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Telecommunications and Economic Development

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Telecommunications and Economic Development

An internship report submitted in partial fulfillment of the requirements for the degree of Master of Science

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ABSTRACT


The thesis examines the relationship between telecommunications development and economic activity of nations. The findings confirm the previously established hypothesis that the causality of the relationship between these two factors exists in both directions. That is, the development of economic activity at any point in time influences the development in telecommunications at a later point in time, and the development in telecommunications at any point in time also influences the economic activity at a later point in time. The major economic principle behind such significant correlation of telecommunications and economic development is that telecommunications helps reduce the transaction cost in different sectors of the economy thereby inducing better efficiency. Also, it influences the economy through the positive effects of network externalities, reduction in information costs, and facilitating the effective and timely coordination among agents. Higher economic growth, on the other hand, places more demand on the existing and newer telecommunications services inducing the development of the sector while the economic growth itself make the necessary investment resources available.

In the present study, a crosssectional regression analysis reveals that the relationship between telecommunications and economic growth is highly significant for both the developed and the developing countries alike. Telecommunications development measured in number of telephone mainlines per hundred inhabitants are found to significantly effect GDP, overall exports, exports of services, and labor productivity measured in real GDP per worker. Many nations are recognizing the increasing importance of telecommunications to economic development. Efforts to reform their telecommunications include deregulation and liberalization strategies to create a suitable environment for the expansion and modernization of the telecommunications system. While substantial progress had been made in this regard, especially in the OECD countries, most of the lesser developed countries (LDCs) are left behind in their effort of modernization and expansion of the telecommunications infrastructure. One possible reason for the under investment in the telecommunications sector in LDCs is that investment in this sector has to compete with other infrastructure - e.g., education, energy, roads and bridges, and other physical infrastructures which are also vital for economic development. In the present study, a cross sectional study of the nations suggests that telecommunications and energy are the most influential infrastructures for economic development.
However, the number of telephones per 100 inhabitants is more influential over per capita energy consumption in spurring economic growth when these two variables are compared for policy implications.

Most state owned telecommunications systems in developing countries will require restructuring in the form of ownership structure to make them suitable for foreign and private capital investments. This study reveals that a scarcity of capital resources in the state owned monopoly is the major impediment in the expansion and modernization of telecommunications infrastructure of the lesser developed nations. Privatization and liberalization may be the strategic choice in this regard.
Acknowledgment

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Chapter One
Introduction

1.1 Background of the study

The importance of telecommunications in the economic development of nations is an undeniable fact. Much research has been published in the past addressing the relationship between the level of economic development and development in telecommunications infrastructure. Policy planners in both the developed as well as developing countries are aware of the strong correlations between these two factors. Therefore, policy planning is being influenced by these factors in varying degrees. However, the cause and effect relationship between these two factors is still ambiguous: whether the growth in the output or GDP causes the increase in demands for telecommunications services and therefore induces the growth of the later factor or the vice versa. While Cronin et. el. (1991), in their analysis of 31 years of U.S. data concluded that the causal effect is in both direction, Norton (1992), in his cross national study differentiating between the developed and developing nations, strongly asserted that growth in the telecommunication sector influences the development in the overall economy. Norton (1992) agrees with Leff (1984) contending that telecommunications, in addition to its all other direct and indirect tangible and intangible positive effects, minimizes the transaction costs that otherwise impede the growth of the economy. Both Norton (1992) and Leff (1984) emphasized the positive externalities caused by the telecommunications. If all the positive effects including the externalities are accounted for, then telecommunications is likely to be
the prime candidate among all infrastructure as a significant catalytic agent for economic development.

Despite the advocacy made in economic literatures, the present trend in the global economy also reflects the importance of telecommunications in the economic development of nations. The world economy evolved from the post war industrial base to an information era in the last decade. The advent of information super highway and knowledge base services have transformed the major economies of the world in a way to concentrate mostly on service industry. Obviously, in such an environment, nations having a modernized telecommunications infrastructure will enjoy a competitive edge. In response to such evolutionary changes in the technology as well as global economy, most developed nations have already restructured their telecommunications sectors through deregulations, privatization, and inducing competitions at different levels of the markets- customer premises, value added networks, long distance services etc. Recognizing the need of the future as well as keeping pace with the global trend, developing countries are also restructuring the telecommunications industry through deregulations, liberalizations, and privatization. Traditionally, the telecommunications sector is a regulated monopoly on the notion that a natural monopoly exists in this industry. However, the evolutionary technological innovations in the last decades leading to wide expansions in the demand for variety of services have severely weakened the monopoly arguments. This is further reinforced by the low cost innovations making better and improved services possible at a much low cost than the past. There is also
a strong arguments from the Chicago School of thought (Capture theory) refuting the justification of regulating natural monopoly. The analysis of the case for developing nations, however, reveals the fact that the changes are mostly driven by the global trend of modernization and expansion of the network rather the nonexistence of the natural monopoly. Though, significant development is noticeable in the OECD and some middle income economies, most of the third world nations are still leapfrogging in their effort to modernize and improve telecommunications infrastructure. Norton (1992) unambiguously articulated that a low telecommunications infrastructure is one reason why some parts of the world have not developed. Leff (1984) provides one possible answer by noting that many policy analysts in developing countries underestimate the positive effects of telecommunications where financing in this sectors needs to compete with other infrastructures like energy, transportation- roads and highways, educations etc.

In the above situation, it is worthwhile to investigate the impacts of telecommunications and improved telephone services on the economic development. Also, it is important to investigate the relative impacts of different infrastructures- telecommunications, Energy, Transportation- Roads and Highways, Educations etc. on economic development of the nations. A review of the present status of the telecommunications infrastructure across the nations along with their strategic policies for modernization and expansion is a timely and relevant effort from the research perspective.
1.2 Objectives of the Present Study

The present study is planned with the following objectives in mind.

a) An empirical study will be made to investigate how do the level of telecommunications development and quality of services impact on the economic development of the OECD economies.

b) A cross national empirical study will address the relative impact of major infrastructures -Telecommunications, Energy, Transportation- Roads and Highways, Educations etc. on the economic development. The main focus is to investigate which sectors play the most influential role.

c) How does the telecommunications sector affect the export of a nations? If the transaction cost minimization effect of telecommunications is true, and if it positively impacts other services like the growth of banking, and if it facilitates global businesses, then it is likely to improve the external trade of a nations.

d) Telecommunications is expected to provide efficient decisions making within the firm by making the information flow more efficient and easier. Also, it helps better and timely decisions by making industry and other external information easily available. So, it is likely to impact positively on the productivity of a nation. A cross national empirical study will be made to investigate the presence of any correlation between productivity and level of development in telecommunications.

e) A detail investigation study will be made through literature survey to study the status of telecommunications networks across the nations in general, in terms of the industry structure and modernization.
f) On the basis of the study and finding, a telecomm. expansion and development strategy will be formulated for the nations in general and developing countries in particular.

1.3 Methodology/ Model

a) Some of the earlier studies investigating the relationship between economic development and telecommunications are provided by Jipp (1963) and Hardy (1980). Hardy (1980) extensively analyzed the effect of telecommunications on economic activity by regressing cross sectional data for GDP per capita on telephone penetration rate (number of mainlines per 100 inhabitants). Similar work is also done by Cronin et. al. (1991).

However, no study is so far reported that incorporates the quality of services as one explanatory variable. Percentage of call matured in a particular year can be used as a proxy for quality of services. As such data is available for OECD nations only, the cross sectional study will be limited to OECD nations only.

So, the model will be:

\[ GDP/\text{Capita} = f(\text{Penetration rate, } \% \text{ of Call matured}) \]

b) Empirical study investigating the relative impact of various infrastructures on economic development was performed by Dholakia (1994) by analyzing data for 50 U.S. states. A similar study incorporating Cobb-Douglas production was carried out by Stone (1991) for cross national study to investigate the relative investment effects of various infrastructures on socioeconomic development measures. In the present model, a multiple regression will be done with education, energy,
telecommunications, transportation as the explanatory variables while GDP per capita is the dependent variable. For energy, per capita Kg equivalent of fuel; for education, percentage literacy rate; for transportation, per capita road length; and for telecommunications, number of mainlines per 100 populations will be used as a proxy variable.

\[
GDP/\text{Capita} = f(\% \text{ literacy rate, Per capita Road length, Per capita Energy consumption, telephone penetration rate})
\]

c) An earlier study examining the relationship between developing country export performance and domestic telecommunications infrastructure is done by Boatman (1992). In the present study, the following model will be used:

\[
\text{Export/Capita} = f(\text{ telephone penetration rate, quality of services, network modernization})
\]

d) No empirical study has been noted by me examining the relationship between telecommunications and productivity, or between telecommunications and foreign direct investment. In the present study, the following two relationship will be examined:

\[
\text{Productivity} = f(\text{ Penetration rate, Quality of service})
\]

\[
\text{Productivity} = f(\text{ penetration rate, per capita energy consumption, per capita investment in machinery, per capita investment in transportation equipment, level of education})
\]
Data to be used

a) For analysis on OECD nations’ performance, OECD (1995, 1993) data will be used.

b) For telephone penetration rate both OECD as well as United Nations data will be used.

c) For all other parameters, Penn World Data base will be used.
Chapter Two

Literature Survey

A substantial body of empirical evidence supports the conviction that there is a strong positive correlation between telecommunications development and economic activity of a nation. That evidence is summarized in a number of places, including Shapiro (1976), Hardy (1980), Saunders et. al. (1983), Cronin et. al. (1991). However, the causal relationship between telecommunications and economic development is not clearly established though a large number of literatures had focused on that aspect as well. Shapiro (1976) is one of the few earliest researchers who had addressed this causality factor in examining the relationship between GDP per capita and telephone density in ten Latin American countries. In Shapiro's findings, causality is observed in both directions. The same finding is advanced in Hardy (1980), Cronin et. al. (1991), DRI/McGraw Hill report (1991). Using time lagged statistical analysis, Hardy (1980) found statistically significant result in both directions, including specifically a strong relationship between the number of telephones per capita in a third world country in one year and the per capita GDP in the following year. Hardy used data from 45 countries for the period 1960-73. He found that both business and residential telephone contributed to that effect. He also

---

1 Does high telecommunications density result from more highly developed economic need, and being able to afford more communications? Is telecommunications investment a stimulus contributing to economic growth, or is it merely a consequence of growth? or is it both?

2 Number of telephone mainlines per 100 inhabitants, also called teledensity or penetration rate.

found that the magnitude of the effect was greater for countries with a lower density of telephones per capita. Hardy also examined the relationship of radios per capita to GDP and was unable to find any statistically significant relationship. Another most recent but extensive research in this regard is done by Cronin et. al. where the relationship between GDP per capita and investments in telecommunication is examined. In their analysis with 31 years of U.S. data (1958-88, inclusive), Cronin et. al. found not only that increases in output or GNP lead to increases in telecommunications investment, but also that the converse is true: increases in telecommunications investment stimulate overall economic growth. This same hypothesis advanced by Cronin et. al. in 1991, is tested by Cronin (1993) at the more localized state and substate level and for two specific sub categories of telecommunications infrastructure investment: central office equipment, and cable and wire. For time series of these two sub categories of telecommunications investment compiled for Pennsylvania and 2 of its counties, the analysis tested two causal hypothesis: 1. The level of economic activity at any point in time is a reliable predictor of the amount of telecommunications investment at a later point in time. 2. The amount of telecommunications investment at any point in time is a reliable predictor of economic activity at a later point in time. The findings at both the state and county level support the conclusion that telecommunications investment affects economic activity and that economic activity can affect telecommunications investment.
Specific analysis on a particular country level is also done by Chen (1985). In his analysis with data from Singapore, it is evident that telecommunications infrastructure depends on a sound economic base for growth and optimal utilization. However, growth in telecommunications facilitates economic development by providing an efficient information system for management, marketing, production, and distribution.

Apart from examining the relationship between telecommunications development and aggregate economic activity such as GDP/GNP per capita, numerous research works have also investigated the effect of telecommunications development on specific economic activities like productivity, export volume, and foreign direct investment. The importance of telecommunications development in productivity improvement is advocated by Antonelli (1993), Cronin et. al. (1993b). According to Antonelli, the availability of an advanced telecommunications infrastructure is essential to provide universal, reliable, high quality, and low cost advanced information and communication services upon which a full array of technological and organizational innovations such as flexible manufacturing system, just-in-time management system, and distributed data networks are based. Telecommunications thus help improve productivity by facilitating the adoption of such later techniques/methods in the production and operation systems. Cronin et. al. (1993b) analyzed 33 years of U.S. data (1959-90, inclusive) employing three measures of aggregate productivity and two statistical tests. Their analysis shows that a causal relationship between telecommunications infrastructure and productivity does exist.
Furthermore, in Cronin et. al. (1993b), analysis relying on a combination of sectoral translog production functions and interindustry economics is employed to measure the magnitude of the effect of telecommunications infrastructure investment on aggregate and sectoral productivity growth rates. They found that the portion of aggregate productivity growth due to improvements in telecommunications productivity and consumption efficiencies was about 25% over the late 1970s to 1991 interval. Finance, transportation, trade, real estate and petroleum refining are among the individual sectors where telecommunications has significantly contributed to productivity growth. Another study by DRI/McGraw Hill\textsuperscript{3} using sophisticated econometric and statistical techniques examined the relationship between telecommunications investment on the one hand and productivity and economic growth on the other. DRI plugged econometric data from the year 1963 to 1982 into an input output matrix and then tried to calculate how much less efficient the economy would be if the use of telecommunications had been frozen at 1963 levels. It concludes that for the 1982 economy, there was $46.5 billion in resource savings (in 1990 dollar) due to increased efficiency in the supply of telecommunications services and equipment; $34.8 billion in net savings resulted from other industries' substitution of telecommunications for other inputs.

