_1 + 2.760x_2$. Please notice the positive signs of the unstandardized (B) coefficients for both of the independent variables. This indicates that the relationships between the independent variables and the dependent variables are in the positive direction as hypothesized. A stepwise regression test rejected the third independent variable Infrastructure (x_3) and removed it from the final model. That variable did not sufficiently improve the explanatory nature of the model. It was also unacceptable from a multi-collinearity perspective because it correlated very highly with the other variables. Table 2.4 and Table 2.5 on the next page summarize the results of the regression analysis for the model that was final accepted (please see the Appendix for further statistical details on the rejected model of multiple regression with all three independent variables).

Table 2.4: Correlations for Variables Predicting Linux Users

Variable	Zero-order	Partial
Income	0.798	0.339
Education	0.835	0.512

Table 2.5: Summary of Regression Analysis for Predicting Linux Users

	Unstandardized Coefficients		Standardized Coefficients
Variable	B	Std. Error	Beta
(Constant)	-6.339	2.157	
Income	0.111	0.040	0.335
Education	2.760	0.598	0.556

Above, Education (x_2) has a higher zero-order and partial correlation with Linux (Y) than Income (x_1). In addition, the results of the regression analysis show that Education (x_2) has a higher beta coefficient than Income (x_1). The beta coefficients indicate which independent variable has a greater impact on the dependent variable.

2.4.5 The Results: A Discussion

According to the statistical analysis in the previous section, education and income influence a country's ability to transfer technology in the case of Linux software. It also indicates that human capital and education play an important role in determining how ready and willing a country is to take advantage of Linux software.

The following graphs also help the individual relationships between each independent variable (Income and Education) and number of Linux users.

Figure 2.2: Scatter Plot – Linux Users and Education Level

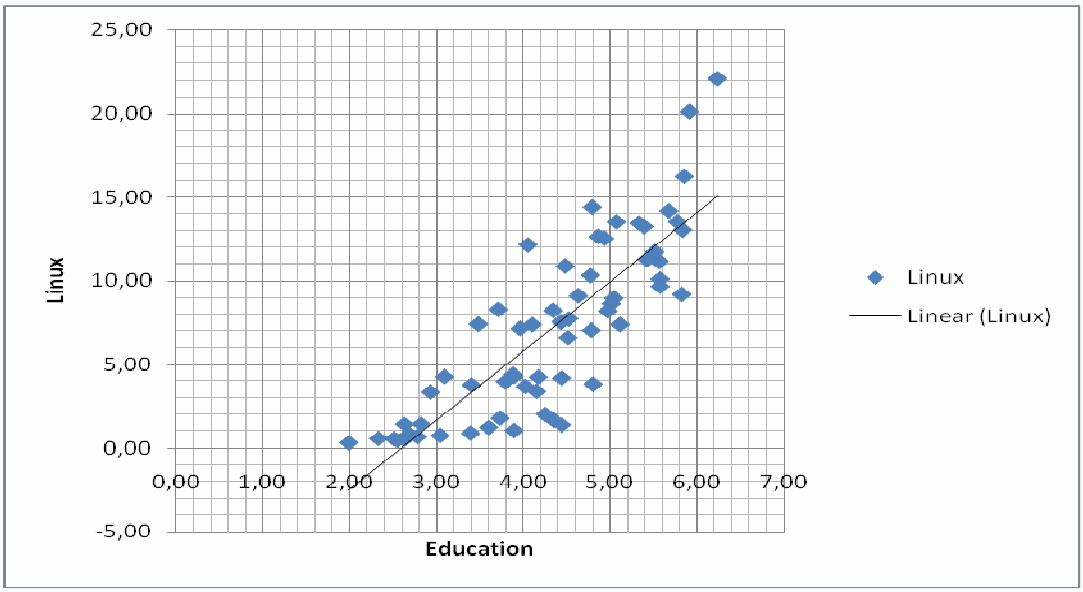
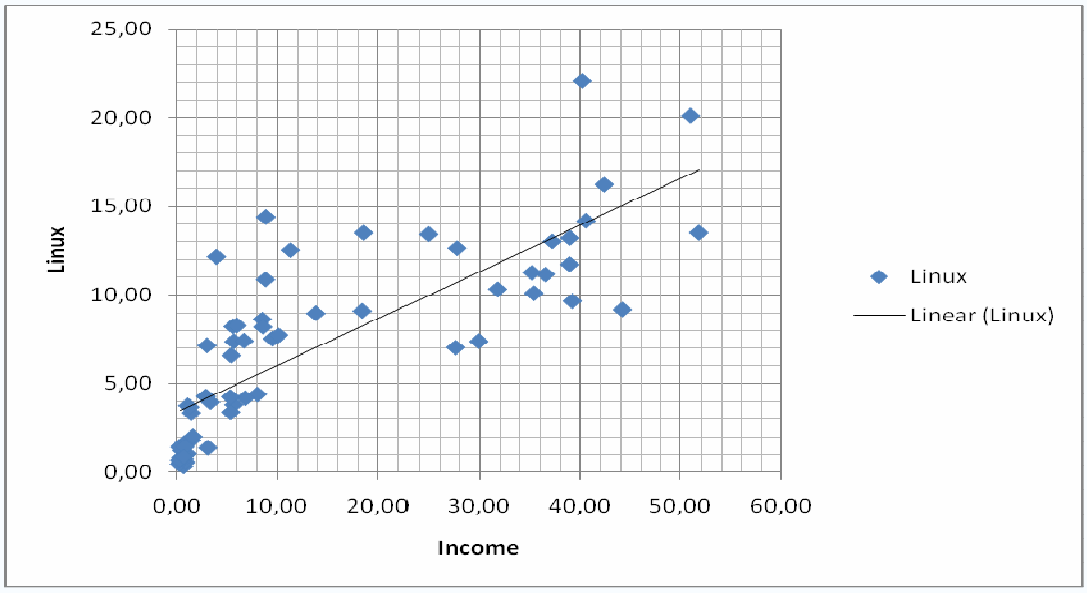


Figure 2.3: Figure 2.2: Scatter Plot – Linux Users and Income



This also completes the second part of the assertion in the Abstract. In the first study, it was suggested that computer technology positively influences economic growth. In this second study, it is suggested that human capital positively influences the use of computer technology.

2.5 Conclusion

In this study, the hypothesis was that Income per capita and Human Capital / Higher Education and Training are the two key factors that influence the Use of Linux (free) Software in a given country. Then the statistical analysis of the data supported this hypothesis. As was discussed in the early parts of this study, software and technology adoption is important for less developed countries. It is in the interests of people in the less developed countries to adopt Linux. As part of their development, they are trying to catch up with developed countries in terms of computer use, and technical education. They can reach these objectives sooner if they take advantage of good technologies that are freely available. Thus it is clear that computer education and training must be supported in these countries. The variation in average income across countries is a basic and hard fact of economic asymmetry. People in less developed countries and their governments may only slowly improve their average incomes over time. On the other hand, improving education may be relatively easier to handle. People and their governments are able (to a certain extent) to shift more of their public and private resources into education and training (instead of other investments).

