AN EMPIRICAL INVESTIGATION OF COST SUBADDITIVITY OF THE ETHIOPIAN TELECOMMUNICATIONS CORPORATION: IS THERE A ROOM FOR COMPETITION?

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ABSTRACT

A public utility theory argues that industries such as telecommunications, electricity, postal services and water & sewage should be run by a single firm viewed from economic efficiency. This has to do with the existence of various impediments to entry in such market which guarantee the incumbent industry to be a 'natural monopoly'. The Ethiopian telecommunications corporation in its hundred plus years of operation remains on the hands of the government enjoying an exclusive right in provision of telecoms services in the country. However, the sector performed poor in many standards of quality judged against the threshold for developing countries. Noting inefficiencies of the sector, the government separated activities of operation from regulation in 1999. Notwithstanding the positive moves seen in recent years, the regulatory authority considered the industry for granted as a natural monopoly without any empirical verification. The purpose of the study was to determine whether cost efficiency is the raison detre for the monopoly market structure in Ethiopian telecoms sector. Accordingly, cost function of etc is studied in line with a mutiproduct firm setting so as to test cost subadditivity. Both the traditional and the Evans & Heckman approach proved that the industry has indeed been a natural monopoly and calls for an effective regulation so as to achieve in a competitive outcome.

CHAPTER ONE

INTRODUCTION

1.1 Background

Since the introduction of telecommunications service in Ethiopia in the late nineteen century, it has undergone in the course of series development phases. So far, the government was aimed at linking the capital city with major administrative regions of the country. Recognizing a role telecommunications plays in economic development of the country, various governments have been mobilizing resources in building the infrastructure, extending access and improving qualities of the service in line with the global technological progresses. Establishment of the Board of Telecommunications of Ethiopia in 1952 whereby the operator was granted full administrative and financial autonomy to exclusively provide telecoms services in the country is a refection of reform made in response to the then demanding circumstances. In the transitional era, several projects have been executed by the government ranging from a rehabilitating work to the network damaged during the military regime to an objective of universal access of telecoms services across the country.

The year 1999 marked a major reform in telecommunications sector of the country as activities of service provision is separated from regulatory tasks of the then Ethiopian Telecommunications Authority. Under Proclamation No. 49/1996 (as amended) the Ethiopian Telecommunication Agency (ETA) is established as autonomous federal regulator of telecoms services aimed at promoting the development of high quality,

efficient, reliable and affordable telecommunications Services in the Country. Whereas the Ethiopian Telecommunication Corporation (ETC) is licensed to be a sole provider of telecom services in the country.

Since the restructure of the telecommunication industry apparent development has been registered in the sector. Services such as internet, mobile telephone, virtual telephony services, digital data network service, smart calling cards, international mobile roaming service and multi-media are among major recent developments added on the service menu of the incumbent operator. Moreover quality aspect of the telecom services is not immune from change as broadband internet, multimedia and VSAT technology are commenced.

With regard to ownership of the sector, ETC has remained as a legal public monopoly. Up until 2004, when the telecommunication License Fee Directive is proclaimed to issue license for resale and tele-center in telecommunication service, the private sector was almost exclusively prohibited in provision of telecom services. Inefficiencies are inherent characteristics of a monopoly and ETC has not been a different. ETA is established to discipline and direct ETC to an optimal outcome that would have been attained if there were a competitive market structure. The reality is the other way round. The country is registering poor performance in the sector as compared to the standards of many sub-Saharan countries. There is no likelihood of competition in the near future since almost nothing has been done so as to facilitate entry of firms which paves the way to competition.

1.2 Statement of the Problem

Currently policy makers are questioning the validity of a public utility theory. The theory argues that industries such as telecommunications, electricity, water supply, postal services and the like should be supplied by a single entity so as to be economically efficient. This has to do with the existence of various impediments to entry in such activities which guarantee the incumbent industry to be a 'natural' monopoly.

In Ethiopia the telecommunication sector has been, and is, immune from actual or potential entry of firms. This is due to the fact that the industry is perceived to be a natural monopoly. Nor does competitive portion of the industry is identified so as to allow restricted entry of competing firms. Currently ETC is aiming at achieving a universal access in telecom services across the country with affordable tariff. However it is performing below the standard when judged against its counterpart in many developing countries.

Economic theories argue that in a concentrated market structure, price would be higher while lower quantities are produced than in a competitive market. The Ethiopian telecoms sector has not been at odd with this view. A study by Abdulsemed (1998) pointed that prices of basic telephony services have been over and above the optimal level from the point of view of efficient resource allocation. This has to do with the company's reliance on a backward looking traditional accounting approach in setting prices which is aimed at recovery of historical or sunk costs so as to secure its financial viability rather than achieving a national welfare in provision of telecoms

services. Moreover, the standards of all telecommunication services being provided by ETC is poor as compared to other African countries as it is characterized by low penetration (teledensity), uneven distribution of services in favor of urban areas, low telecoms revenue and investment, few number of subscribers despite the fact that there is substantial unmet demand as evident from the waiting lists, and the like, Tillahun (2005). Such inefficiencies are inevitable in a monopoly service provider like ETC which has never felt a threat of actual or potential competition.