The relationship between telecommunications infrastructure and developing country export performance is examined by Boatman (1992). Boatman asserted that a high quality telecommunications system can enhance a country's export performance in at least three ways. First, telecommunications capabilities increase
an exporting firm's ability to receive accurate information about the overseas market which it serves. Second, a good telecommunications system can promote exports by helping to attract exporting multinational corporations and facilitating the global integration of production. Finally, a high quality telecommunications system can promote exports by facilitating entry into non traditional export markets. In Boatman's study, results of OLS regression on aggregate per capita exports suggest that telecommunication plays an important role in explaining developing nations' export performance. The results also suggest that telecommunications quality has a positive influence on incoming direct foreign investment.

Despite its influential effect on the economic development of a nation, telecommunications in most developing nations are not given due priority in the sectoral investment allocations. In most developing nations, telecommunications investments follow that in other infrastructures like transportation, energy, and education. However, the recent trends in technological change, increased demand for information and communication related services, convergence between computers and communications, and global shift to an information era reasonably question the validity of such traditional ranking in infrastructure investment decisions. Such is the argument also advanced by Parker (1992). Though, a large number of literatures address the relationship between economic development and telecommunications assuming the later as the single developmental input, empirical work on the ranking of infrastructures, including telecommunications, with respect to their relative influence on economic development is very few- Stone (1991), and Dholakia (1994).
Stone's analysis purported to 'rank order' the infrastructure investment alternatives on their respective impact level is done with nine country cross sectional time series data. It concludes that telecommunications shows relatively greater importance in those countries with higher level of per capita GNP. Overall in the sample, telecommunications is fourth in relative importance leading to the conclusion that they should not be priority investment alternative for government spending. In sharp contrast to Stones (1991), Dholakia (1994) contended that investment in telecommunications infrastructure can be justified due to the positive impact on economic development. In an econometric analysis with data for 50 U.S. states, Dholakia's findings suggest that the influence of telecommunications is very strong when viewed as the only developmental input as well as when it is compared with other inputs such as education, energy, and physical infrastructure.

Developing nation's underinvestment in telecommunications is also pointed out by Saunders (1983), Norton (1992), and Leff (1984). Saunders' (1983) analysis with cross country data supports the contention that there is significant underinvestment in telecommunications services in less developed countries. Norton (1992), in an analysis with data from 47 countries, contended that a low telecommunications is one reason why some parts of the world have not developed. According to Norton, one possible reason for low investment in telecommunications is the failure of the policy makers to recognize its impact on economic activity. The same argument is also advanced in Leff (1984). Leff specifically pointed out the indirect benefits of telecommunications: reduction in transactions, information, and coordination costs;
spill over effects from positive externalities; consumer surplus; and the shadow prices of the benefits. In project evaluation, all of these benefits are not accounted properly. Leff strongly argued that if all the direct and indirect benefits are counted, the social return on telecommunications will far exceed the present conservative estimate. Leff (1984) also criticized World Bank for its research emphasis on the development of 'Social Benefit Cost Analysis (SBCA)' as a tool for project appraisal by government in developing nations while the bank itself does not use SBCA for its own investment project evaluation. However, World Bank officials recognize that despite the underestimation of the benefits of telecommunications investments, the conservative estimate is still much higher and the non adoption of SBCA tool may have had non neutral allocation consequences.

In the last decade, telecommunications industry have faced dramatic structural changes. Major OECD countries have deregulated their telecommunications industry inducing competitions. In general, deregulation have spurred competitions, and induced telcos to integrate into other related and unrelated industries. The publication of literatures addressing the structural reforms in the developed countries is quite large in volume. Some of those extremely relevant to the present study are mentioned here. Staranczak (1994) in his cross sectional time series econometric analysis with data from OECD countries concluded that private ownership of the network increases productivity while competitions have no significant effect on telecommunications industry productivity. His findings of greater output leading to greater productivity coupled with the non observance of
significant relationship between competition and productivity, support the existence of natural monopoly in telecommunications industry. Post divestiture performance of U.S. telecommunications industry is examined by Noam (1993), Noll (1994), and Majumder (1992) among many others. While Noam’s study shows some improvements in telecommunications productivity, rate structure, and service quality in post divestiture era, Noll argued that the decrease in the long distance rate is due to forward progress of technological innovations coupled with increases in productivity and market demand. Majumder (1992) examined the impact of deregulation on the performance of firms in the U.S. telecommunications service industry. The performance of the top 39 local exchange companies is measured over the period 1981-87 using a multiperiod, multiproduct ratio analysis. The findings indicate that deregulation has a significant effect on different dimensions of firm’s performance in general, and it is also found that individual firms display different pattern of response in each of these dimensions of performance.

Developed and developing nations alike are increasingly recognizing the importance of telecommunications. To modernize the network, developed countries have responded through the deregulation of the industry thereby opening the opportunities for competition. Apart from the developed countries, most developing nations have their telecommunications industry administered as the state owned monopoly until the late 90s. On recognizing the global trend, most developing nations are also formulating strategy to reorganize the industry in order to achieve modernization and induce competitions. Reorganization strategy in the European
countries are discussed in a large volume of literatures published in the "Telecommunication Policy" journal in the last few years. For the sake of brevity, those are not mentioned in the present discussion. However, one extensive work revealing major structural and organizational reforms in France, Germany, and Britain is credited to Pospischil (1993). Reorganizations in other OECD economies - Japan, USA are also discussed in a large volume of publications in "Telecommunications Policy". However, apart from some detailed literatures on how ASEAN countries are responding to the global trend of reorganizations, literatures on the status of other least developed countries are very rare. However, most literatures reveal privatization as the common strategy being adopted by developing nations. No empirical analysis evaluating privatization as the strategic tool is noticed so far. However, Parker (1992), Kok (1992), Thompson (1992) addressed the different pros and cons of privatization as a strategic tool for telecommunications reorganization.

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Chapter Three
Telecommunications and economic development

3.1 Introduction

Nations throughout the world are increasingly recognizing the impact of telecommunications infrastructure development on the economic growth. The scholarly literature specifically addressing the relationship between these two variables generally end up with the conviction that there is a strong positive correlation between telecommunications development and economic growth. As the global economy is shifting from an industrial concentration to information base, the general awareness of the importance of telecommunications and information infrastructure is further mounting up among the nations across the globe. The fundamental reasoning, in this section, is how does the two parameters relate. Improved telecommunications positively affects both the aggregate as well as sectoral productivity and efficiency, reduces the transaction and coordination costs in multinational as well as local business, induces the foreign direct investments and boosts up the export performance of a nation. Additionally, telecommunications

7 See Cronin et. al (1993)
8 See Muller (1993) - A review essay on "The contribution of Telecommunications infrastructure to Aggregate and Sectoral Efficiency, (by DRJ/McGraw Hill)". For the 1982 U.S. economy, there was $46.5 billion in resource savings (in 1990 Dollar) due to increased efficiency in the supply of telecommunications services and equipment; $34.8 billion in net savings resulted from other industries' substitutions of telecommunications for other inputs.
9 See Antonelli (1984)- Empirical analysis between U.S. and 46 nations shows that multinational firms employ international telecommunications to lower coordination costs, and are strong customers of leased lines and telephones.
10 See Boatman (1992).
helps other infrastructures- education\textsuperscript{11}, health and financial services\textsuperscript{12}, government administration\textsuperscript{13} in efficient and smooth operations despite its direct effects of service provisions in today's rapidly growing information industry\textsuperscript{14}. A tremendous growth in the economy, employment, and services is expected in the nearest future with the full scale exploitations of the opportunities offered by the potential reform in the telecommunications sector\textsuperscript{15}.

Numerous research works have been carried out in the past examining the statistical relationships between the measures of telecommunications improvements and that of economic developments. However, only a few literatures\textsuperscript{16} have addressed the fundamental economic principles underlying the very facts of

Cumulative cost savings, from 1963 to 1991, in the U.S. educational service sector due to advances in telecommunications production and education's consumption of telecommunications had reached $76.7 billion in 1991 dollar. Through distance learning program, among its other variety of applications in educational services, telecommunications may efficiently promote a more equitable distribution of educational and informational resources among the relatively resource poor.

\textsuperscript{12} See Clark (1980), and Borg (1989)
Borg (1989) — Immediate communications has created a global financial market in which daily transactions exceed $1 trillion - or about the same as the entire annual budget of the U.S. government. Most of these transactions move electronically across national borders via international computer networks. The October 19, 1987, stock market crash- which reverberated instantaneously in financial markets around the world- confirmed how pervasive these networks have become.

\textsuperscript{13} See Parker (1992).

\textsuperscript{14} See McGovern et. al. (1992)-
Between 50\% and 65\% of all U.S. jobs involve information processing, goods or services. In fact, 90\% of the jobs created during the last decade were information related, which represent nearly 6\% of the gross national products.

\textsuperscript{15} See Williams (1992) -
A recent study completed by WEFA group, a economic forecasting company in Bala Cynwyd, Pa., projects that full and immediate telecom competition would bring an increase of 3.4 million new jobs and a gross domestic product increase-beyond normal growth- of $298 billion of the U.S. by 2005. The GDP would increase from a projected $5.5 trillion during 1995 to $7.3 trillion by 2005, according to the study. This is a compound annual growth rate of 2.9\% over 10-year period. Employment is expected to increase from 134.8 million during 1995 to 138.2 million by 2005 as a result of the immediate reform. In this scenario, not only is manufacturing expected to gain nearly 500,000 new jobs by 2005, but ancillary industries such as retail and construction are expected to add nearly 1.3 million jobs between 1995 and 2005 as increased personal income leads to more consumer spending and investment.

\textsuperscript{16} See Leff (1984), and Norton (1992)
telecommunications' positive effects on the economic activities. Leff (1984), and Norton (1992) have attempted to analyze the effects of telecommunications in terms of the theory of transaction costs, information costs, and externalities.

In this section, an attempt is made to investigate the fundamental principles behind telecommunications and economic development by importing the concept of transaction costs, information costs, and externality in the process of analysis. From the existing literature review, an attempt is also made to develop a generalized economic concept. Also, a general overview of how does telecommunications contribute to business and economic growth will be attempted.

3.2 Transaction costs and Telecommunication

Norton\textsuperscript{17} asserted that if transaction costs are high enough markets for certain

\begin{align*}
P' &= a - bQ \quad \text{(1)}
\end{align*}

\begin{align*}
P &= c + dQ \quad \text{(2)}
\end{align*}

where $Q$ is the quantity demanded or supplied, and $P'$ and $P$ are the prices paid by buyers and received by sellers, respectively.

Transaction costs are presumed to be the equilibrium gap, $G$, between buying and selling prices, or

\begin{equation}
G = P' - P \quad \text{(3)}
\end{equation}

Solving Eq. (1), (2), and (3), the equilibria in the market are

\begin{align*}
Q &= \frac{a - c - G}{b + d} \quad \text{(4)}
\end{align*}

\begin{align*}
P &= \frac{ad + b(c + G)}{b + d} \quad \text{(5)}
\end{align*}

\begin{align*}
P' &= \frac{ad + b(c + G)}{b + d} \quad \text{(6)}
\end{align*}

Two points are relevant. First, the simple comparative statics suggests that output rates are negatively related to transaction costs, or
goods will not exist at all, significant gains from labor specializations will be lost, and the aggregate output of an economy clearly will be lower than that of otherwise comparable economies with lower transaction costs.

According to Norton (1992), the relationship between transaction costs, telecommunications, and macroeconomic growth rests on two facts. First, in many less developed economies, there is lack of rapidly available information, which is costly. Decisions are not made or are made slowly because agents do not know the alternatives. In short, the information markets are relatively inefficient compared to those in the developed world. Second, in addition to their effects in information markets, telecommunications are extremely important to the functioning of products and factor markets. A telecommunications infrastructure reduces transaction costs in numerous markets and leads in turn to high aggregate output.\(^{18}\)

\[
\frac{\delta Q^e}{\delta G} = \frac{1}{b + d} < 0 \tag{7}
\]

thus, the mundane proposition is that output rates are lower as transaction cost rise. Second, it is possible to identify a level of transaction costs, \(G^*\), sufficiently high for autarky to obtain; that is, no viable market (zero output) exists when

\[
G^* > a - c \tag{8}
\]

\(^{18}\) See Parker (1992).

"Telecommunications can provide widespread amplification of human information power and intelligence, just as electrification can provide amplification of human labor power. Therefore telecommunications can be a useful adjunct to all forms of development activity, including the provision of infrastructure that has historically preceded telecommunications. Even in a situation as primitive as the Guatemala highlands, development workers assisting villagers to improve water and sanitation could operate much more efficiently if a portable radio telephone could be used to save weeks of delay when a shortage of one bag of cement stalls well construction, or when tricky terrain or drainage problems
Leff\(^{19}\) has carefully documented the argument that telecommunications lower transaction costs. The particular feature of telecommunications that Leff identifies include: (1) Communication costs are lower, and therefore communications are specially useful in reducing resource allocations decision costs between the urban and rural sectors of the economy; (2) as communication cost fall, the optimal amount of search rises, and thus the quantity and quality of information used expands and marginally better decisions will be made; (3) lower communication costs increase arbitrage opportunities and make financial markets more efficient, which in turn lower capital costs; and (4) lower communication costs lead to more information on the probability distribution of prices and permits the transformation of uncertainty into risk.

Empirical research on transaction costs and telecommunications are not abundant. However, Norton (1992) concluded through empirical investigations that

"All the results are consistent with the hypothesis that telecommunications lower the costs of capital markets and perhaps that the efficiency generated by lower costs is more efficient than the investment ratio per se."

To summarize, some theoretical foundations exist to suggest that transaction costs fall with the advent of telecommunications and some case or historical studies provide corroboration.

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\(^{19}\) See Leff (1984)
3.3 Telecommunications and Externalities

Leff (1984b) pointed out the following external economies associated with the expansion and modernization of a telecommunications network.

1) The expansion of the network leads to the benefits of the lower average cost services to both the existing as well as newly connected users. The lowering of average cost from the expansion of the network can be attributed to the economies of scale and scope.

2) Benefits of telecommunications investment increase exponentially as expansion permits new participants to join the system. A special property of telecommunications investments is that each subscriber's welfare rises with the number of other people who have access to the network and with whom communications can therefore be made.

3) Expansion of the network reduces the information cost and makes information easily available. Wide scale availability of information improves the efficiency in organizational and economic decisions.