2.5.1 Argument for Free Software in Less Developed Countries

Despite Microsoft's worldwide market dominance, China, India, and other countries from South America, Africa, and Asia are making efforts to adopt Linux and other open source software (Jorgenson & Wessner, 2006). Free Linux software enables future programmers to view and examine the code of a real product (versus a commercial which keeps it hidden); this by itself helps train the future generation of programmers. It is therefore in the economic interests of any country to maintain individuals who cooperate on and develop free software (Jorgenson & Wessner, 2006). The innovative community of world wide free software programmers will grow tremendously as Linux becomes adopted by many new users around the world and in less developed countries.

2.5.2 Governments and Universities Setting the Trend

Many reasons were discussed above as to why it is difficult for the people to normally choose Linux over Windows. This is why governments and universities have taken the lead in these countries. One example of the government taking an active role in implementing Linux in all public organizations instead of Windows is Brazil (Benson, 2005). University professors such as Arnando Mandel have also been in the news for implementing Linux in Brazil (Ashurst, 2004). They have publicly stated similar arguments: to have more control of their information systems as opposed to being dependant on Microsoft.

Kabissa, a non-governmental non-profit pan-African organization which was discussed in Chapter 1, also promotes free and open source software (including Linux) in Africa in order to increase its efficiency and reduce its costs (as well as those of the people and organizations which it is assisting).

2.5.3 Inexpensive Hardware Bundled with Free Software

Finally, some of the recent efforts to reduce the cost of computers (as a way to tackle the problem of computer technology adoption in less developed countries) need to be mentioned. Software is only a part of a computer system. Therefore, even if software is free, the relatively high price of computer hardware itself makes it difficult for computer technology to spread among the population in low income countries. The future of worldwide computer technology transfer relies on the price of computer hardware becoming much lower. Of course, this is quite a probable predicate because computer hardware technology is not so new. Personal computers have been around for about 25 years.

There is no need to wait another decade or two before personal computers cost $100 because there are already two projects / products that are expected to be in the market and / or directly sold to less developed country governments starting in 2007. One of these products has been planned and marketed by the non-profit "One Laptop per Child" (OLPC) project led by Nicholas Negroponte (M.I.T. professor and Motorola executive). One laptop costs only $100, and this product has been marketed to the governments of China, India, Brazil, Argentina, Egypt, Nigeria, and Thailand (Schadt, 2006). The other product has been created by a Chinese company called "Yellow-Sheep-River" and priced at $150 (Carney, 2006). As far as operating system software goes, both of these systems use Linux. Therefore, the number and ratio of Linux users in less developed countries are expected to grow with the spread of these and similar other personal computers.

As a result of the kind of recent projects discussed above, the spread of more computers and software may be facilitated despite the many apparent disadvantages that people in less developed countries face (which were discussed in the body of this study). From the perspective of the statistical analysis in this study, these projects are aimed at overcoming the disparities in income and increasing Linux use despite low incomes.

Even though, these projects are steps in the right direction, they have not made as much progress as planned earlier. There may be a number of reasons for this. On one hand, these $100 - $150 machines may be perceived as inferior. Thus potential users in less developed countries may be waiting until they are able to afford the better conmputers. On the other hand, these inexpensive machines are generally intended for children. But this would actually make them a luxury because children in less developed countries have other needs as well, and even many adults are not able to learn and use computers. Another approach (a complementary one) would be to address and improve the human capital and education aspect of the issue first (as suggested by the stong statistical relationships) and then indirectly expect people to better adopt Linux and other software technologies. This seems to be in line with the historical experience of developed countries where Linux has flourished naturally without any special subsidies or reductions on the price of hardware.

With the help of more information technology resources, the quality of human capital is expected to improve. Then, reciprocally, as this study showed, higher levels of human capital are more capable of absorbing further technology. Thus the improved human capital is expected to continue to benefit from technology transfers in the long term.

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Appendix

Appendix 2.1: Components of the Higher Education and Training Measurement

Source: World Economic Forum Global Competitiveness Report 2006-2007 (http://www.weforum.org)

1. Secondary enrolment ratio (hard data)
2. Tertiary enrolment ratio (hard data)
3. Quality of the education system
4. Quality of math and science education
5. Quality of management schools
6. Local availability of specialized research and training services
7. Extent of staff training

Appendix 2.2: Components of the Infrastructure Measurement

Source: World Economic Forum Global Competitiveness Report 2006-2007 (http://www.weforum.org)

1. Overall infrastructure quality
2. Railroad infrastructure development
3. Quality of port infrastructure
4. Quality of air transport infrastructure
5. Quality of electric supply
6. Telephone lines (hard data)

Appendix 2.3: Statistical calculations with all three independent variables

SUMMARY

Regression Statistics	
Multiple R	0,86
R Square	0,74
Adjusted R Sq.	0,73
Standard Error	2,75
Observations	63

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	1.269,55	423,18	55,99	0,00
Residual	59	445,94	7,56		
Total	62	1.715,48			

LINUX	*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95%*	*Upper 95%*
Intercept	(6,26)	2,14	(2,92)	0,00	(10,55)	(1,98)	(10,55)	(1,98)
Infrastructure	(1,07)	0,77	(1,38)	0,17	(2,62)	0,48	(2,62)	0,48
Education	3,58	0,84	4,26	0,00	1,90	5,26	1,90	5,26
Income	0,15	0,05	3,08	0,00	0,05	0,25	0,05	0,25

Appendix 2.4: The sample data used in the regression analysis (Part 1).

Country	Income ($1,000)	Infrastructure	Education	Organization
Argentina	5.46	3.26	4.51	MERCOSUR
Australia	36.55	5.42	5.56	OECD
Austria	38.96	5.43	5.39	EU
Bangladesh	0.45	2.03	2.68	ACD
Belgium	37.21	5.85	5.83	EU
Bolivia	1.12	2.22	3.40	MERCOSUR
Brazil	5.72	3.29	4.10	MERCOSUR
Bulgaria	3.99	3.41	4.05	EU
Burkina Faso	0.45	2.14	2.51	AU
Cambodia	0.50	2.48	2.63	ACD
Canada	38.95	5.81	5.51	G8
Chad	0.71	1.43	1.99	AU
Chile	8.86	4.41	4.48	APEC
Colombia	2.89	3.15	3.89	MERCOSUR
Croatia	9.56	3.98	4.43	EU
Czech Republic	13.85	4.50	5.04	EU
Denmark	50.97	6.24	5.91	EU
Ecuador	2.99	2.65	3.09	MERCOSUR
Egypt	1.49	3.72	3.73	AU
Finland	40.20	5.91	6.23	EU
France	35.40	6.25	5.57	G8
Germany	35.20	6.51	5.42	G8
Greece	27.61	4.71	4.78	EU
Hungary	11.34	4.05	4.93	EU
India	0.80	3.50	4.35	ACD
Indonesia	1.64	2.72	4.25	APEC
Italy	31.79	4.00	4.77	G8
Krgyzstan	0.54	2.30	3.60	
Latvia	8.55	4.33	5.01	EU
Lithuania	8.61	4.14	4.97	EU
Macedonia	3.06	2.83	3.96	EU
Madagascar	0.30	2.03	2.55	AU

(Continued on the next page)

Country	Income ($1,000)	Infrastructure	Education	Organization
Malaysia	5.72	5.09	4.80	APEC
Mauritania	0.92	2.09	2.33	AU
Mexico	8.07	3.41	3.88	OECD
Mongolia	1.08	2.24	3.89	ACD
Nepal	0.34	1.83	2.63	
Netherlands	40.57	6.09	5.67	EU
New Zealand	24.94	4.88	5.33	OECD
Nigeria	0.77	2.26	3.04	AU
Pakistan	0.83	3.36	2.82	ACD
Paraguay	1.48	2.15	2.93	MERCOSUR
Peru	3.37	2.69	3.79	APEC
Philippines	1.34	2.73	4.02	APEC
Poland	8.89	3.64	4.79	EU
Portugal	18.46	4.93	4.63	EU
Romania	5.63	3.05	4.34	EU
Russia	6.86	3.52	4.44	G8
Singapore	29.92	6.16	5.11	APEC
Slovak Republic	10.16	4.08	4.52	EU
Slovenia	18.61	4.51	5.07	EU
South Africa	5.38	4.04	4.17	AU
Spain	27.77	5.22	4.86	EU
Sweden	42.38	5.97	5.85	EU
Switzerland	51.77	6.34	5.77	OECD
Thailand	3.14	4.36	4.44	APEC
Turkey	5.41	3.46	4.15	OECD
Uganda	0.32	1.99	2.78	AU
United Kingdom	39.21	5.74	5.57	G8
United States	44.19	5.82	5.82	G8
Uruguay	6.01	3.59	3.71	MERCOSUR
Venezuela	6.74	2.78	3.48	MERCOSUR
Vietnam	0.72	2.79	3.39	APEC

Appendix 2.5: The sample data used in the regression analysis (Part 2).

Country	Linux (LU) per mil.	Sqr Rt Linux (SRL)	PC's per 1,000	Rescaled SRL / PC
Argentina	43.86	6.62	82	7.31
Australia	125.08	11.18	565.1	4.70
Austria	175.60	13.25	369.3	6.90
Bangladesh	0.74	0.86	7.8	3.08
Belgium	170.33	13.05	318.1	7.32
Bolivia	14.38	3.79	22.8	7.94
Brazil	54.88	7.41	74.8	8.57
Bulgaria	148.23	12.17	51.9	16.90
Burkina Faso	0.34	0.58	2.1	4.02
Cambodia	0.30	0.55	2.3	3.61
Canada	138.19	11.76	487	5.33
Chad	0.12	0.35	1.7	2.66
Chile	118.76	10.90	119.3	9.98
Colombia	18.50	4.30	49.3	6.13
Croatia	57.14	7.56	173.8	5.73
Czech Rep.	80.80	8.99	177.4	6.75
Denmark	405.48	20.14	576.8	8.38
Ecuador	18.43	4.29	31.1	7.70
Egypt	3.32	1.82	21.9	3.89
Finland	488.41	22.10	441.7	10.52
France	102.48	10.12	347.1	5.43
Germany	127.43	11.29	484.7	5.13
Greece	49.98	7.07	81.7	7.82
Hungary	157.49	12.55	108.4	12.05
India	2.85	1.69	7.2	6.29
Indonesia	4.20	2.05	11.9	5.94
Italy	106.95	10.34	230.7	6.81
Krgyzstan	1.60	1.26	12.7	3.55
Latvia	74.81	8.65	188	6.31
Lithuania	67.77	8.23	109.7	7.86
Macedonia	51.50	7.18	221.7	4.82
Madagascar	0.24	0.49	4.9	2.21

(Continued on the next page)

Country	Linux (LU) per mil.	Sqr Rt Linux (SRL)	PC's per 1,000	Rescaled SRL / PC
Malaysia	14.80	3.85	166.9	2.98
Mauritania	0.36	0.60	10.8	1.83
Mexico	19.59	4.43	82	4.89
Mongolia	1.17	1.08	77.3	1.23
Nepal	2.12	1.46	3.7	7.57
Netherlands	201.72	14.20	466.6	6.58
New Zealand	181.19	13.46	413.8	6.62
Nigeria	0.61	0.78	7.1	2.93
Pakistan	2.15	1.47	4.2	7.15
Paraguay	11.35	3.37	34.6	5.73
Peru	15.94	3.99	43	6.09
Philippines	13.76	3.71	27.7	7.05
Poland	208.01	14.42	142	12.10
Portugal	83.32	9.13	134.4	7.87
Romania	68.19	8.26	96.6	8.40
Russia	17.78	4.22	88.7	4.48
Singapore	55.01	7.42	622	2.97
Slovak Rep.	60.14	7.75	180.4	5.77
Slovenia	183.28	13.54	300.6	7.81
South Africa	18.24	4.27	72.6	5.01
Spain	160.35	12.66	196	9.04
Sweden	264.20	16.25	621.3	6.52
Switzerland	183.40	13.54	708.7	5.09
Thailand	2.00	1.41	39.8	2.24
Turkey	11.64	3.41	44.6	5.11
Uganda	0.50	0.71	4	3.54
UK	93.81	9.69	405.7	4.81
USA	84.80	9.21	658.9	3.59
Uruguay	69.03	8.31	110.1	7.92
Venezuela	55.33	7.44	60.9	9.53
Vietnam	0.84	0.92	9.8	2.93

Appendix 2.6: Note on excluded countries

The following countries (of typically small population) that are members of OECD, EU, or APEC were not included in this study because their data were not available: Brunei (APEC), Cyprus (EU), Iceland (OECD), Luxembourg (EU), Malta (EU), and Papua New Guinea (APEC).

CHAPTER 3

International Software Outsourcing

3.1 Introduction: A Qualitative Study on Outsourcing

3.1.1 Purpose of the Qualitative Study

This 3rd study is on international offshore software development outsourcing. It is qualitative in nature as it does not involve variables and statistical data analysis. Rather than being a systematic study on this interesting matter, it attempts to provide the readers a subjective view on the economic nature and impact of outsourcing. This is done from two perspectives. The first perspective is to look at a single example of an outsourcing company as a means to help describe the activities that are involved in an outsourcing business relationship. The second perspective is to review the broad economic theories and other international perspectives that are relevant to this field to explain the economic nature of an outsourcing relationship.