4) More information makes the users aware of the contingencies of which they had previously been ignorant.

Parker (1992) argued there is substantial evidence that, when effectively used, the availability of telephones raises the efficiency and accessibility of social services, including health and education, in addition to its substantial contribution to business efficiency.
3.4 Telecommunications' Contribution to Economic Growth: Business Perspectives.

A modern network contributes to economic growth in four ways:

**Business attraction/ Business retention**: A sophisticated low cost telecommunications infrastructure makes information flow efficiently to and from more remote areas and is a factor when information-intensive corporations relocate. The same argument is extended by Boyle when he contends that the quality of telecommunications and mail services are the factors most often mentioned by the decision makers in case of corporate head quarters location or relocation.

**Diversification of Economic Base**: Most economists agree that diversity is the key to growth and stability. The less dependent a local economy is on one particular industry, the more likely it is to withstand cyclical downturns. Enhanced telecommunications services supported by a sophisticated network will allow small businesses/entrepreneurs to compete with large corporations that often have installed sophisticated private networks.

**Enhancement of quality of life / delivery of vital social services**: In many large cities, rush hour grid lock and poorly maintained roadways are all too familiar. In response, some government have implemented commuter and fuel taxes to discourage heavy use of public roads. Others have offered telecommuting as a solution. Without a modern telecom network, however, telecommuting is impossible.

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20 See Mcgovern et. al. (1992)

21 See Boyle (1988)
Increased competitiveness of existing firms: The manufacturing industry, for example, can more efficiently handle product design, inventory control and customer services using an advanced telecom network and computers. Service sector industry can provide more efficient transactions and electronic data interchange through extensive use of improved and advanced telecommunications.

3.5 Reasons for underinvestments in the telecommunications sector of the developing nations.

Despite its significant impact on the economic development, telecommunications in developing nations is characterized by low density, old technology, poor and low quality service standard, and overall, a low investment compared to other infrastructures. One possible reason can be attributed to the failures of the policy makers in recognizing the extent of telecommunications' significant impact on economic activities. In most developing nations where telecommunications is a state owned monopoly, investments in this sector follow that in other infrastructures like Energy, Transportation, Education etc. That made sense when telecommunications equipment was bulky and required both substantial transport to its desired locations and electrical power to operate. Now the miniaturization and reduced power consumption of the electronic components used in computers and telecommunications systems, combined with recent advances in battery and solar power technology, permit a rethinking of that traditional order.

Another factor to be noted is the underestimation of the social benefits contributed

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22 See Parker (1992)
by telecommunications. If all the social benefits such as significant positive externality, reduction in transaction cost, consumer surplus are accurately counted, the social benefits of telecommunications will far exceed its present conservative estimate. Planners in developing countries should immediately be concerned about their ignorance in this regard. World bank, in its effort to accurately measure the social benefits from telecommunications investments, have long been emphasizing on the adoption of "Social Benefit Cost Analysis (SBCA)" as a tool for project analysis. However, it has categorically avoided the use of SBCA tool in its own decision making on project evaluation.

In the followings, an empirical analysis is attempted to examine the effect of telecommunications on the economic activities. In particular, the relative impact of various infrastructures on economic activity is also being addressed.

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23 See Leff (1984)

24 See Leff (1984)
Chapter Four
Empirical Analysis

4.1 Relationship between telecommunications and economic activity

The importance of telecommunications in economic development is also discussed in the previous sections. In this section, an attempt is made to analyze the empirical relationship between telecommunications and economic development through cross sectional study. Generally, GDP per capita is used as a measure of national economic activity. Such normalization of the data by converting it to per capita figure rather than using the total or aggregate values eliminates the effects of cross country variations in absolute sizes. Various measures can be used for quantifying the development in telecommunications; the number of telephone mainlines, investment in telecommunications, level of modernization of the network (percentage of digitalization in the network- both switching and transmission), types of available value added services. However, one of the best measure invariably used by the earlier researchers as well as used in the present study is the telephone penetration rate or teledensity -which is the number of mainlines per 100 inhabitants of a nation. Thus, the measure of telephone mainlines is also normalized as the penetration rate is used. In this section, an empirical investigation between these two variables will focus on the statistical significance of their relationship. Special effort is made to observe the variation in significance from year to year, and among countries in terms of their level of economic development.
The following simple linear regression model is used:

\[ \text{GDP per capita} = f(\text{telephone penetration rate}) \tag{4.1} \]

For OECD nations, the data for the two variables in 1990 and 1992 is presented in table 4.1 below. The relationship between the two variables is also observed through graphical analysis (Scatter Plot).

<table>
<thead>
<tr>
<th>COUNTRIES</th>
<th>PRATE* 90</th>
<th>GDP** 90</th>
<th>PRATE92</th>
<th>GDP92</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>47.1</td>
<td>17282</td>
<td>48.7</td>
<td>16528</td>
</tr>
<tr>
<td>Austria</td>
<td>41.8</td>
<td>20391</td>
<td>43.9</td>
<td>23413</td>
</tr>
<tr>
<td>Belgium</td>
<td>39.3</td>
<td>19303</td>
<td>42.5</td>
<td>21829</td>
</tr>
<tr>
<td>Canada</td>
<td>57.5</td>
<td>21418</td>
<td>59.2</td>
<td>20751</td>
</tr>
<tr>
<td>Denmark</td>
<td>56.6</td>
<td>25478</td>
<td>58.1</td>
<td>27542</td>
</tr>
<tr>
<td>Finland</td>
<td>53.5</td>
<td>27527</td>
<td>54.4</td>
<td>21027</td>
</tr>
<tr>
<td>France</td>
<td>49.8</td>
<td>21105</td>
<td>52.5</td>
<td>23039</td>
</tr>
<tr>
<td>Germany</td>
<td>47.4</td>
<td>23536</td>
<td>43.9</td>
<td>22193</td>
</tr>
<tr>
<td>Greece</td>
<td>38.9</td>
<td>6505</td>
<td>43.6</td>
<td>7568</td>
</tr>
<tr>
<td>Iceland</td>
<td>51.4</td>
<td>22875</td>
<td>53.9</td>
<td>25516</td>
</tr>
<tr>
<td>Ireland</td>
<td>28.1</td>
<td>12131</td>
<td>31.4</td>
<td>13722</td>
</tr>
<tr>
<td>Italy</td>
<td>38.7</td>
<td>18921</td>
<td>41.1</td>
<td>21172</td>
</tr>
<tr>
<td>Japan</td>
<td>44.2</td>
<td>23822</td>
<td>46.4</td>
<td>29513</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>48.1</td>
<td>22895</td>
<td>60.6</td>
<td>31054</td>
</tr>
<tr>
<td>Netherlands</td>
<td>46.4</td>
<td>18676</td>
<td>48.7</td>
<td>21108</td>
</tr>
<tr>
<td>New Zealand</td>
<td>43.6</td>
<td>12656</td>
<td>44.4</td>
<td>12110</td>
</tr>
<tr>
<td>Norway</td>
<td>50.3</td>
<td>24953</td>
<td>52.9</td>
<td>26345</td>
</tr>
<tr>
<td>Portugal</td>
<td>24.1</td>
<td>6085</td>
<td>30.6</td>
<td>8561</td>
</tr>
<tr>
<td>Spain</td>
<td>32.3</td>
<td>12609</td>
<td>40.5</td>
<td>16861</td>
</tr>
<tr>
<td>Sweden</td>
<td>68.3</td>
<td>26652</td>
<td>68.2</td>
<td>28423</td>
</tr>
<tr>
<td>Switzerland</td>
<td>58</td>
<td>33085</td>
<td>60.3</td>
<td>34967</td>
</tr>
<tr>
<td>Turkey</td>
<td>12.2</td>
<td>1896</td>
<td>16.1</td>
<td>2633</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>44.2</td>
<td>16985</td>
<td>45.2</td>
<td>18080</td>
</tr>
<tr>
<td>United States</td>
<td>54.2</td>
<td>21449</td>
<td>56.5</td>
<td>23679</td>
</tr>
</tbody>
</table>

* Prate is number of telephone mainlines per 100 inhabitants
** GDP here stands for GDP per capita in U.S. dollar
Source: OECD Communications Outlook 1993 & 1995
The scatter plot for the two variables—telephone penetration rate and GDP per capita is shown below in fig 4.1a and fig. 4.1b. The scatter plots for both the years show a linear relationship between telephone penetration rate and GDP per capita. So, GDP per capita is regressed on the telephone penetration rate with the data shown in table 4.1 for the OECD countries.

![Scatter plot of telephone penetration rate and GDP per capita in 1990 U.S. dollar for the OECD countries.](image1)

**Fig. 4.1a**

![Scatter plot of penetration rate and GDP per capita in 1992 U.S. dollar for OECD countries](image2)

**Fig. 4.1b**

The causal relationship between these two variables is also examined by reversing the dependent and independent variables in the above mentioned regression.
model. The relevant output from SAS is presented below in table 4.2. As summarized in the table 4.1, GDP per capita at 1990 and 1992 is regressed on the telephone penetration rate of the corresponding years. An R square of 0.7204 for 1990 data and 0.6206 for 1992 data show a strong correlation between the two variables in a sample of 24 countries. In both cases, the intercept term is negative.

Table 4.2
Regression between telephone penetration rate and GDP per Capita (OECD Countries)

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Intercept</th>
<th>Independent Variable</th>
<th>R Square</th>
<th>F Statistics</th>
<th>D F</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP_{90}</td>
<td>-4329.4445*</td>
<td>PRT_{90} 522.4365</td>
<td>.7204</td>
<td>60.272</td>
<td>23</td>
<td>Intercept is negative; but it is insignificant even at 10% level.</td>
</tr>
<tr>
<td>GDP_{92}</td>
<td>-5336.2256</td>
<td>PRT_{92} 547.1827</td>
<td>.6206</td>
<td>38.624</td>
<td>23</td>
<td>Intercept is negative; but it is insignificant even at 10% level.</td>
</tr>
<tr>
<td>GDP_{92}</td>
<td>-2651.1272</td>
<td>PRT_{91} 510.7480</td>
<td>.5874</td>
<td>33.744</td>
<td>23</td>
<td>GDP per capita is regressed on telephone penetration rate with one year lag.</td>
</tr>
<tr>
<td>PRT_{90}</td>
<td>18.059769</td>
<td>GDP_{90} 0.001402</td>
<td>.7204</td>
<td>60.272</td>
<td>23</td>
<td>Telephone penetration rate is regressed on GDP per capita to examine reverse relationship.</td>
</tr>
<tr>
<td>PRT_{91}</td>
<td>19.886825</td>
<td>GDP_{90} 0.001357</td>
<td>.7037</td>
<td>55.628</td>
<td>23</td>
<td>Telephone penetration rate is regressed on one year lagged value of GDP/capita.</td>
</tr>
<tr>
<td>PRT_{92}</td>
<td>23.3861</td>
<td>GDP_{90} 0.001271</td>
<td>.6713</td>
<td>47.972</td>
<td>23</td>
<td>Telephone penetration rate is regressed on two year lagged value of GDP/capita.</td>
</tr>
<tr>
<td>PRT_{92}</td>
<td>23.503525</td>
<td>GDP_{92} 0.001164</td>
<td>.6206</td>
<td>38.624</td>
<td>23</td>
<td>Telephone penetration rate at 1992 is regressed on GDP/capita at 1992.</td>
</tr>
</tbody>
</table>

GDP stands for GDP per capita in U.S. dollar at the current value, PRT means number of mainlines per 100 inhabitants.
*Figures within the parentheses show probability values: Prob > absolute value of T; a probability value less than .05 implies that the parameter is significant at 5% level.
However, the intercept term is insignificant even at a level of significance as high as 10%. On the other hand, the penetration rate as an explanatory variable is highly significant (p=0.0001). The high values of R square and F statistics coupled with the statistical significance of the explanatory variable clearly suggest the existence of correlation between the two variables. For 1990 data, a $1000 GDP per capita is associated with a telephone penetration rate of 1.9 as suggested by the parameter estimate.

To examine the lagged effect of telecommunications development on economic activity, GDP per capita at 1992 is also regressed on telephone penetration rate at 1991. With one year lagged effect of telecommunications development, the model shows an R square of 0.5874 which is comparatively a high value for a cross sectional analysis with a sample size of only 24 observations. The reverse relationship between the two variables is also examined to investigate the causal effect. Telephone penetration rate in each of the year 1990 and 1992 is regressed on GDP per capita of the corresponding year. Penetration rate at 1991 is regressed on one year lag value of GDP per capita at 1990 ($R^2 = 0.7037$), and penetration rate at 1992 is regressed on two year lagged value GDP per capita at 1990 ($R^2 = 0.6713$). As summarized in table 4.1, in all of these cases, the model is significant implying the correlation between GDP per capita and telephone penetration rate. This study also confirms the previous findings$^{25}$ that the effect is in both directions: the development in telecommunications at any one point of time influences the growth.

in economic activity and vice versa.

Apart from emphasizing only one measure of telecommunications such as penetration rate, GDP per capita in 1992 for the OECD countries is also regressed on lagged value of telecommunications investment per capita. The three years average (1989-91) of per capita telecommunications investment is used as the single explanatory variable. The result is summarized at table 4.3. Though the R square is low (.3962), it shows the existence of a relationship specially when the sample size is as low as 24.

Table 4.3
Regression of GDP per capita on telecommunications investments per capita
(For OECD countries only)

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Intercept</th>
<th>Independent Variable</th>
<th>R Square</th>
<th>F Statistics</th>
<th>DF</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP_{92}</td>
<td>9622.19</td>
<td>INV_{8991}</td>
<td>0.3962</td>
<td>16.094</td>
<td>23</td>
<td>INV_{8991} means average per capita investment in three years</td>
</tr>
</tbody>
</table>

Source: data used from OECD communication Outlook 1993 & 1995
* Figures within the parentheses show probability values.