Offshore outsourcing is the practice of hiring an external organization to perform some or all business functions in a country other than the one where the product or service will be sold or consumed (http://en.wikipedia.org/wiki/Offshore_outsourcing). Computer software development is essentially suitable for outsourcing because the content of this work is information and this work can be transmitted over the Internet.

Some of the major countries/districts that provide such services are India (Programming and IT), Bangladesh (Programming and IT), Russia (Programming and R&D), Pakistan (Programming, Customer Support, Call Center), Bulgaria (Programming and R&D), Ukraine (Programming and Design), Belarus (Software development, Design, Engineering), Romania (Programming and IT), the Philippines (Data Entry and Customer Support), Egypt (Customer Support and Programming), China (Programming), and Latin America (solution providers).

The success of some countries in this field has caught a lot of attention such that these countries are expected to become major economic powers within the next 50 years. As a result of their labor pools, recent economic growth, and fast technology transfer, acronyms such as BRIC (Brazil-Russia-India-China) and BRICET (Brazil-Russia-India-China-Eastern Europe-Turkey) have been coined and are commonly used for those countries (Goldman Sachs, 2006). Major IT vendors such as IBM, Microsoft, SAP, etc. have regarded these as strategic markets; and now as more and more countries attempt to catch up in terms of technology, the major IT vendors are expanding in other countries as well (International Data Corporation, 2007).

The major purpose of this study is to illustrate how computer technology can economically help less developed countries through outsourcing transactions. The existence of sufficient human capital is a prerequisite for less developed countries' ability to economically benefit from the outsourcing sector. There are many less developed countries that are unable to take advantage of this opportunity due to a shortage of human resources with computer technology skills. Human capital is a critical factor in overall economic development, and outsourcing is fine example of this assertion.

3.1.2 Profile: Hidden Brains InfoTech Pvt. Ltd.

Hidden Brains InfoTech is a private limited company, whose ownership is made up of shares but these shares are not sold in the stock markets. It was founded in September of 2004. The company headquarters is located in the city of Ahmedabad, State of Gujarat, in India. The company does not have any other large offices elsewhere but is planning to open one in the city of Hyderabad, State of Andhra Pradesh, in India. The company also has a representative (for sales and accounting) in an office in New York, USA. The total number of employees of this company is 80. Mr. Ram Binod Chhawchharia is the Chief Technology Officer and General Director of the company. Hidden Brains Info Tech Pvt. Ltd. (HBIPL) is a 100% Export Oriented Software Development Company based in Ahmedabad. It offers solutions for website development, designing yahoo stores, e-commerce solutions, multimedia solutions, provides consultancy, and other related services (R. B. Chhawchharia, 2006).

The company provides customized and comprehensive solutions to its clients in a cost effective manner. The company is engaged in high quality projects, where it can apply creative and innovative designs in order to satisfy the customers outside of India. The company is 100% export oriented, which means that it can not cater to the local market. In order to enjoy the Indian government's tax exemption benefit, it has to cater only to customers abroad. This year's annual revenue in US$ is an estimated $9 million; and its annual net income in US$ is expected to be $5 million (M. Chhawchharia, personal communication, November 1, 2006).

3.2 The Economics of Outsourcing

3.2.1 Summary of Economic Theories of International Trade

In order to understand the economic basis of outsourcing, there is a need to review the economic rationale behind why countries conduct trade with each other, and what each side has to gain from this trade. According to the laws of comparative advantage which go back to classical economists Ricardo and Mill, the net national product in both countries must increase in the long run (Samuelson, 2004). In addition, when the United States buys a product from China or India, American consumers will gain a lot by virtue of the cheaper imports even though some American producers may lose. Since the United States economy will achieve equilibrium in the long-run, the impact on American production will not be one of jobs lost but rather a decrease in the labor market wages of US workers.

In the case of computer technology, most of the innovations originated from the United States and spread across the world to the capable and educated workforce of Europe and Asia. This non-US workforce, less costly and more productive, now competes with its American counterpart. This trend may cause a creative destruction whereby the national economies will adjust their labor and production appropriately toward the most desired goods and services. Certain sectors of the economy will arise or grow whereas others will shrink. When goods such as technology or software (which themselves can be used as factors of production for other services or goods) are exchanged, then these technical goods can strongly benefit the US economy by helping some American businesses become more successful and generate higher revenues.

After the theory of comparative advantage, in more recent history, other economists formulated new models and ideas such as the Heckscher-Ohlin model of trade, Mundell framework, and Kemp's newer Heckscher-Ohlin model (Tombazos, Yang, & Zhang, 2005). These models contain additional parameters to describe international trade such as comparative endowment advantage, comparative technological advantage, international capital mobility, and transactions costs of trade. From these newer models, it may be seen that the countries which provide services to the wealthier out-sourcing countries are endowed with a greater abundance of human resources (as a result of larger and younger populations such as those in China and India), that they possess certain knowledge as to how to produce and provide certain goods and services more efficiently, and that despite the transactions costs of trade with China and India, their products and services are still cheaper than domestic production, as well as cheaper than what it would cost to bring and use those foreign resources within the United States or Western Europe.

3.2.2 Review of Other Studies on Outsourcing

The reason for a company within the United States or Western Europe to outsource its computer software development to Asia and Eastern Europe is the great cost savings sometimes as high as 70% (Beeler, 2006). This so-called offshore software outsourcing has other theoretical and practical benefits. The companies that outsource their software development improve their flexibility, marketing, and timing by obtaining the same resources cheaper and faster from foreign developers. There are many companies from many different countries to choose from; nevertheless companies from India seem to lead due to their experience, past references, and their adherence to international quality standards (Beeler, 2006). Examples of such standards are ISO (International Organization for Standardization), SEI (Software

Engineering Institute) and SW-CMM (Capability Maturity Model for Software). On the other hand, even the most vocal supporters of offshore software outsourcing recognize the precautions that must be taken, and the need to plan and manage the projects carefully. Top management needs to get involved in choosing the right foreign companies, and only those projects that have a high-priority and have clear specifications must be chosen for outsourcing. Finally, a liaison is very instrumental to the success of such projects (whether he/she a local representative of the foreign company, or an employee of the client company, or a third-party professional) by assisting in the communication and planning.

Software outsourcing has become a subject of recent academic studies. Some of these studies address issues related to additional financial costs that arise from outsourcing projects; whereas some of them address cultural and communication issues between the two parties. Similarly often the concern for cultural issues is due to additional financial costs arising from increased control, traveling, and planning when there is a lack of sufficient cultural understanding or communication.

There are variations even among western countries as to what countries they prefer to outsource to. Companies in North America and Britain tend to prefer Indian partners because of their knowledge of English, whereas companies in Western Europe prefer Eastern European partners due to their physical proximity and some acquaintance with Western European languages (Krishna, Sahay, & Walsham, 2004). One of the advantages of Indian companies, due to their wider variety of clients and past partnerships with other technology companies, is that they now also possess some strategic and business expertise (aside from pure computer programming), which many client companies around the world find valuable and therefore are willing to pay for this additional business consulting.

Enhancing the cultural understanding between the client and foreign companies will not only improve the delivery of the services in question but also will contribute to better international and intercultural relations overall. According to Krishna et al. (2004), enhancing this cultural understanding can be done by focusing on three basic areas: cultivating the relationship, appropriate staffing, and training. On the technical side of the relationship, it is more harmonious if both of the client and supplier companies use the same or compatible computer equipment, operating systems software, and communications tools. On the cultural side of the relationship, harmonious relationships in the past have been those where both sides were aware of and adjusted themselves to the cultural habits of their partners. The most appropriate liaison staff typically includes people who have lived or studied in both countries. In addition to technical competence, the liaison staff must be adaptable to different environments. Finally, Krishna et al. (2004) recommend some formal and informal cultural training (seminars, books, films, visits, face-to-face interaction, etc.) to the relevant employees of both companies in an outsourcing project.

There have been cases where the software outsourcing projects have involved difficulties; in these situations small client companies do not have the financial, political, and knowledge resources that large companies have in order to cope with such difficulties. These difficulties may be delays in software delivery or the quality and functionality not being up to expectations. These difficulties may result in (a) contact costs (extra travel/video-conferences/phone calls/faxes/emails), (b) contract costs (cost of creating contracts/legal fees), and (c) control costs negotiating/measuring) (Carmel & Nicholson, 2005). Therefore small client companies need less expensive but intelligent strategies to cope with such difficulties.

Similarly, the companies that provide services to their western clients can use intelligent strategies to prevent any difficulties, and to ensure that the business relationship is also fair for them. The client companies can use one of two of their appropriate employees as liaison staff, try to gain experience and learn as much as they can from the process, and look out for certain things in the other company such as being on schedule, or not skipping any requirements, and assuring quality by testing and fixing the software where necessary. In return, the company providing the services can benefit from a local representative in the client's country of the, try to simplify the contract in the beginning, create its own control mechanisms to ensure the project continues successfully, and standardize its services across their client portfolios so that it will be easier to manage their projects and to demonstrate their quality compliance.

In India, NASSCOM (National Association of Software and Service Companies) acts as the trade body and chamber of commerce of IT software and services industries (NASSCOM, 2006a). Its objectives are to facilitate business and trade with clients in western countries, to facilitate the further growth and quality of this sector in India, and to create a community between Indian companies to support one another. NASSCOM constantly sponsors, distributes, and helps Indian companies share new technical research, market intelligence, and international business knowledge. According to a broad NASSCOM (2006b) analysis of the Indian IT industry, software and services (as opposed to hardware) make up the majority of the industry's total revenues. Similarly, the majority of the industry's revenues come from exports (as opposed to domestic business). Over the recent years, revenues and exports have been growing and are expected to continue to grow. The number of people employed in India's IT sector has gone up from 284,000 in 2000 to an

estimated 1,287,000 in 2006. Sixty eight percent of India's software services export clients are in North America and South America. In comparison, European clients consist of 23%. India has thousands of companies in this sector but the 14 large companies with revenues greater than $100 million make up 70% of the sector's total export revenues.

Table 3.1: India's IT Industry Revenues – the Share of IT Exports (NASSCOM)

USD billion	FY 2004	FY 2005	FY 2006E
IT Services	10.4	13.5	17.5
-Exports	7.3	10.0	13.2
-Domestic	3.1	3.5	4.3
ITES-BPO	3.4	5.2	7.2
-Exports	3.1	4.6	6.3
-Domestic	0.3	0.6	0.9
Engineering Services and R&D, Software Products	2.9	3.9	4.8
-Exports	2.5	3.1	3.9
-Domestic	0.4	0.7	0.9
Total Software and Services Revenues	16.7	22.6	29.5
Of which, exports are	12.9	17.7	23.4
Hardware	5.0	5.9	6.9
Total IT Industry (including Hardware)	21.6	28.4	36.3

One of the requirements for competing in the global IT sector is complete proficiency in constantly emerging new software technologies. Recently, the greater demand for Indian software services is coming from smaller western companies. This adds more pressure on Indian companies to deliver better, cheaper, and faster; the so-called new Web 2.0 software tools can help them in this regard (Dutta, 2006). Most of these new tools make web pages more real-time and interactive. Incorporating these features into the client's web sites can enhance the quality of the product; developers and clients can also take advantage of these types of tool during the development work itself by collaborating more effectively in a real-time online environment (exchanging ideas, making changes to the site while discussing, and demonstrating the effects). These types of interactive features can help clients' web sites go from static advertisement and information to a world of dynamic marketing and consumer community.

The accomplishments of India's IT industry in the past do not guarantee success in the future as well, especially in the global environment of growing competition. Many Indian scholars, technical experts, and businessmen think that India needs to go one step higher in the development of its IT sector. Rather than just generate code for common services and products, they believe that India must start creating and innovating new ideas and products. These could open doors to more business in the future and new revenues. Then India would start exporting the basic productivity and programming tools rather than importing them from the west. The desire of many of these scholars and business and technical experts is for India to create and sell new software package products like Microsoft, and other American and European companies (rather than mainly providing auxiliary outsourcing services such as coding and maintenance support as it is doing today).

There are many who believe that the Indian government can do more in order not to hinder the IT industry in India (Chandra, Fealey, & Rau, 2006). The authors think that India has a competitive advantage due to a large labor pool, low wages, a healthy level of domestic competition between Indian companies, and overall English-language capability to help with exporting. In addition, certain state governments have helped companies creating a good tax environment, and by attracting World Bank monies to improve their resources. But the federal government also needs to help more by investing in India's basic logistical, financial, health, energy, educational, technological, communications, and internet infrastructure (Chandra et al., 2006).

In order for India to have companies like Microsoft, Nokia, Apple, Sony, Siemens, SAP, Oracle, etc., India's businessmen and technical experts have to become more innovative. To do so, new ideas are needed and Indian companies need to find gaps in western products that are currently available in the market. On top of this, a great amount of venture financial capital is required to start the development and marketing of new products (NASSCOM, 2006c).