The relationship between GDP per capita and telephone penetration rate is also examined for the non OECD high and middle income countries, low income economies, and combining both OECD as well as non OECD countries. In order to examine the effect of sample size, different sample size is arbitrarily chosen for the present analysis. The output of the regression is summarized in table 4.4. In this regression models, telephone penetration rate is the number of telephones per 100 inhabitants and United Nations statistics is used as a source. GDP per capita is the real GDP per capita at constant (1985) U. S. dollar (RGDPCH), and the data from
Penn World\textsuperscript{26} is used in the analysis.

As is evident from the regression results summarized in table 4.4, the relationship is highly significant for the developed as well as the developing countries. However, it seems to be more effective for the high income economies than the low income economies. For example, R square is 0.7773 and 0.8749 with 1988 and 1989 data respectively for 22 most high income economies\textsuperscript{27} while that for 29 low income economies (RGDPCH < $3000)\textsuperscript{28} with 1990 data is 0.2850. However, when all the countries are taken together regardless of their level of economic development, R square is found surprisingly high specially when the observations are cross sectional. With 1990 data, real GDP per capita is regressed on penetration rate for 74 countries. With an R square of 0.7870, the model as well as the explanatory variable (penetration rate) is found statistically significant even at 1\% level. As the table 4.4 shows, the lagged effect of telecommunications is also significant in influencing the economic activity. With the data from 33 nations, a one year lagged effect of telecommunications gives an R square of 0.7357, while two year lagged effect gives an R square of 0.7147. As mentioned before, there are various measures for quantifying the development in telecommunications. Telephone penetration rate is one such measure for which data across the nation is widely available. The previous

\footnotesize
\textsuperscript{26} Penn World is a large data base for around 250 nations covering almost 700 variables. It is a combination of data compiled by University of Pennsylvania and the World Bank.

\textsuperscript{27} High income economies include most OECD countries excluding Greece, Portugal, and Turkey. Also it includes other non OECD countries like Hong kong, Singapore.

\textsuperscript{28} From the list of countries in the PennWorld database, OECD countries are excluded. Then among the non OECD countries only those having RGDPCH< $3000 is used in the computation.
section examined the relationship between penetration rate and GDP per capita. However, apart from the absolute numbers of telephone per capita, quality of telecommunication services is also likely to be an influential factor in the economic activity of a nation. Quality or performance measures for a telecommunication operator can be quantified by a number of factors: waiting time for connection of new service, number of outstanding connections, number of payphones in the service areas, call failure rates, faults per 100 lines per annum, faults repaired within 24 hours.

In the present study, 'mean completion rate' is used as a proxy for the quality of service, and the following regression model is examined for 24 OECD countries with 1992 data:

\[ GDP \text{ Per Capita} = f(\text{penetration rate, Quality of Services}) \]  \hspace{1cm} (4.2)

The same regression model does not include other countries primarily due to non-availability of data for those countries. Secondly, countries differ extensively in terms of their level of economic development as well as the state-of-art of the network. Also, the non-homogeneity in the measurement methods and techniques leads to inaccurate and incomparable figures for other countries specially in the third world. So, the present analysis is restricted to OECD countries. The regression result is presented in the table 4.5 below.

31 'Mean Completion Rate' is indeed the answer seizure ratio measured by the public telecom operators in each country. It is just the average ratio of the call matured to call seized in the destination country in case of international traffic from originating countries. However, the reasons for failures may be numerous though an aggregate measure is used in computation. It is also important to note that these are unweighted averages and do not distinguish between different operators in the same country. While the application of information technology in networks should enable extremely accurate measurement of call completion ratios the reasons for "failures" are so varied as to make this only a broad measure of performance.
Table 4.4
Regression between RGDPC^30 and telephone penetration rate^31

<table>
<thead>
<tr>
<th>DF</th>
<th>Dependent Variable</th>
<th>Intercept</th>
<th>Independent Variable</th>
<th>R Square</th>
<th>F Statistics</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>73</td>
<td>RGDPC_{90}</td>
<td>1926.6064 (0.0001)*</td>
<td>PRT_{90} 196.1626 (0.0001)</td>
<td>0.7870</td>
<td>270.690</td>
<td>1990 Data. All countries for which data available is covered</td>
</tr>
<tr>
<td>52</td>
<td>RGDPC_{90}</td>
<td>1558.3605 (0.0001)</td>
<td>PRT_{90} 182.1492 (0.0001)</td>
<td>0.7429</td>
<td>148.336</td>
<td>1990 Data. OECD countries are excluded.</td>
</tr>
<tr>
<td>22</td>
<td>RGDPC_{90}</td>
<td>2885.6163 (0.0001)</td>
<td>PRT_{90} 153.5325 (0.0001)</td>
<td>0.6950</td>
<td>51.142</td>
<td>1990 data. Those non OECD countries with RGDPC&gt;3000.</td>
</tr>
<tr>
<td>28</td>
<td>RGDPC_{90}</td>
<td>1289.5468 (0.0001)</td>
<td>PRT_{90} 72.6803 (0.0001)</td>
<td>0.2850</td>
<td>12.159</td>
<td>1990 data. Non OECD countries with RGDPC&lt;3000.</td>
</tr>
<tr>
<td>21</td>
<td>RGDPC_{90}</td>
<td>2444.0703 (0.0009)</td>
<td>PRT_{89} 220.6293 (0.0001)</td>
<td>0.8749</td>
<td>147.858</td>
<td>1989 data. 22 high income economies.</td>
</tr>
<tr>
<td>21</td>
<td>RGDPC_{90}</td>
<td>3170.3854 (0.0008)</td>
<td>PRT_{88} 181.1029 (0.0001)</td>
<td>0.7773</td>
<td>74.304</td>
<td>1988 data. 22 high income economies</td>
</tr>
<tr>
<td>32</td>
<td>RGDPC_{90}</td>
<td>2599.0089 (0.0026)</td>
<td>PRT_{89} 222.786 (0.0001)</td>
<td>0.7357</td>
<td>90.070</td>
<td>1990 Data for RGDPC. Penetration rate is lagged by one year ('89). 33 high income economies.</td>
</tr>
<tr>
<td>32</td>
<td>RGDPC_{90}</td>
<td>2913.5861 (0.0010)</td>
<td>PRT_{88} 198.3464 (0.0001)</td>
<td>0.7147</td>
<td>81.171</td>
<td>penetration rate is lagged by 2 years. 33 high income economies.</td>
</tr>
</tbody>
</table>

*Figures within the parentheses are the 'P' values. A 'P' value of less than 0.05 implies that the parameter is significant at 5% level. 't' values are omitted here for the sake of brevity. However, a 't' value does not imply anything more than what the 'p' value shows.

29 RGDPC is Real GDP per capita in constant U.S. dollar (Penn World Source).

30 United Nations Statistics

34
Table 4.5
Regression of GDP per capita on Penetration rate and Quality of services
(OECD Countries)

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Intercept</th>
<th>Independent Variable</th>
<th>Independent Variable</th>
<th>R Square</th>
<th>F Statistics</th>
<th>DF</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP$_{y2}$</td>
<td>-18909</td>
<td>PRATE$_{y2}$</td>
<td>QSERV$_{y2}$</td>
<td>0.6833</td>
<td>25.812</td>
<td>23</td>
<td>1990 Data is used. Both the explanatory variables are highly significant.</td>
</tr>
<tr>
<td></td>
<td>-2.677</td>
<td>388.3572</td>
<td>361.0063</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0141)</td>
<td>3.673</td>
<td>2.314</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: data used from "OECD Communications Outlook 1995".
' Figures indicate the 't' Statistics.
" Figures indicate the 'p' value reported in the SAS output.

As it is evident from the table 4.5, quality of service is also highly significant at 5% level in explaining the variation of GDP per capita across the nation in addition to the significant effect of telephone penetration rate. An adjusted R square' of 0.6833 along with an F Statistics' of 25.812 indicates that the model is statistically significant for a cross sectional analysis specially when the degrees of freedom is as low as 23. The model is examined for the existence of multicollinearity between the explanatory variables. The 'condition index' available from the SAS output is less than 5 implying the absence of multicollinearity.

From the above discussions with the empirical analysis, it can be clearly concluded that the development in telecommunications is positively correlated with the economic development of a nations. The causal effect is observed in both

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32 See Belsey, Kuh, and Welsch (1980)-

Belsey, kuh, and Welsch have developed a methodology for analyzing whether or not the collinearity that exists between independent variables is harmful. They examined 'Condition Number', the ratio of the largest to the smallest characteristic root of the ($XX^T$) matrix, to identify harmful collinearity. Based on empirical testing, the authors suggest that a condition index of less than 15 indicates that multicollinearity does not present a problem; condition index between 15 and 30 suggest the presence of multicollinearity; Condition index exceeding 30 suggest the presence of harmful collinearity.
directions, and countries regardless of their level of economic development do have their economic activity more or less significantly influenced by the development in telecommunications. In the following sections, the effect of telecommunications on more specific economic factors like productivity, and export of nations is examined through cross country analysis.

4.2 Relationship between productivity and development in telecommunications

The importance of telecommunications in productivity improvement is examined by Cronin et al (1993b), Antonelli 1993) as mentioned in the literature survey. In this section, an attempt is made to investigate the effect of telecommunications development on the overall productivity improvement through cross sectional study. Cronin et al (1993b) investigated the effect of telecommunications investment or infrastructure development on the total factor productivity of the U. S. during the period 1963-91. Their findings confirm the views of the traditional economists (Keynesian approach) on public expenditure as a means of inducing economic growth or productivity. With U.S. time series data for the period 1958 to 1990, Cronin et al (1993b) strongly concluded that the level of US telecommunications investment at any point in time is a reliable predictor ('Cause') of the level of US productivity at a later point in time. As they argued, a theoretical basis for the reverse hypothesis - that the level of US productivity at any point in time is a reliable predictor of the amount of US telecommunications investment at a later point in time- is not apparent. So, the causality is not in both directions in this regard. As the economy is shifting to be more service oriented, telecommunications is playing
increasingly significant role in the aggregate as well as sectoral productivity. Cronin et al (1993b) showed that traditional service sectors are the heavy users of telecommunication services: six of the top eight most telecommunications-intensive\(^{33}\) industries are service oriented—finance and insurance, personal and miscellaneous services, business services, wholesale and retail trade, and transportation and warehousing. Furthermore, the top eight telecommunications-intensive sectors produced 44.1% of total US output in 1987. This is significant as an indicator of the relative degree to which the national economy, in general, depends on telecommunications as an input. The advancement and modernization in the telecommunications network have made the better quality and low cost services easily available. Productivity in telecommunications industry itself have also improved as a result of modernization and advancement in addition to its dramatic effect on the economy in general and other service industries in particular.

While the effect of telecommunications on the aggregate and sectoral productivity was examined by Cronin et al (1993) for U.S. economy, Staranczak (1994) investigated the productivity growth of the telecommunications industry itself by using

\(^{33}\) Telecommunications intensive industries: Industries intensively using telecommunications as an input. Input intensity measures the consumption of an input as a proportion of output. For example, increases in intensity of telecommunications usage by industries reflect a relative increase in telecommunications services as input to their production process. This could be the result of the integration of more advanced telecommunications technologies. The analysis of the industry specific telecommunications intensity provides insight into the importance of telecommunications to individual industries and to sectoral and state wide productivity. Whether an industry is telecommunications intensive or not, an observed high rate of intensity growth reveals that the industry has found better ways to produce its output by using relatively more cost effective telecommunications. From 1965 to 87, telecommunications industry itself had experienced an average annual telecommunications intensity growth rate of 4.36%, other industries having higher average annual telecommunications intensity growth rate are; Crude petroleum mining and refining (8.35%), Mining (7.8%), Stone, Clay and Glass (6.36%), Fabricated materials (6.29%). Finance and insurance, Wholesale and retail trade, Business Services, Transport and Warehousing etc are already a heavy users of telecommunications since 1965 (Source: Cronin et al (1993b).
cross sectional time series data for OECD countries. Staranczak concluded that the output growth is the most important determinant of productivity growth in telecommunications industry confirming the existence of economies of scale and scope. Also, his findings suggest that private ownership increases the productivity. Apart from the research works carried out by Cronin et al (1993b) or, Staranczak (1994) as mentioned here, scholarly publications examining the relationship between aggregate productivity and telecommunications development through cross sectional data analysis is rare. A cross country analysis of productivity as an effect of telecommunications development is attempted here.

In the present analysis, real GDP per worker (RGDPW) in 1985 international price is used as a proxy for the overall labor productivity. Telephone penetration rate is used to quantify the level of telecommunications development across the nations. In order to investigate the relative effect of telecommunications on the aggregate productivity in the presence of other relevant variables, such variables as - energy consumption per capita, per capita investment in transportation equipment, per capita machinery investments, secondary enrollment ratio of the total population (education)

34 are also included in the initial model. These variables are used in the model, while ignoring more other direct and specific variables, considering the fact

34 Percentage literacy rate was initially used as a proxy for the level of education. However, an overview of the data shows that even the most poorest countries have high literacy rate as most third world countries use a lower standard for counting peoples as literate. For example, countries like Bangladesh counts those people as literate who can just sign on their names. Such measurement does not differentiate the countries well in terms of the level of education that can contribute to productivity differences. Consideration of the 'tertiary enrollment ratio' as a proxy will lead to a large number countries having extremely lower value that does not provide a suitable basis for cross country analysis. However, education does definitely effect the productivity of a nation in a technology oriented economy of today's world.
that telecommunications as an infrastructure will have indirect effect on the productivity. Investment in transportation equipment is also likely to have similar effect on productivity. However, investment in machineries is expected to have more direct and pronounced effect as the later will help to replace the inefficient and outdated production process. Energy consumption per capita is likely to have both the direct as well as indirect effects: more per capita energy consumption in Kg. equivalent of oil reflects more usage and involvement of machineries replacing labor; more energy consumption may mean more usage of infrastructures like transportation, and a greater indirect but positive spill over effect of better standard of living due to more energy consumptions. The following regression model is examined using United Nations statistics for telephone penetration rate and Penn World source for other variables.

\[ RGDPW = f( PRATE, PCENGY, PCMINV, PCTRINV, EDULVL) \]  

Where,

\[ RGDPW = \text{Real GDP per worker in 1985 international price.} \]

\[ PRATE = \text{Number of telephones per 100 inhabitants.} \]

\[ PCENGY = \text{Per capita Energy consumption in Kg. Equivalent of oil.} \]

\[ PCMINV = \text{Per Capita Machineries investment in 1985 international price.} \]

\[ PCTRINV = \text{Per capita investment in transportation equipment in 1985 Int't price.} \]

\[ EDULVL = \text{Secondary enrollment ratio.} \]

The relevant regression result from the SAS output is reproduced in the table 4.6.
As mentioned before, all of these variables are used since they are likely to have similar effect on the productivity of a nation. However, as the model A in table 4.6 shows, none of the parameters except per capita energy consumption, and per capita investment in machineries is significant as explanatory variable while the model is highly significant with an adjusted R Square of 0.8625 for a cross country analysis of 33 nations using 1990 data. However, the 'condition index' shows no sign of multicollinearity. Variables like telephone penetration rate, per capita investment in transportation equipment, and education are found most insignificant while per capita energy consumption, and per capita investment in machineries are highly significant. The inclusion of most directly influencing variables may some times cause the indirectly influencing variables to be insignificant. In this particular case, while all other variables are more or less similar in terms of their effect as infrastructures on economic development, investment in machineries are likely to have most direct effect. Investment in machineries may lead to the complete replacement of old and inefficient machineries, replacement of labor by machine, and can thus spur a higher level of productivity. So, in the model B, investment in machineries is dropped. As the per capita investment in machineries’ is dropped from the list of the explanatory variables, telephone penetration rate becomes highly significant (t=3.175, p=0.0036\textsuperscript{35}) while education, and per capita investment in transportation are still highly insignificant.