Culturally, Satya Rao (2006) thinks that India does not really have a disadvantage. Many young Indians are no longer karmic or deterministic or spiritual. They do care about success and material things. Besides, western examples suggest that, it does not take an expensively-trained scientific genius to innovate new products. This is usually done by skilful businessmen with common sense. To do this, the Indian education system needs to be based less on conformity and memorization and more on critical thinking and independent research (Rao, 2006). Young Indian businessmen need to understand western ideas without totally copying them so that they can add more to them or improve them. They need to take more risk, and

increase quality with the world market in mind (rather than sticking to the level of quality which may be acceptable domestically). Currently, India is behind many other countries in the number of patents generated for inventions (Breja, A. & Mathew, M. K., 2005). Some blame India's past socialist governments for this. Therefore privatization and more domestic economic competition can help reduce the costs of basic inputs such energy and communications costs.

India's companies need to invest more time and money to collecting and analyzing data about global markets and trends in order to come up with ways to grow. Indian companies need to establish a higher reputation over time just like the case of Japan in the latter half of the 20th century (Japanese automobiles were initially considered cheap, copies of western automobiles, small, and plain but later became respected for their genuineness, appearance, sturdiness, and luxury).

Certain societal factors may have slowed economic activity in the past such as the diversity in India, and the nature of most companies being founder owned and led. On the other hand, diversity also means a higher potential for different and new ideas. Similarly, just as founders of businesses can be more conservative, when it comes to having to take risks or spend enormous efforts, they can be bolder than executives who are hired for relatively short periods of time.

The large labor pool argument raises another point which needs to be shortly mentioned here. Please see the Appendix, which shows some data from the International Monetary Fund (IMF) in order to state how small countries with small pools of labor skills spend a greater portion of their GDP on importing information technology services. Although this seems often the case, there are exceptions. In 2004, Ein-Dor, Myers, and Raman studied four small countries that have had solid IT industries of their own: Finland, Israel, New Zealand, and Singapore. The authors credited the following factors for this success: concentration of human capital, research and development, technological infrastructure, good strategies used by national firms, and the availability of financial capital.

3.3 Illustrative Study and Findings

3.3.1 How Hidden Brains InfoTech Inc. Has Started and Grown

The firm started its operations with a small asset base of only three personal computers. Mr. Ram Binod Chhawchharia, the present General Director of the company, founded the company as a sole proprietorship in June 2003. He used his aggressive style and competent managerial skills, and expanded the business rapidly and converted the firm into a private limited company on September 2004. Presently, the company works with a staff of 80 members. In order to provide around the clock support to its global clients, the company staff works in two shifts. The company is currently a regionally well-known export-oriented unit. Over a short span of history, Hidden Brains has accumulated a lot of experience – so far almost 700 web applications, 50 software application developments, and many third party outsourcing development assignments (M. Chhawchharia, 2006).

The Indian government's foreign policies have been a boon to the company. After on-going liberalization of the economy, the country has gained reputation in the world. Also, India's good name in the IT Industry has helped the small companies to grow fast. The government has also established liberal policies for the exporters because they bring foreign exchange into the country, which helps India's development (M. Chhawchharia, 2006).

3.3.2 The Nature of the Clients that Outsource Web Software Development

Some of the clients are web development companies themselves who contract their work to Hidden Brains, while some are direct end users of this company's services. The end-user clients include small companies, medium-size companies, and even individuals. The clients are not just in one industry. They belong to many different sectors, even including retailers. But the companies that contract out their

work to Hidden Brains are large software development companies. Hidden Brains has clients mostly from US, Canada, Australia, and Dubai. Currently, the company is interested in the European Market (M. Chhawchharia, personal communication, November 1, 2006).

There are many reasons for clients to work with this company. It is cost effective to the client i.e. they get quality work at a cheaper rate. Also there is time difference advantage for western countries: the software development in India takes place at times when the western company does not normally operate (early morning or night). Virtually, together with the Indian partner, the western company can be seen as working 24-hours of the day rather than just utilizing half of the day. Western companies can outsource this type of work (web development) and then just concentrate on their core competencies to strengthen their own business. The quality of the work delivered is world standard. Hidden Brains uses advanced technology. The company's goal is not to just satisfy the customers but please them so that this might result in good references and more business in the future. Hidden Brains provides extensive technical support to clients 24 hours – 6 days of the week, which is another good reason to work with this company (M. Chhawchharia, 2006).

3.3.3 The Nature of the Competition in the Sector

Knowing one's competitors well helps individual companies shape their own products, services and marketing practices. It also enables them to make sure that their prices are competitive. Small organizations like Hidden Brains InfoTech face competition from local Indian companies and not from the biggest Indian internationally dominant companies. The foreign competition is relatively less as opposed to Indian competition. One reason for this is the edge in pricing that Indian companies have over western companies. On the other hand, there is a big market

untapped and many companies from anywhere in the world have the opportunity to target this big market. Clients approach Indian companies through their websites, by the bids posted by the Indian Companies as a result of their outsourcing requirements, or as a result of informal referrals such as word of mouth publicity and new acquaintances at tradeshows and conferences (M. Chhawchharia, personal communication, November 20, 2006).

The small and medium size organizations face the problem of constantly recruiting skilled manpower. In some cities such as Ahmedabad, there is a shortage of highly skilled manpower to match the demands of the companies' services. So companies need to enhance them through extensive training. This training and the learning cycle does cost companies money and other resources whereas the companies may rather prefer to invest the money for marketing and growth. Thus there is an employee retention problem in small and medium organizations. The multinational companies from western countries as well the biggest Indian companies continue to expand to different cities. There they are able to steal the trained people away from the smaller companies by offering a lot more pay. In order to manage the competition among themselves, small and medium Indian company heads and owners have come together to form local informal or formal committees where they discuss such recruiting and inter-company transfers. As a principle, they have decided not to hire the employees of the other local companies. This will help each company retain their employees. If one company hires an employee from another company, it takes place after consulting and obtaining the consent of the previous employer (M. Chhawchharia, personal communication, November 20, 2006).

3.4 The Growth and Benefits of the IT Sector & Outsourcing

3.4.1 The Benefits of the IT Sector in Less Developed Countries

Indian IT companies contribute to their local cities (as well as the country in general) by providing employment and income as well as immaterial benefits such as job satisfaction. India being the world's second highly populated country, human resources are in abundance. There is a significant number of highly qualified and technically skilled English speaking computer professionals who need sophisticated employment opportunities where they can further develop themselves in their profession. India needs to earn a lot of foreign exchange to help invest in its further development purposes. Costs of life are much lower in India than in developed countries. Thus, as a result of lower wages, offshore outsourcing to India offers considerable economical benefits for western companies. In return, Indian IT companies bring foreign exchange in to the country (M. Chhawchharia, personal communication, November 20, 2006).