\textsuperscript{35} P value available from the SAS output indicates the probability that the absolute value of |V| is greater than what is computed here. A 'p' value of less than .05 implies that the parameter is significant at 5% level.
### Table 4.6
Relationship between Productivity, telecommunications, and other infrastructures

<table>
<thead>
<tr>
<th>DF/ MODEL</th>
<th>Dependent Variable</th>
<th>Intercept</th>
<th>Independent Variable</th>
<th>Independent Variable</th>
<th>Independent Variable</th>
<th>Independent Variable</th>
<th>R Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>32/ A</td>
<td>RGDPW</td>
<td>3926.83(\cdot .1040)</td>
<td>PRATE 49.1396(\cdot .5291)</td>
<td>PCENGY 2.4964(\cdot .0020)</td>
<td>EDULVL 7473.6828(\cdot .0616)</td>
<td>PCTRIN V -582.90(\cdot .8911)</td>
<td>0.8625</td>
</tr>
<tr>
<td>32/B</td>
<td>RGDPW</td>
<td>4167.67(\cdot .0993)</td>
<td>PRATE 162.204(\cdot .0036)</td>
<td>PCENGY 2.6312(\cdot .0018)</td>
<td>EDULVL 35.9642(\cdot .4872)</td>
<td>PCTRIN V -463.6857(\cdot .9172)</td>
<td>.8487</td>
</tr>
<tr>
<td>45/C</td>
<td>RGDPW</td>
<td>5902.89(\cdot .0001)</td>
<td>PRATE 86.6442(\cdot .0627)</td>
<td>PCENGY 2.6564(\cdot .0001)</td>
<td>PCMINV 6239.54(\cdot .0169)</td>
<td></td>
<td>.8681</td>
</tr>
<tr>
<td>32/D</td>
<td>RGDPW</td>
<td>7665.74(\cdot .0001)</td>
<td>PRATE 389.395(\cdot .0001)</td>
<td></td>
<td></td>
<td>Comment 1990 Real GDP per worker is regressed on 1990 telephone penetration rate. Sample Size =33</td>
<td>.6766</td>
</tr>
<tr>
<td>32/E</td>
<td>RGDPW</td>
<td>7721.67(\cdot .0001)</td>
<td>PRATE 414.039(\cdot .001)</td>
<td></td>
<td></td>
<td>Comment 1990 RGDPW is regressed on 1989(LAGGED) telephone penetration rate. Sample Size =33</td>
<td>.6987</td>
</tr>
<tr>
<td>21/F</td>
<td>RGDPW</td>
<td>7177.25(\cdot .0001)</td>
<td>PRATE 388.9344(\cdot .0001)</td>
<td></td>
<td></td>
<td>Comment 1990 RGDPW is regressed on 1990 telephone penetration rate. Sample Size = 22 OECD countries</td>
<td>.7715</td>
</tr>
<tr>
<td>21/G</td>
<td>RGDPW</td>
<td>7298.24(\cdot .0001)</td>
<td>PRATE 417.366(\cdot .0001)</td>
<td></td>
<td></td>
<td>Comment 1990 RGDPW is regressed on 1989(LAGGED) telephone penetration rate. Sample Size = 22 OECD countries</td>
<td>.8032</td>
</tr>
</tbody>
</table>

Source: Penn world database; United Nations Statistics (telephone penetration rate)

Figures within the parentheses are the ‘p’ values. A ‘p’ value of less than 0.05 implies that the parameter is significant at 5% level.

One important observation is that the decline in R square is very much insignificant with the drop of the 'machinery investment' variable. Since, 'Education', and 'per capita investment in transportation equipment' is highly insignificant, they are dropped from the list of explanatory variables, and in the model C, only three explanatory variables—telephone penetration rate, per capita energy consumption, and per capita machinery investment are used with data from 46 nations in the year 1990.
1990. Surprisingly, in model C, telephone penetration is significant with 10% level (p=0.0627) while the other two variables are also highly significant. With 'telephone penetration rate' as the single explanatory variable, the model is still significant. However, for the developed countries (OECD), the model is more significant as reflected by the high value of R square in model F and G compared to that in model D and E. One important observation is that for 22 OECD nations (model G), a one year lagged (1989) value of telephone penetration rate explains 80.32% variations in the real GDP per worker (Productivity) in 1990. Clearly, the relationship between productivity and development in telecommunications is established.

4.3 Relationship between telecommunications and exports

As mentioned in the previous chapter on literature survey, relationship between telecommunications and exports performance was examined by Boatman 1992). Boatman, in his study of the developing countries' export performance, contended that the level of telecommunications development has significant effects on the export performance of the developing nations. Similar arguments were also advanced by Bishop et al (1995). In a general discussion on the importance of telecommunications in economic development, Bishop et al strongly asserted that both the quantity (lines per population) and the quality of telecommunications are critical for generating exports and attracting foreign investment. Exports of products characterized by seasonal demands (e.g., apparel) and requiring close contact with customers (e.g., auto parts) are particularly reliant on good communications. Boatman
(1992) contended that a high quality telecommunications system can enhance a country's export performance in at least three ways. First, telecommunications capabilities increase an exporting firm's ability to receive accurate information about the overseas market which it serves. Second, a good telecommunications system can promote exports by helping to attract exporting multinational corporations and facilitating the global integration of production. Finally, a high quality telecommunications system can promote exports by facilitating entry into non traditional exports markets.

In the basic formulation of his model, Boatman (1992) used export per capita as the dependent variable while the development in telecommunications along with other internal variables such as population and GDP per capita are included as the explanatory variables. In Boatman's model, both the quality as well as quantity of telecommunications services are accounted. Density\textsuperscript{36} and ESS\textsuperscript{37} are the two measurements of telecommunications services used in his model. As the previous sections of this study show, there exists a strong positive correlation between GDP per capita and telecommunication density. So, Boatman's basic approach incorporating both 'GDP per capita' and 'density' as the independent variables are likely to result in severe multicollinearity. Indeed Boatman noticed the presence of harmful multicollinearity in a sample of industrialized countries though he argues in favor of

\textsuperscript{36} Same as the penetration rate - number of telephones per 100 inhabitants. Boatman used the term 'density' instead of the term 'penetration rate' used in the present study.

\textsuperscript{37} ESS is a quality variable. It measures the number of access lines which use solid state switching devices and computer-like operations to complete calls. ESS switching is somewhat more sophisticated than EMSS (Electromechanical) switching; it allows more rapid call completion.
its absence from the sample of developing countries\textsuperscript{38}. In the present study, GDP per capita is excluded as an explanatory variable to avoid the effect of multicollinearity as well as to distinctly notice the influence of telecommunications on export performance. An inclusion of large number of variables may raise the value of $R^2$ making the model highly significant while blurring the effect of variables under examination. For instance, Boatman included ‘population’ as an explanatory variables in examining the relationship between export performance and telecommunications. As the principal objective of the present study is to investigate the relationship between telecommunications and export performance, population is excluded from the present model unlike Boatman’s formulation. In the present study, the following regression model (4.4) is used primarily for the highly developed OECD economies. These countries are more or less similar in their adaptation with advanced technology; atleast the wide diversity in the state-of-the-art of telecommunication technology among the developing countries are eliminated with the choice of such sample.

$$EXPCA = f(\ PRATE,\ QSERV,\ MDRN)$$

(4.4)

Where,

$EXPCA \ = \ \text{Export per capita in 1990 current dollar}.$

$PRATE \ = \ \text{Telephone penetration rate- number of mainlines per 100 inhabitants}.$

\textsuperscript{38} In the sample for industrialized countries, Boatman observed a 'Condition number' of 226 and 257 with data for 1985 and 1986 respectively. For developing countries, however, the 'condition number' is 10.42 at year 1985 and 11.56 at year 1986. As mentioned in footnote 8, a condition number between 15 to 30 shows sign of multicollinearity while above 30 warns against the presence of harmful multicollinearity.
\[ QSERV = \text{Quality of services}; \]
\[ \text{measured as the percentage mean completion rate}^{39}. \]

\[ MDRN = \text{State of network modernization}; \]
\[ \text{measured as the percentage of mainlines using digital switching}. \]

For 24 OECD countries, the regression model 4.4 is tested with 1990 data. Data for telecommunications related variables are taken from OECD sources (OECD Communications Outlook 1995) and for export variables, PennWorld database is used. The SAS output of the multiple regression model is presented in table 4.7. Out of the 24 OECD countries, 18 were used in computation in the regression model as six countries have missing values. With such a smaller sample size especially in cross sectional analysis, it is hardly possible to observe a high value of R square. However, in order to explore the influence of telecommunications on different categories of exports, the dependent variable is chosen at 10 different categories depending on the availability of data nations in aggregate.

As the quality of services and state of network modernization is found insignificant in all of the models discussed in table 4.7, and as the reliable measures for these two variables are not widely available across the nation besides their great variation along a large continuum, these two variables are dropped from the list of explanatory variables in the analysis with a large sample of countries regardless of their level of economic development. The model is observed more meaningful for the exports of merchandise, non food primary products, machinery, goods and services while for the export categories such as primary products, fuel, food,

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39 See footnote 7
minerals the relationship is the weakest and most meaningless.

Table 4.7
Relationship between telecommunications and export performance
(OECD countries only -1990)

<table>
<thead>
<tr>
<th>DF</th>
<th>Dependent Variable</th>
<th>Intercept</th>
<th>PRATE</th>
<th>QSERV</th>
<th>MDRN</th>
<th>R Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>Per capita merchandise exports</td>
<td>-224194</td>
<td>120743</td>
<td>-11543</td>
<td>-5244.278</td>
<td>0.2533</td>
</tr>
<tr>
<td></td>
<td></td>
<td>t = -0.068</td>
<td>t = 2.441</td>
<td>t = -0.344</td>
<td>t = -0.155</td>
<td>p = 0.9467</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p = 0.9467</td>
<td>p = 0.0285</td>
<td>p = 0.7359</td>
<td>p = 0.8793</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Per capita exports of non food primary products</td>
<td>-465113</td>
<td>16943</td>
<td>1551.4983</td>
<td>2002.5643</td>
<td>0.3232</td>
</tr>
<tr>
<td></td>
<td></td>
<td>t = -1.273</td>
<td>t = 3.088</td>
<td>t = 0.417</td>
<td>t = 0.532</td>
<td>p = 0.2236</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p = 0.2236</td>
<td>p = 0.0080</td>
<td>p = 0.6832</td>
<td>p = 0.6028</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Per capita exports of machinery</td>
<td>446798</td>
<td>33186</td>
<td>-12854</td>
<td>-5498.391</td>
<td>0.2811</td>
</tr>
<tr>
<td></td>
<td></td>
<td>t = 0.407</td>
<td>t = 2.011</td>
<td>t = -1.148</td>
<td>t = -0.486</td>
<td>p = 0.6903</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p = 0.6903</td>
<td>p = 0.0640</td>
<td>p = 0.2701</td>
<td>p = 0.6344</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Per capita exports of goods and services</td>
<td>-1217245</td>
<td>204754</td>
<td>-2254.1380</td>
<td>-22578</td>
<td>0.238517</td>
</tr>
<tr>
<td></td>
<td></td>
<td>t = -0.224</td>
<td>t = 2.513</td>
<td>t = -0.041</td>
<td>t = -0.404</td>
<td>p = 0.1997</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p = 0.8256</td>
<td>p = 0.0248</td>
<td>p = 0.9680</td>
<td>p = 0.6921</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Per capita exports of primary products</td>
<td>-1178733</td>
<td>42644</td>
<td>4806.5132</td>
<td>16050</td>
<td>-0.0618</td>
</tr>
<tr>
<td></td>
<td></td>
<td>t = -0.496</td>
<td>t = 1.195</td>
<td>t = 0.199</td>
<td>t = 0.656</td>
<td>p = 0.6903</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p = 0.6274</td>
<td>p = 0.2520</td>
<td>p = 0.8455</td>
<td>p = 0.5224</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Per capita exports of fuel</td>
<td>264484</td>
<td>7762.0101</td>
<td>-7073.894</td>
<td>-969.2703</td>
<td>-0.1478</td>
</tr>
<tr>
<td></td>
<td></td>
<td>t = 0.202</td>
<td>t = 0.395</td>
<td>t = -0.530</td>
<td>t = -0.072</td>
<td>p = 0.1997</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p = 0.8428</td>
<td>p = 0.6990</td>
<td>p = 0.6042</td>
<td>p = 0.9437</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Per capita exports of non fuel primary products</td>
<td>-1443216</td>
<td>34882</td>
<td>11880</td>
<td>17019</td>
<td>-0.0499</td>
</tr>
<tr>
<td></td>
<td></td>
<td>t = -0.777</td>
<td>t = 1.250</td>
<td>t = 0.628</td>
<td>t = -0.890</td>
<td>p = 0.4501</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p = 0.4501</td>
<td>p = 0.2318</td>
<td>p = 0.5404</td>
<td>p = 0.3887</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Per capita exports of food</td>
<td>-978103</td>
<td>17939</td>
<td>10329</td>
<td>15016</td>
<td>-0.1213</td>
</tr>
<tr>
<td></td>
<td></td>
<td>t = -0.576</td>
<td>t = 0.703</td>
<td>t = 0.597</td>
<td>t = 0.859</td>
<td>p = 0.5736</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p = 0.5736</td>
<td>p = 0.4933</td>
<td>p = 0.5600</td>
<td>p = 0.4048</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Per capita exports of metal minerals</td>
<td>-248500</td>
<td>9162.8124</td>
<td>1071.7939</td>
<td>515.0773</td>
<td>0.0998</td>
</tr>
<tr>
<td></td>
<td></td>
<td>t = -0.853</td>
<td>t = 2.094</td>
<td>t = 0.361</td>
<td>t = 0.172</td>
<td>p = 0.4080</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p = 0.4080</td>
<td>p = 0.0550</td>
<td>p = 0.7235</td>
<td>p = 0.8661</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Per capita exports of manufactures</td>
<td>954537</td>
<td>78099</td>
<td>-16349</td>
<td>-21294</td>
<td>0.1472</td>
</tr>
<tr>
<td></td>
<td></td>
<td>t = 0.327</td>
<td>t = 1.782</td>
<td>t = -0.550</td>
<td>t = -0.709</td>
<td>p = 0.7484</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p = 0.0965</td>
<td>p = 0.5911</td>
<td>p = 0.4902</td>
<td>p = 0.4902</td>
<td></td>
</tr>
</tbody>
</table>