Much of India's communication facilities have been built and improved as a result of India's growing IT sector, which does business with the rest of the world. These include general telecommunications networks, Internet Service Providers, cellular phone networks, satellite and submarine communication links that facilitate good band connectivity with the rest of the world. Thus Indian companies that are in the software outsourcing market can be in touch with the vendors without any connection hurdles. The role of India's IT sector in India's economic development may be a good example of Walt Whitman Rostow's leading industry argument. One successful industry can cause a chain reaction and simulate other industries as well.

The service sector in India contributes to 51% of the national GDP. Within this sector, computer software exporting is a prominent example with a growth rate of 40%-50% per year during the 1990's. India has become the second largest software exporter in the world; other national sectors that do business with the IT sector are also growing together. As a result of the benefits of the IT sector, India's government is pro-IT, and its policies, tax laws, energy and telecommunications policies, industrial parks, and special zones help the technology related industries. The government supports software firms by providing all of the basic facilities required for an outsourcing company to flourish. Therefore the government also plays a major role in contributing to the success of the IT outsourcing sector in India. IT is regarded as one of the top five priority industries in India. IT is a part of the national agenda, and new policies are framed in order to obtain the maximum benefit out of IT outsourcing to India (NASSCOM, 2006a).

The entry of large foreign IT companies into India through new factories and subsidiaries also helps India's own IT sector. This entry is a result of certain liberalization and deregulation initiatives taken by the government in order to support the integration with the global economy. New policies have also made it favorable for Indians who live abroad (so-called non-resident Indians) to invest in India by founding Overseas Corporate Bodies (OCB's). These include tax incentives for certain firms involved in the offshore IT software outsourcing sector. The IT bill, passed in 2000, provides a legal framework for the recognition of electronic contracts, prevention of computer crimes, and electronic filing of contract documents. NASSCOM, along with the government, plays a notable role in protecting the interests of the IT sector (NASSCOM, 2006a).

Another important point regarding the information technology and outsourcing sector and India's economic development has to do with maintaining and increasing the number of software development professionals. This point is about higher education and sophisticated human capital development. One possible goal is to establish an IIT (Indian Institute of Technology) or an IIIT (Indian Institute of Information Technology) in each state in India. These schools turn out fresh IT graduates or post graduates. They are joint initiatives by the government and the industry, which aim to give both computer software engineering degrees as well as conduct short-term courses. These institutes allow private sector companies to sponsor or affiliate with them. Ideally, this might cause academic programs and syllabi to take into account the constant changes in the actual IT industry and the currently popular software tools and practices (M. Chhawchharia, personal communication, November 20, 2006).

Although the priority is to produce practical software developers, India also needs post graduate and doctoral computer scientists to take part in management, innovation, and research and development. It is also important for other engineering departments to become prepared to utilize computer technology to a full extent by having students take some computer technology related courses. Information technology can significantly enhance productivity in other engineering disciplines as well (M. Chhawchharia, personal communication, November 20, 2006).

The cooperation between different schools and organizations will increase and be more unified over time with the help of the Internet. Of course, students first need to become familiar with computer information technology at the primary and secondary school levels. Therefore primary and secondary schools teachers also need

to be trained accordingly. Managers and professionals in the IT industry also need to retrain themselves as necessary to achieve more at their work and to help the national economy in general. There is competition in the markets for the talented labor (not just between companies in those countries but also from foreign companies that recruit in India and elsewhere. These less developed countries' economies are growing overall across many different sectors. Therefore the future labor force is not really flocking to software development. According to Goolsby (2006), the outsourcing sector accounts for $30 billion out of India's $600-700 billion economy. Therefore, in order to shift human capital toward technology related professions, more universities are needed. This can be done only with the help of private investments into education alongside public schools. The governments are expected to relax certain laws and encourage private contributions to education.

3.4.2 How the Developed Economies Benefit from Outsourcing

The other side that receives benefits from outsourcing is made up of the client companies in western countries, and the economies of these western countries in general. Although there are organizations in other less developed countries lacking their own IT industries that also outsource to foreign companies, most of the clients come from large high-income countries where there is a great demand that surpasses domestic production. Please refer to the Appendix; a graph illustrates the large OECD member countries whose Information and Communication Technology (ICT) imports surpass their ICT exports.

The benefits of outsourcing at the microeconomic level of individual client companies have already been discussed. In short, outsourcing the responsibility and work of software development frees client companies to focus more of their resources toward their core businesses and expanding those companies themselves. It leaves that work in the hands of those who have specialized in it and reduces the companies' costs at the same time. The software i.e. web sites and electronic commerce tools gained through outsourcing helps client companies become more effective in marketing and sales.

The macroeconomic benefits of western economies are very interesting and therefore they are illustrated in detail in the following example (Chandran, 2003). For every dollar spent on offshore outsourcing by the US in 2002, the total value derived by the global economy was approximately **$1.47**. Seventy eight percent of this total value, approximately **$1.14**, was retained in the US. The remaining 22%, **$0.33**, went to offshore destinations such as India. This calculation comes from a report by the San Francisco-based McKinsey Global Institute (as cited in Chandran, 2003). Below is a summary of how the **$1.14** can be broken down.

Every dollar paid for outsourced services resulted in savings of **58 cents** to US investors and consumers. Additionally, it resulted in an increased import of US goods and services by providers in India. For every dollar spent offshore, the offshore software developers go on to buy an additional **5 cents** worth of goods and services from the US economy, thereby creating exports and extra revenues for the US economy. Those developers in the low-wage less developed countries need American computers, telecommunications equipment, other hardware, and software to do their work. In addition, they also buy legal, financial and marketing services from the US.

Some of the foreign companies that provide services to the US are also incorporated in the US. In that case, these companies repatriate their earnings back to the US, which amounts to an additional **4 cents** out of every dollar spent offshore. Finally, the US labor freed due to offshore outsourcing adds another **47 cents** of value to the US economy. US service workers are expected to find employment more quickly than manufacturing workers; and, theoretically, job-displacement will put them in new jobs that the US economy has a greater need for. The total value retained in the US thus adds up to **$1.14**. In this example above, offshore outsourcing creates a net additional value for the US economy worth **14 cents** for every dollar spent offshore.

Then offshore destinations like India capture **33 cents** out of every dollar spent by the US. Out of this, **1 cent** goes to the state government, including sales tax and energy fees. Another **3 cents** go to the central government in the form of income taxes and corporate taxes. The individual employees' salaries comprise **10 cents.** Company profits retained in countries like India are another **10 cents**. The remaining **9 cents** go toward the operational and administrative costs of the IT development companies in countries like India.