Source: Telecomunications related data from OECD: "OECD Communications Outlook 1995"
Export related data from Penn world source. A 'p' value of less than 0.05 implies that the parameter is significant at 5% level.
Clearly, those advanced manufacturing and services that need extensive use of telecommunications in their production and operations are most consistently influenced by the telecommunications. For some of the export categories, R square is observed too low and even negative. In all of these cases (4 models have negative R square), none of the parameters is significant. However, for those models that exhibit a comparatively high value of R square, in the range of 0.24 to 0.32, the only explanatory variable that is significant at 5% level is the telephone penetration rate while the 'quality of service', and 'state of network modernization' are found statistically insignificant. The two explanatory variables- 'quality of services' and 'state of network modernization' are likely to have a strong correlation between them as it is expected that the extent of network modernization reduces the frequency of fault occurrence and thereby improves the quality of services. In the multiple regression models presented in the table 4.7, collinearity diagnosis reveals the highest 'condition number' to be 13.1371 for modernization variable followed by 5.20668 for quality of services. As mentioned before, such condition number does not suggest the existence of multicollinearity.

If the fact of smaller sample size for cross country analysis is considered, then the present findings on the OECD countries certainly signals the positive effect of telecommunications on at least some categories of exports. The preliminary analysis on OECD economies have paved the way for further extensive analysis on the world. Also, in the analysis that follows, only the exports of manufacturing and services that is greatly influenced by telecommunications is considered. So, the
following simple linear regression model is examined using the cross sectional data as a further endeavor to explore the relationship between telecommunications and export performance.

\[ EXPCA = f (PRATE, DUMMY) \quad (4.5) \]

The variables bear the same meaning as it do in case of equation 4.4. However, a dummy variable is included here to identify if there is any difference in effect depending on the level of economic development of the nations. With the inclusion of the dummy variable, the world nations are divided into three groups depending on whether the real GDP per capita is greater than $10000, less than $1000, and in between $1000 to $10000. The SAS output of the regression model (4.5) is presented in the following table 4.8.

As it is observed from the table 4.8, all the models exhibit both the intercept term and dummy variable being highly insignificant. However, almost all the models exhibit a comparatively high value of R square with the telephone penetration rate being statistically significant in all cases. This finding confirms the hypothesis that the telecommunications system influences the export performance of services, and manufacturing. It is also noted that telecommunications have more significant effect on the export of services (model D, \( R^2 = 0.5618 \), df = 72) than on that of manufacturing (model H, \( R^2 = 0.40 \), df = 69) or, both goods and services in aggregate (model F, \( R^2 = 0.5045 \), df = 69). This is, however, not inconsistent with the belief that as an economy prospers, there are proportionately more generation and usage of services than manufacturing. As telecommunication induces economic
growth and development, more generation and exports of services are likely to be associated with the higher level of telecommunications development

Table 4.8
Relationship between telecommunications and export performance

<table>
<thead>
<tr>
<th>DF/Model</th>
<th>Dependent Variable</th>
<th>Intercept</th>
<th>PRATE</th>
<th>DUMMY</th>
<th>R Square</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>94/A</td>
<td>Per capita exports of services</td>
<td>58356</td>
<td>38937</td>
<td>-31535</td>
<td>0.5563</td>
<td>All countries with 1988 data available</td>
</tr>
<tr>
<td>72/B</td>
<td>Per capita exports of services</td>
<td>98542</td>
<td>42757</td>
<td>-53278</td>
<td>0.4869</td>
<td>All countries with 1989 data available</td>
</tr>
<tr>
<td>72/C</td>
<td>Per capita exports of services</td>
<td>-305930</td>
<td>51535</td>
<td>149016</td>
<td>0.5566</td>
<td>All countries with 1990 data available</td>
</tr>
<tr>
<td>72/D</td>
<td>Per capita exports of services</td>
<td>-116759</td>
<td>50697</td>
<td>-31535</td>
<td>0.5618</td>
<td>All countries with 1990 data available</td>
</tr>
<tr>
<td>70/E</td>
<td>Per capita exports of goods and services</td>
<td>-3577.14</td>
<td>151910</td>
<td>-195881</td>
<td>0.4995</td>
<td>All countries with 1990 data available</td>
</tr>
<tr>
<td>69/F</td>
<td>Per capita exports of goods and services</td>
<td>-155235</td>
<td>150986</td>
<td>149016</td>
<td>0.5045</td>
<td>All countries with 1990 data available</td>
</tr>
<tr>
<td>70/G</td>
<td>Per capita exports of manufacturing</td>
<td>-34869</td>
<td>56082</td>
<td>-68438</td>
<td>0.3940</td>
<td>All countries with 1990 data available</td>
</tr>
<tr>
<td>69/H</td>
<td>Per capita exports of manufacturing</td>
<td>-84027</td>
<td>55687</td>
<td>146239</td>
<td>0.40</td>
<td>All countries with 1990 data available</td>
</tr>
<tr>
<td>32/I</td>
<td>Per capita exports of goods and services</td>
<td>-421319</td>
<td>141130</td>
<td>149016</td>
<td>0.2779</td>
<td>Low income countries with 1990 data available</td>
</tr>
<tr>
<td>32/J</td>
<td>Per capita exports of manufacturing</td>
<td>208398</td>
<td>50788</td>
<td>146239</td>
<td>0.1692</td>
<td>Low income countries with 1990 data available</td>
</tr>
<tr>
<td>21/K</td>
<td>Per capita exports of goods and services</td>
<td>-112847</td>
<td>146239</td>
<td>149016</td>
<td>0.6492</td>
<td>High income countries with 1990 data available</td>
</tr>
<tr>
<td>21/L</td>
<td>Per capita exports of manufacturing</td>
<td>-195209</td>
<td>57456</td>
<td>149016</td>
<td>0.5458</td>
<td>High income countries with 1990 data available</td>
</tr>
</tbody>
</table>

Source: PennWorld data is used for export variables; telephone penetration rate variable is collected from United Nations.
'a p' value of < 0.05 implies that the parameter is significant at 5% level.
Also, a high quality telecommunications system directly provides a competitive advantage in the export and operation of such services as banking, finance, tourism, and airlines etc. The insignificance of the dummy variable implies that the level of economic development of nations have no influence in the relationship. Quite contrary to that, separate regressions on 33 low income (Model - I and Model - J) and 22 high income (model - K and model - L) economies exhibit the different R² implying that the effect is more pronounced and influential in case of the high income economies. The reason may be analyzed in terms of the fact that in models (A,B,C,E,G) that include the dummy variable, countries are differentiated into three groups depending on their level of economic development measured by GDP per capita. So, all the countries including middle income economies are considered in computation which is directly in contrast with individual models for high income and low income economies that consider only the extremes of the continuum of economies ignoring the middle income countries. However, the present study confirms the positive influence of telecommunications on the export performance in general and exports of services and manufacturing in particular.

4.4 Relative impact of telecommunications on economic development

Empirical analyses in the previous sections have extended support to the earlier research works by confirming that telecommunications have significant influence on the developed as well as the developing economies. Also, some of the research works including the present study have clearly established the both way causal effect

between telecommunications and economic development. It is no denying a fact that as the national economies are becoming more and more globally integrated, as the economy is becoming more service oriented, as the convergence between computer and telecommunications happens more faster and extensively, telecommunications will essentially play an increasingly greater role in the economy of the nations as well as the world. Despite its tremendous growth opportunities and significant influence on the economic development, telecommunications sector in most developing countries is still characterized by older technology, low investment, poor performance, and dilapidated condition of the crumbling network. In a globally integrated information system of today's world, such a state of telecommunications systems particularly in the developing world is a matter of great concern for the policy makers there and international business players in the global market. As mentioned in the literature review section, Developing nation's underinvestment in telecommunications is illuminated in the analysis of Saunders (1983), Norton (1984), and Leff (1984). According to Norton (1984), one possible reason for low investment in telecommunications is the failure of the policy makers to recognize its impact on economic activity. In fact, in developing countries, other sectors (energy, physical infrastructure, education) can also make strong claims in investment resource allocation as they are also crucial for economic development. This situation points to a basic problem for development planners: how to allocate scarce resources between attractive competing projects which, together, more than exhaust the available investment budget. In other words, it warrants an analysis of the relative impact of
various infrastructures (energy, telecommunications, education, physical infrastructure- transportation, roads) on the economic development of the nations.

An earlier work in this regard is carried out by Stone (1991). Stone (1991) relates International Monetary Fund and United Nations data on fixed capital formation, telecommunications investments and government finance spending in public services, education, health care, social welfare and economic services to a selection of commonly used socioeconomic development measures. An expansion of the Cobb Douglas input/output function was used to regress the investment alternatives on eight measures of development. With nine country cross sectional time series data, Stone (1991) attempted to 'rank order' the investment alternatives on their respective impact level (importance) as measured by the standardized regression coefficients. Stone concluded that telecommunications shows relatively greater importance in those countries with higher level of per capita GNP. Overall in the sample telecommunications is fourth in relative importance leading to the conclusion that they should not be a priority investment alternative for government spending.

Another recent work done in this regard is credited to Dholakia et al (1994) where they examined the relationship between economic development and competing inputs. The competing inputs used in the said comparative analysis include physical infrastructure such as roads and bridges, human capital through education, energy, and telecommunications. Using statistical data for 50 states of the USA, econometric analysis suggest that the influence of telecommunications is very strong when viewed as the single developmental input as well as when it is compared
with other inputs such as education, energy, and physical infrastructure. The multiple regression analysis provides a comparative perspective on resource inputs. Their analysis also suggests that it is not a question of simple trade-offs between investment in one input with that of another. Instead, investment has to be made in multiple inputs including education, telecommunications and physical infrastructure.

Apart from the work done by Stone (1991), and Dholakia et al (1994), no other empirical study addressing the comparative analysis of the investment alternatives including telecommunications is noticed by the present author. While Stone's (1991) work examined only a sample of nine countries with time series cross sectional data, Dholakia et al (1994) kept their analysis limited to the 50 U.S. states. In the present study, an attempt is made to analyze the relative importance of the competing infrastructure investment alternatives on the economic development across the nations. As the countries included are not homogeneous at the state of economic development, no time series cross sectional data is used. Instead, cross sectional data across the nation is used in the present analysis considering all the nations together as well as dropping the most highly developed OECD nations from the rest. The selection of the respective nation is primarily dependent upon the availability data, for all the variables under examination, from the PennWorld, OECD, United Nations sources. Likewise the regression models examined in the previous sections, real GDP per capita is used as the dependent variable as a measure for the economic development of the nations. The following regression model is used to examine the relative impact of the most competing infrastructure investment alternatives.
\[ RGDPCH = f \left( PRATE, ENERGY, ROADS, EDUCATION \right) \]  \hspace{1cm} (4.6)

Where,

\[ RGDPCH = \text{Real GDP per Capita in constant dollar} \]

\[ PRATE = \text{Telephone penetration rate : Number of mainlines per 100 population.} \]

\[ ENERGY = \text{Per capita consumption of energy measured in Kg. equivalent of oil.} \]

\[ EDUCATION = \text{Level of education , measured as literacy rate, or secondary enrollment as \% of total .} \]

\[ ROADS = \text{Physical infrastructure, measured as the per capita road length, Per capita investment in transportation equipment.} \]

Countries differ widely in terms of their level of economic development measured in real GDP. Also, there are wide scale variations among the countries in terms of other variables. In cross sectional analysis when observations have such wide variations, it is most likely to result in error from heteroskedasticity. However, as the variables are normalized by transforming into per capita value, the chance from heteroskedastic error is greatly reduced. All parameters are therefore stated as per capita value instead of their absolute figures. Also, except the dependent variable- real GDP per capita, all other parameters are in non dollar physical units. That eliminates the chances of imperfection in measurements caused by the error in valuation of input variables specially when cross country analysis is made. All other parameters except telephone penetration rate are measured in per capita while the later is the number of telephones per 100 population. This may appear inconsistent specially when comparing the relative impact on the dependent variable in terms of the
parameter estimates. However, conventionally telecommunications is measured as the number of mainlines per 100 population while all other parameters are in per person. So, from the investment decision perspective, such comparison will not make irrational choice. The multiple regression model (4.6) is presented in table 4.9.

In table 4.9, seven multiple regression results are shown with cross sectional data for the individual year 1990, 1989, 1988, and 1987. SAMPLES size or degrees of freedom among models differ as the data for all the variables in each year are not available.

Table 4.9
Relationship between Economic activity and infrastructures development including telecommunications

<table>
<thead>
<tr>
<th>DF/Model</th>
<th>Dependent Variable</th>
<th>Intercept</th>
<th>PRATE</th>
<th>ENERGY</th>
<th>ROADS</th>
<th>EDUCATION</th>
<th>R²</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>57/A</td>
<td>RGDPCH</td>
<td>191.8186</td>
<td>66.0719</td>
<td>2.4116</td>
<td>45.2114</td>
<td>10.055*</td>
<td>0.9116</td>
<td>1990 Data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p=0.4803*</td>
<td>p=0.0038</td>
<td>p=0.001</td>
<td>p=.1797</td>
<td>p= 0.0455</td>
<td></td>
<td></td>
</tr>
<tr>
<td>38/B</td>
<td>RGDPCH</td>
<td>115.5055</td>
<td>66.1118</td>
<td>2.235106</td>
<td>50.1292</td>
<td>11.063275*</td>
<td>0.9198</td>
<td>1990 Data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p=0.7963</td>
<td>p=0.0026</td>
<td>p=0.001</td>
<td>p=2.744</td>
<td>p=0.1508</td>
<td></td>
<td></td>
</tr>
<tr>
<td>45/C</td>
<td>RGDPCH</td>
<td>985.68117</td>
<td>86.9992</td>
<td>1.4865</td>
<td>-25.829</td>
<td>13.7937*</td>
<td>0.9556</td>
<td>1990 Data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p=0.0243</td>
<td>p=0.0001</td>
<td>p=0.0001</td>
<td>p=0.447</td>
<td>p=0.1557</td>
<td></td>
<td></td>
</tr>
<tr>
<td>45/D</td>
<td>RGDPCH</td>
<td>1741.945</td>
<td>93.3812</td>
<td>1.4069</td>
<td>1532.69*</td>
<td>0.9305</td>
<td>1990 Data</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>p=0.0001</td>
<td>p=0.001</td>
<td>p=0.0001</td>
<td>p=.3232</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21/E</td>
<td>RGDPCH</td>
<td>1062.795</td>
<td>90.4073</td>
<td>0.8589</td>
<td>-10.079</td>
<td>38.6063*</td>
<td>0.9142</td>
<td>1989 Data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p=0.3443</td>
<td>p=0.0002</td>
<td>p=0.0061</td>
<td>p=0.7898</td>
<td>p=0.1013</td>
<td></td>
<td></td>
</tr>
<tr>
<td>35/F</td>
<td>RGDPCH</td>
<td>975.9448</td>
<td>82.2241</td>
<td>1.3716</td>
<td>6.6665</td>
<td>14.8170*</td>
<td>0.9197</td>
<td>1988 Data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p=0.2215</td>
<td>p=0.0001</td>
<td>p=0.0001</td>
<td>p=0.8523</td>
<td>p=0.3637*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>39/G</td>
<td>RGDPCH</td>
<td>833.5521</td>
<td>84.0371</td>
<td>1.2759</td>
<td>-8.6891</td>
<td>20.239*</td>
<td>0.9044</td>
<td>1987 Data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p=0.2167</td>
<td>p=0.0001</td>
<td>p=0.0001</td>
<td>p=0.8075</td>
<td>p=0.2003</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A *p* value of less than 0.05 indicates that the parameter is significant at 5% level.

* Percentage literacy rate is used as a proxy measure for education.

* Secondary enrollment proportion is used as a proxy for education.

* Per capita investment in transportation equipment.
Except model D, all other six models include all the four explanatory variables. The multiple regression models are also tested for multicollinearity. The condition numbers reported in the SAS output (generally less than 6)\footnote{All models used in this thesis are extensively tested for collinearity among the explanatory variables in case of multiple regression. As no presence of multicollinearity is observed, they are not presented in the report for the sake of brevity.} are well below the range (15 to 30) that suggests the presence of multicollinearity. The high value of $R^2$ square in the range of 90% and high $F$ statistics' suggest that the models are statistically significant. However, in all the cases, intercept term is insignificant. Among the explanatory variables, telephone penetration rate and per capita energy consumption are always highly significant while variables for physical infrastructure—roads, and education are always insignificant except in model A where education is significant at 5% level. In model A and B, percentage literacy rate is used as a proxy for education. However, a closer look at the data in the Penn world source reveals that nations do not differ significantly in terms of their percentage literacy rate as they do in their level of economic activity. As mentioned in a previous section 4.2, nations differ widely in standardizing the measurement for literacy. Some of the least developed countries like Bangladesh count on those citizens as literate who can just sign on their names. A careful observation on the Penn world data base reveals that the secondary enrollment proportion of the population can be a better proxy for education while the tertiary enrollment is likely to show skewed distribution among the countries. So, in the model C, secondary enrollment proportion is substituted for the literacy rate as a proxy for education variable. In a sample of 46
nations with 1990 data, education again appears insignificant even after substitution with the new proxy.

In their extensive cross sectional analysis with data from the 50 US states, Dholakia et al (1994) used road length per land area as a measure for the development in physical infrastructure. As the states of U.S.A. do not differ too much widely in their land area, that measure may be a better representative of the development in physical infrastructure for the US states. But, in a world wide analysis where countries differ significantly in their land area\(^{42}\), road length per capita may be a better measurement in physical infrastructure development. Since in all of the model presented in table 4.9, road length per capita appears insignificant, it is substituted with per capita investment in transportation equipment in model D. However, once again it appears insignificant.

Therefore, education and physical infrastructure, unlike the findings of Dholakia et al (1994), are insignificant in the present cross sectional analysis with the nations of the world. However, as table 4.9 shows, between the two highly significant explanatory variable- telephone penetration rate has always a high parameter estimate than the per capita energy consumption.

Since education and physical infrastructure-roads appear to be insignificant in the cross country analysis of the relationship between infrastructures and economic activity, these two variables are in turn dropped from the list of the explanatory variables to observe the changes that can happen to the significance of the model as

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\(^{42}\) Bangladesh is just as large as Wisconsin of the United States in geographic area. However, its population is just half as much as the whole United States.
As mentioned before, none of the model shows the presence of multicollinearity. Since, road length per capita appears insignificant in all of these cases, another search can be made by dropping that from the list of the independent variables. Results of the multiple regression with energy and penetration rate as the explanatory variables are presented in the table 4.10. As is evident from table 4.10, all the models are highly significant as reflected by the high value of R square. However, in each of the cases both telephone penetration rate and energy consumption per capita are highly significant while road length per capita is highly insignificant as before. Interestingly, with the drop of the education variable, the value of R square does not decline at all. Parameter estimate for telephone penetration rate improved while that for energy went down.

Table 4.10
Relationship between infrastructure development and economic activity

<table>
<thead>
<tr>
<th>DF/Model</th>
<th>Dependent Variable</th>
<th>Intercept</th>
<th>PRATE</th>
<th>ENERGY</th>
<th>ROADS</th>
<th>R Square</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>23/A</td>
<td>RGDPCH</td>
<td>2341.4248</td>
<td>109.3205</td>
<td>1.1639</td>
<td>2.4149</td>
<td>0.9172</td>
<td>1989 Data</td>
</tr>
<tr>
<td>33/B</td>
<td>RGDPCH</td>
<td>1557.4566</td>
<td>97.3907</td>
<td>1.3303</td>
<td>17.1012</td>
<td>0.9302</td>
<td>1988 Data</td>
</tr>
<tr>
<td>35/C</td>
<td>RGDPCH</td>
<td>1314.5972</td>
<td>95.0429</td>
<td>1.332913</td>
<td>25.8864</td>
<td>0.9339</td>
<td>1987 Data</td>
</tr>
<tr>
<td>28/D</td>
<td>RGDPCH</td>
<td>2077.1262</td>
<td>87.3669</td>
<td>1.5937</td>
<td>-35.0187</td>
<td>0.9272</td>
<td>1990 Data</td>
</tr>
</tbody>
</table>

Source: Penn Word data base, United Nations Statistics

The SAS output of the multiple regression with telephone penetration rate, energy per capita, and road length per capita as the explanatory variables are presented in the table 4.10. As is evident from table 4.10, all the models are highly significant as reflected by the high value of R square. However, in each of the cases both telephone penetration rate and energy consumption per capita are highly significant while road length per capita is highly insignificant as before. Interestingly, with the drop of the education variable, the value of R square does not decline at all. Parameter estimate for telephone penetration rate improved while that for energy went down.
variables is shown in table 4.11. With the drop of the physical infrastructure variable, real GDP per capita is regressed on energy per capita, and telephone penetration rate. Surprisingly, the model is still significant with no noticeable decline in the value of $R$ square. All the parameters including the intercept are highly significant. The regression models with varying sample size for each and every years also reflect that the model is significant even when the sample size is smaller. In model B, a dummy variable is included to observe the effect of variations among the nations in terms of their level of economic activity. The dummy variable is, however, insignificant at 5% level.

Table 4.11
Relationship of economic activity with energy consumption and telephone penetration

<table>
<thead>
<tr>
<th>DF/Model</th>
<th>Dependent Variable</th>
<th>Intercept</th>
<th>PRATE</th>
<th>ENERGY</th>
<th>Dummy</th>
<th>$R$ Square</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>73/A</td>
<td>RGDPCH</td>
<td>1235.0216</td>
<td>102.1057</td>
<td>1.4825</td>
<td>0.9123</td>
<td>1990 Data</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$p=0.0001$</td>
<td>$p=0.0001$</td>
<td>$p=0.0001$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>73/B</td>
<td>RGDPCH</td>
<td>5688.05737</td>
<td>99.418230</td>
<td>1.442163</td>
<td>938.58</td>
<td>0.9146</td>
<td>1990 Data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$p=0.2232$</td>
<td>$p=0.0001$</td>
<td>$p=0.0001$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>76/C</td>
<td>RGDPCH</td>
<td>1600.0909</td>
<td>135.57</td>
<td>0.92524</td>
<td>0.8938</td>
<td>1989 Data</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$p=0.0001$</td>
<td>$p=0.0001$</td>
<td>$p=0.0001$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>99/D</td>
<td>RGDPCH</td>
<td>1407.444</td>
<td>140.61709</td>
<td>0.779580</td>
<td>0.8828</td>
<td>1988 Data</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$P=0.0001$</td>
<td>$P=0.0001$</td>
<td>$P=0.0001$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>99/E</td>
<td>RGDPCH</td>
<td>1405.600</td>
<td>133.4973</td>
<td>0.8179</td>
<td>0.8932</td>
<td>1987 Data</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$P=0.0001$</td>
<td>$P=0.0001$</td>
<td>$P=0.0001$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33/F</td>
<td>RGDPCH</td>
<td>1599.53</td>
<td>98.0247</td>
<td>1.3730</td>
<td>0.9317</td>
<td>1988 Data</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$p=0.0002$</td>
<td>$p=0.0001$</td>
<td>$p=0.0001$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35/G</td>
<td>RGDPCH</td>
<td>1392.9762</td>
<td>96.6847</td>
<td>1.3852</td>
<td>0.9347</td>
<td>1987 Data</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$P=0.0003$</td>
<td>$P=0.0001$</td>
<td>$P=0.0001$</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>23/H</td>
<td>RGDPCH</td>
<td>2347.5803</td>
<td>109.4718</td>
<td>1.1686</td>
<td>0.9212</td>
<td>1989 Data</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$p=0.0001$</td>
<td>$p=0.0001$</td>
<td>$p=0.0001$</td>
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</tbody>
</table>

Source: Penn world data base, United Nations Statistics.

* A 'p' value of < 0.05 implies that the parameter is significant at 5% level.
As mentioned before, telephone penetration rate still shows more relative impact on the economic activity than energy. With all of these empirical evidence, it is clearly established that telecommunications significantly affect the economic activity of a nation both as a single developmental input as well as when viewed with other infrastructures like education, energy, physical infrastructures-roads and bridges. This is, however, consistent with the findings of Dholakia et al (1994) in their analysis with the data from 50 US states.
Chapter Five
Summary and Conclusions

5.1 Summary

This study examined the relationship between telecommunications infrastructure and economic growth. The findings of the empirical research performed in the present study can be summarized as follows.

a) The level of economic activity at any point of time has significant influence on the development of telecommunications at another point of time and vice versa. The causal relationship is therefore in both directions. This finding also confirms the findings of the earlier studies in this regard as cited before in the previous sections.

In order to investigate the differences in effect caused by the wider differences in level of economic activity among nations, empirical study is also designed with two extreme groups of countries - the most developed (OECD), and the least developed countries. It is observed that relationship between GDP per capita and telephone penetration rate is more significant in case of developed countries than for the least developed ones. However, when both groups are combined in a bigger sample, there is still a highly significant relationship between the variables under investigation.

The effect of sample size is also investigated by arbitrarily dropping countries from the model. However, in all cases with different sample size, the model is still significant. The empirical results also confirm the current as well as the lagged effect of the variables.
Specifically, for the OECD countries (24 nations), the effect of the quality of telecommunications service on economic activity is also examined. With a sample of only 24 nations, quality of service (mean call completion rate) is significant at 5% level with an R square of 0.6833.

b) An empirical study examining the relationship between the current values of overall economic productivity (real GDP per worker) and telephone penetration rate confirms the statistically significant relationship between the two variables with an R square of 0.6766 in a sample of 32 countries. However, with the lagged effect of the penetration rate, R square is still much higher implying that a higher penetration rate at any particular point of time has a much greater effect on the productivity at a later point. This is no doubt plausible as the development in telecommunications reduces transaction and information costs in organizations inducing a higher level of productivity. For instance, with a sample of 22 OECD countries, the regression of 1990 real GDP per worker on 1989 telephone penetration rate ends up with an R square of 0.8032. This is surprisingly a high R square specially for cross sectional study with 22 nations.