3.5 Conclusion

3.5.1 The Internet and its Influence on Outsourcing

The widespread use and availability of the internet has also enabled individuals and small businesses in developed countries to contract companies from all over the world. In less developed countries, such services are offered at a lower cost due to lower wages and property prices. Having another company develop computer software for fewer costs allows companies in developed countries to concentrate their planning efforts and their resources toward their own core businesses. Therefore, they can more efficiently work on developing, producing, marketing, and selling their own products. The results are savings to investors and consumers in the developed countries.

Due to the Internet, outsourcing is not limited to big corporations. The Internet helps to strengthen small client business' capacity to compete with their bigger competitors by taking advantage of services in offshore locations.

3.5.2 Prospects for Client Companies from Developed Countries

The client companies, more and more, see these partnerships as strategic opportunities to innovate and grow rather than just a way to cut their information technology expenditures. According to Goolsby (2006), this is one of the reasons it takes longer now than it used to for companies to make an outsourcing contract with each other. They discuss their deals in much more detail before the project begins.

In 2007, the clients will have even more options as new companies are founded in many different countries around the world. As a result, prices may go down. Another trend for larger client companies is, more and more, to outsource different components of computer information technology to different companies – at the same time – making these companies not only accountable to the client but also to each other (Goolsby, 2006).

According to Bendor-Samuel (2006), there are too many companies in less developed countries that are seeking outsourcing contracts. Even in less developed countries, there is pressure to increase wages and other costs. In this environment, small companies may not be able to thrive. Therefore, mergers between these companies or acquisitions of smaller companies by bigger ones are inevitable. As a result, the bigger companies will continue to offer more standardized software services at convenient costs. In summary, the future prospects in this sector are expected to be favorable for client companies from developed countries.

3.5.3 Empowering Companies in Less-Developed Countries

It is obvious from the various sources reviewed throughout this study that the Internet has created a large market for companies in less developed countries in the computer software development outsourcing sector. The outsourcing sector benefits many different people and entities in less developed countries. These include: (a) local and national governments that collect taxes and utilities fees, (b) the people of those countries who are employed in this sector, and (c) the entrepreneurs in those countries who are owners of such companies.

Even though there are still many client companies in western companies that outsource their work to companies in the same countries as they are, this is likely to change in the future. As communication and collaboration technology continues to improve and become cheaper, it is becoming easy to work on projects with companies outside the borders of one country. Therefore the Internet will continue to help companies in less developed countries by empowering them to reach more clients. There is an additional reason for hope for small and medium companies in the less developed countries. Some clients may rather prefer to work with smaller partners because they may easily be lost in a large company's profile and may not get the same attention and service.

In recent years, there has been an increased interest in Eastern European, Latin American, Chinese, and other countries around the world. Therefore, there is an opportunity in the outsourcing sector for almost every country (Goolsby, 2006). For 2007, the area of World Wide Web services is high on the list of customers' demands. By bringing together client and software companies from all around the world, the Internet acts as a unique form of international economic integration. In summary, this international market that the Internet has created is expected to remain strong and to provide a favorable environment for software companies in less developed countries.

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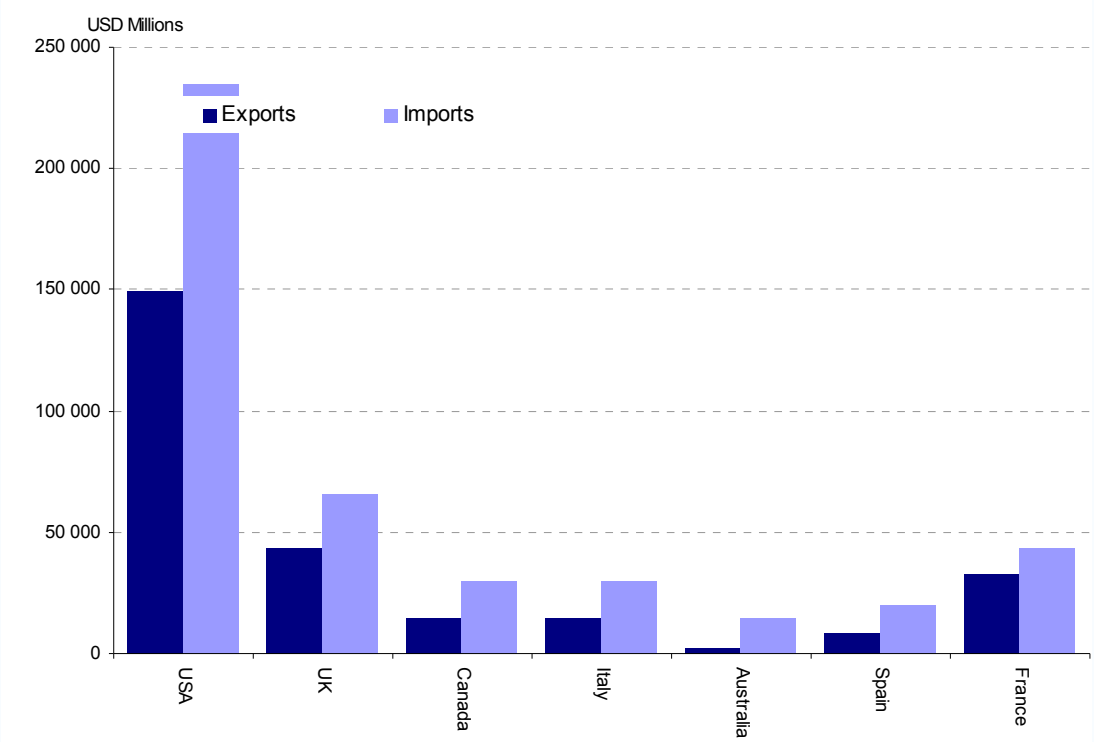
Appendix

Appendix 3.1: Top ten outsourcing countries according to the share of their GDP spent offshore for computer and information services. Note that these are all small countries, including less developed countries (Guyana and Namibia). This leads to the fact that, although large western economies spend high amounts of money in absolute terms, the outsourcing phenomena is not limited to them. Small countries proportionally spend more since they are more likely to lack the computer technology skills within their small labor pool.

Country	**Share of GDP (percent)**
Luxembourg	1.06
Guyana	0.91
Belgium	0.43
Croatia	0.43
Sweden	0.42
Ireland	0.39
Slovenia	0.36
Cape Verde	0.34
Namibia	0.32
Hungary	0.29

Source: IMF, Balance of Payments Statistics Yearbook, 2003. Available online: http://www.imf.org/external/pubs/ft/fandd/2004/12/pdf/amiti.pdf

Appendix 3.2: Trade in ICT, 2004, USD millions. The Organisation for Economic Co-operation and Development (OECD) has data for its member countries on imports and exports of Information and Communication Technology goods and services. The graph below is a subset derived from that data showing only the large OECD countries whose imports surpass their ICT exports.



Source: OECD, Key ICT Indicators, 2004. Available online:

http://www.oecd.org/sti/ICTindicators