The relative impact of telephone penetration rate among other infrastructure variables on overall productivity is examined. In a sample of 50 nations, real GDP per worker is regressed on per capita machinery investments, per capita energy consumption, and telephone penetration rate. An R square of 0.8681 with all the explanatory variables being highly significant implies that the impact of telecommunications is not undermined even when other more directly influencing
variables are included into the model.

C) Relationship between telecommunications and export performance is examined. It is observed that the development of telecommunications has greater impact on the exports of goods and services (R square = 0.5618) than that of manufacturing (R square = 0.3940) for a sample of 70 countries.

d) Relative impact of telecommunications among other infrastructures on overall economic activity is examined. Level of education, per capita energy consumptions, telephone penetration rate, physical infrastructures- per capita road length are considered as the independent variables and GDP per capita is regressed on these variables. Six regression models with sample size arbitrarily varying from 21 to 57 is tested for 1990, 1989, 1988, and 1987 data independently. Surprisingly, in all cases R square is above 90% and telephone penetration rate is highly significant. The multiple regression model shows no sign of multicollinearity. Per capita road length, and education variables are insignificant while telephone penetration rate, and per capita energy consumption is highly significant. Between energy and telecommunications, the findings confirm that telephone penetration rate is more influential on overall economic activity than a corresponding per capita energy consumption as the former has a higher parameter estimate in all cases.

5.2 Conclusion

On the basis of the above findings, it can be unequivocally concluded that the development in telecommunications have a significant influence on the overall economic activity, productivity, and exports of a nation. This impact of
telecommunications is not insignificant even when a comparison is made among competing infrastructures in terms of their effect on the economy. As the national economies are becoming more globally oriented, telecommunications is likely to play an increasingly dominating role among the infrastructures.

Despite all of its importance, telecommunications sector in most nations are yet to get its due priority in infrastructure development financing. Policy makers across the nations are, however, increasingly recognizing its importance for economic development. Most developed nations are responding by deregulating telecommunications which is likely to induce competition in the industry. A competitive industry environment will lead to modernization, expansion, innovation, and introduction of improved variety of services.

But, for the least developed nations, the scenario is different. Most telecommunications network is publicly owned monopoly characterized with a poor quality of service, low penetration rate, and age old technology. Deregulation and competition in the market is less likely to result in a significant growth of the sector unless financing problem is mitigated.

In the next section, an attempt is made to examine the present status of the telecommunications network in both the developed and developing nations. The present strategic policy issues perused by the developed and developing nations are analyzed, and a policy directions specially for the developing nations are proposed.
Chapter Six
Policy implications in telecommunications development

6.1 Introduction

Despite the inherent limitations in the quantification of all of its tangible and intangible benefits, empirical results have once again established the importance of telecommunications in the economic development of nations. For the economic development and economic superiority, a modern telecommunications infrastructure is undoubtedly a prerequisite. Policy planners around the world are increasingly aware of this fact as the national economies are becoming more and more internationally oriented. However, the new strategic direction set forth in the 80s in telecommunications sector reform is influenced by the prevailing industry structure, availability of financial resources, market orientation of the overall economy, and overall awareness of the national governments. The strategic options available is likely to differ in the developing world from that in the developed one.

Traditionally, telecommunications had been regulated as a relatively straightforward public utility. Economies of scale, political and military sensitivities, and large externalities made telecommunications a typical public service believed to be a natural monopoly. In most developed countries, telecommunications services were provided by government departments or state enterprises, which generally succeeded in building and profitably operating country-wide infrastructures, meeting the demand for basic telephone service, and starting to introduce more advanced services. In the 1980s, however, driven by rapid changes in technology and demand,
a wave of liberalization and privatization led to major changes in telecommunications service structure in most OECD countries. These reforms have accelerated investment, increased responsiveness to user needs, greatly broadened user choices, increased productivity, and reduced prices.

While remarkable strategic changes had been planned and implemented in the telecommunications structure of the developed countries, most of the third world countries are still lagging behind in their effort to modernization and expansion of the telecommunications infrastructures when their strategic choices are still to be tuned up. In the developing countries, telecommunications services were initially run by foreign private companies and colonial government agencies. Most operations were nationalized in the 1960s and taken over by the public sector. These state telecommunications monopolies, however, generally fell far short of meeting needs, as evidenced by persistent large unmet demand for telephone connections, call traffic congestion, poor service quality and reliability, limited territorial coverage, demonstrated willingness of users to pay far higher prices to obtain service, the virtual absence of modern business services, and user pressures to bypass the system by building their own facilities.

In the following section, a review of the present status of the telecommunications sector reform in the developed and developing nations is attempted. With the extensive review of the existing literatures, an attempt is also made to prescribe the policy options for the developing nations.
6.2 Present Status of telecommunications structures in developed countries

In 1992, there were 409 million telecommunication mainlines in the OECD representing 71 percent of connections to the world public switched telecommunication network (PSTN). In times past, virtually all these lines were connected to a telephone. Today the convergence of communication and information technology is enabling a huge variety of equipment to be connected to the PSTN. For example, around 22 million facsimile machines exists in the OECD area. Together with a plethora of other types of user equipment, information technologies are changing the way networks are used to transmit, receive and manage information. At present, around half of all transpacific traffic is data. In the OECD area, a further 21 million users access the PSTN through mobile telecommunications, accounting for 90 percent of world-wide mobile subscribers43.

In 1992, compared to other industrial and service operations, public telecommunication operators (PTOs) in the OECD area continued their record of strong financial performance. At a time when large industrial and service corporations faced a general economic slow down and, in some cases, major restructuring to meet the challenge of increasingly competitive global markets, the telecommunication sector thrived. For example, the largest 25 PTOs in the OECD area were more profitable than the largest 100 commercial banks in the world44. Capital markets have recognized the financial strength of the telecommunication

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44 See footnote 43
sector in an increasing number of privatization in Australia, Canada, Denmark, Japan, the Netherlands, New Zealand, the United Kingdom. At the same time finance has been readily available for new service providers in liberalized markets. Corporations such as Optus in Australia; Unitel in Canada; Clear Communications in New Zealand; DDI, Japan Telecom, Teleway Japan, International Telecom Japan and International Digital Communications in Japan; Tele-2 in Sweden; Mercury and Vodafone in the UK; MCI, Sprint, McCaw in the US have become household names in their respective countries. These corporations have not only added to the value of the global telecommunication system, they have assisted to create an environment in which these networks are used more efficiently.

The challenge before policy makers is to insure a market structure which enables PTOs, and new service suppliers, to compete in the provision of all telecommunication services on a fair and equitable basis. A growing number of OECD countries, in particular those with established network infrastructures, are approaching this task through the liberalization of telecommunication infrastructure provision. The benefits of pursuing such a policy have proven to be price discipline, increasing quality, and improved consumer choice. At the same time there has been no persuasive evidence presented from the experience of these countries that universal service has been eroded when liberalization has been accompanied by appropriate safeguards. On the contrary, it is increasingly evident that the competitive forces some perceive as a threat can be harnessed to improve universal service. Telephone penetration rates have continued to increase in competitive markets. By
way of example, Japan and the United Kingdom have both boosted their telephone penetration rates by more than 30 percent since the introduction of competition. At the same time the price of telecommunication services continues to fall with the largest relative gains since 1990 being made in competitive markets, by business and residential customers.

There has been a marked trend, by both OECD and non-member countries, toward liberalizing market entry for basic telecommunication services and infrastructure. Two developments stand out as a notable shift in telecommunication policies and may lead to considerable change in market structures. First, the move to eliminate monopoly restrictions on service provision and, second, the increasing consideration being given to partial privatization of incumbent monopoly operators and at the same time allowing new entry for facilities based operators.

Major structural changes in the ownership, and competition in the telecommunications market have happened in the last decades. More fundamental changes are still underway. Rapid technological changes, more uses of newer services, and a greater demand for improved and modernized services are making the regulatory process always lagging behind. The decision that may bring about the most fundamental change in the telecommunication market structures of the OECD countries is the agreement by the European countries to liberalize the provision of public voice telephony by 1998 (additional transition periods up to five years were granted to member states with less developed networks. Spain, Ireland, Greece, and

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Portugal to allow for necessary structural adjustments). This move is likely to be followed eventually by the EFTA countries.

Allowing service competition through simple resale can play an important role in putting downward pressure on prices, stimulating new services, enhancing customer choice and encouraging incumbent operators to increase efficiency. Japan had started liberalizing voice services in 1994, on a step by step basis, in the context of international value added network services. The European Union's framework will necessarily include trans-border simple resale which is crucial in the development of trans-European networks, and can play a fundamental role in integrating manufacturing and service industry markets within Europe. The liberalization of service markets should also accelerate the trend which has emerged in recent years by some OECD countries to allow international simple resale.

Although the step to abolish the monopoly for voice telephony service in the European Union is important, if this is going to be effective, it is also necessary to ensure that the right framework conditions are in place since the incumbent infrastructure-based public operators will still maintain a dominant position. In particular, full competition for voice telephony should not be limited to any one infrastructure and appropriate pricing structures need to be available.

During the last several years the most profound changes in opening markets to competitive provision of services and infrastructure occurred in Finland and Sweden. These two countries eliminated all restrictions with respect to market entry. Thus local operators can operate trunk networks in Finland and the trunk operator can
enter into local service markets. As well, six operators were granted concessions for international telecommunication services, but on a limited geographic basis. In Sweden, a second facilities-based operator has begun providing national and international service. Other countries have taken active steps toward moving to new market structures. In Denmark, privatization of Tele Danmark is underway and on completion it is anticipated that further market access will be allowed. In the Netherlands, partial privatization (30 percent) began in 1994. The government share will be gradually reduced over 10 years but it will keep one third ownership. In Switzerland, the legislative proceedings leading to a wider liberalization of the telecommunications market are under way, and the first steps for a partial privatization of the Swiss PTT have been taken. Since the path breaking policy pioneered by the United States with the historic deregulation of A T&T at the early 1980s and the subsequent follow up the British Telecom, and Japanese NTT, significant changes have occurred particularly in OECD countries' telecommunications market reform. The following table 6.1 reproduced here from the OECD source summarized the status of facilities based competition in the OECD areas.

6.3 Present status of telecommunications in the middle and low income countries

Induced by the global trend of telecommunications sector reform particularly in the OECD countries at the 80s and 90s, most middle income and least developed countries have also initiated major strategic changes in their telecommunications

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policy. While remarkable changes have happened in the market structures of middle income economies like China, Malaysia, Philippines, Thailand, Indonesia, Singapore, Mexico, South Korea, most of the least developed countries are still lagging behind in their effort to modernization and expansion of their telecommunications infrastructure. Traditionally, telecommunications sector is a state owned monopoly in most least developed countries.

The fundamental reasons for favoring a government-run telecommunications monopoly have been to:

- Obtain the economies of scale and scope inherent in telecommunications system.

A natural monopoly argument rules out the economic and efficient operation of telecommunications in a competitive market structure. It is under this argument, telecommunications was historically a regulated monopoly in the developed world as well. However, in some developed countries, it was a publicly owned monopoly rather than being 100 percent state owned. In the developing countries, various regulatory limitations and above all, the absence of huge capital for private investment in the infrastructure rules out the possibility of any other kind of ownership rather than being 100 percent government-run.

- Take advantage of the system's profitability in some areas to subsidize nationwide service and other government operations.

- Retain control of an important infrastructure for political, social, economic and defense purposes.

Unfortunately, these traditional benefits of a monopoly system can not offset the
current difficulties countries face in trying to upgrade their systems, stabilize their economic position and stimulate their overall economic growth. Problems result because:

- A government run monopoly is often inflexible, subject to political interference and has no incentive to provide efficient operations, quality service or responsiveness to customer needs.

- The basic telecommunications network does not completely penetrate the country's geographic areas and probably won't do so without subsidization or special financial arrangement.

- Government budgetary problems not only limit investment in telecommunications system, but may also divert system earning to other sectors.

- Domestic and foreign exchange-based financial resources are scarce, limiting investments in any of the country's industries. Combined with the underdeveloped infrastructure, the effect is that economic and social improvement is stifled.

6.4 Strategic policy options for developing nation

Evidently, the major hindrance in the development of the telecommunications sector is the financial resource non availability for the least developed countries. Though the natural monopoly argument will try to establish that the size of the telecommunications service market is small enough to justify the existence of competitive market, the failure of the government run monopoly to provide adequate and quality services for the overall economic growth will more than offset the benefits that may accrue from natural monopoly operation.
Table 6.1
Status of facilities competition in the OECD area, 1994

<table>
<thead>
<tr>
<th>PSTN competition</th>
<th>Data Comms. and Leased Lines</th>
<th>Mobile Communication</th>
<th>Equipment</th>
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<tbody>
<tr>
<td></td>
<td>Local</td>
<td>Trunk</td>
<td>Intl.</td>
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<td>Australia</td>
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<td>M</td>
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</tr>
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<td>Japan</td>
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<tr>
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<tr>
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<td>C</td>
<td>C</td>
</tr>
</tbody>
</table>

Key: C = Competition
D = Duopoly
B = Competition allowed at border of concessions.
199X = Competition expected to be introduced this year
CPE = Consumer Premises Equipment.

Source: OECD Communication Outlook 1995, p14
In the above situation, a major restructuring of the sector is warranted that will promote the mobilization of resources in this sector with the eventual effect on network modernization and expansion. Liberalization and privatization may be the best strategic choice for the development of telecommunications sectors in the developing countries. However, most developing countries do not have adequate internal resources in the private sector for investment in telecommunications.

In a situation of financial scarcity as prevailing in the third world nations, the followings, though not exhaustive, are the strategic alternatives available for financing telecommunications sector.

- Public private alliance.
- Joint venture with foreign companies.
- Build, operate, and transfer (BOT) agreements.
- Build, operate, and own.

Some of these alternatives are now being actively pursued by some ASEAN countries- Malaysia, Indonesia, Philippines, Singapore. It is imperative for the low income nations to immediately adopt such strategic policies if they are to keep pace with the rest of the world. The final policy decision, however, is country specific and dependent on the present social, economic, and political scenario prevailing at the nation concerned. A detailed and in depth study for individual nation is imperative.
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