Notwithstanding the potential market abuses and the prevailing inefficiencies of the ETC, there are incentives of being a sole operator of telecom services in the country. Apart from arguments of scale economies activities such as cross-subsidization, market segmentation and price discrimination might be practiced which self sustain and ensure substantial profit to a firm. The existence of such incentives in public utilities like telecommunications industry might lead to a suboptimal resource allocation in the sector.

Several issues are at the forefront of current policy debates: how to determine which industry structure (and government policies) best promotes new services and production processes; how to determine whether a natural monopoly actually exists given the changing demands and technologies; how to select price configurations that will both recover costs and encourage efficient consumption choices; and how to ensure that those prices are sustainable-that is, not susceptible to the threat of entry or self-production by current customers, Berg and Tschirhart (1995).

It is recently that the government delegating the Ethiopian Telecommunications Agency (ETA) permitted participation of the private sector at end stage telecom services in the form of value added and resale activities. Apart from this change there has been no sound policy reform that is considered as a facilitating condition for the emergence of competition in the telecommunications sector. Rather, the government is further insulating the industry from competitive entry and strengthening its influence by setting up a loose-regulatory body which never has put competition issues in its objectives.

Inefficiencies of the incumbent operator might have been reversed had there been competition in the market, if there were indeed a room for competition. Otherwise there should be an effective regulatory set up so as to direct the market conduct and performance in line with a competitive outcome. The overriding monopoly market structure in telecommunication sector in Ethiopia is dictated by political motives rather than emanating from economical ground. In this regard policy makers have to determine an optimal configuration of operators with an appropriate diversification of services that maximize social welfare in the economy. This can be substantiated by studying the market and technological conditions of the firm for which we have the data.

The ETA, which is empowered to regulate telecommunications services in the country, has no knowledge whether or not the incumbent firm has characteristics of a natural monopoly. Nor does it know potential competitive activities of the industry where multiple firms can operate without hurting productive efficiency. This is due to

the fact that there is lack of an empirical investigation in this area. The regulator is not well structured and its independence from the government is questionable as it prioritizes political motives rather than maximizing economic welfare. ETC has no fear with regard to entry of firms in the foreseeable future. Not only that inefficiencies of the operator lead to welfare loss to the society, customers are deprived of enjoying a variety of services that might have been provided by competitive suppliers.

1.3 Objectives of the Study

In order to determine the optimal size and product mix of the incumbent operator and to resolve the competition versus regulation debate on telecom utility in the country, it is imperative to investigate the market and technological conditions of the industry. For given market conditions behavior of the industry cost function provides an insight to justify the appropriate market structure from the view point of optimal resource allocation in the economy.

The major objective of the study is, therefore, to evaluate whether the Ethiopian Telecommunications Corporation is a natural monopoly, i.e. whether monopoly is a natural outcome of market forces in provision of telecoms services in the country. By studying the incumbent operator's cost function in a multiproduct firm setting, subadditivity test would be commenced to assess whether cost efficiency is the 'raison detre' for a monopoly market structure.

Subsumed in the major objective, the specific objectives are:

- To furnish an insight in achieving a competitive outcome in the telecom sector;
- To identify a potentially competitive segments of the industry;
- To evaluate effectiveness of the regulatory authority in light of facilitating the track towards evolution of a competitive market;
- To provide policy recommendation based on findings of the study.

1.4 Significance of the Study

In Ethiopia the telecommunications sector has been dominated by a publicly owned monopoly operator. The industry is still legally galvanized from competition and policies have been designed aimed at protecting interests of the incumbent operator. Many countries are practicing intense competition in their counter part by allowing entry either to the whole industry or its segment. In this regard the pros and cons of competition have to be studied ahead of deciding over the market setting. However, no research has been done to evaluate whether monopoly is an inevitable outcome for efficiency or else whether there is a room for competition in the sector. The study tries to seal such information gap and provides an input to policy makers in achieving economically efficient telecommunications industry.

1.5 Limitation of the Study

Among the major public utilities, technological progress is rapid in a telecommunications industry which would allow for intensified competition within a reasonably short period of time. Particularly, wireless telecom services are identified as a potentially competitive segment of operation. The study however fails to consider wireless telephone services such as mobile telephone service as distinct output of the firm. This owes to lack of adequate observation point needed for the econometric analysis. Difficulties are encountered in measuring the capital cost of the operating firm as no data is available in this regard. Depreciation expense as obtained from the company's annual statistical bulletin is used as a proxy to the true capital expenses. Moreover data limitation has forced me to use revenues as a proxy to quantities of services. So that I have a reservations in using outputs of the study as those proxies are rough estimations to the real variables of the cost function.

CHAPTER TWO

OVERVIEW OF THE ETHIOPIAN TELECOMMUNICATIONS SECTOR

In Ethiopia a telecommunications service is introduced in 1894, only two decades after the invention of telephone itself. In the same year the Ethiopian Telecommunications Corporation (ETC) was established making it Africa's first modern telecommunications corporation. Since 1953 the corporation has been granted full administrative and financial autonomy by Proclamation No 131/53 in provision of telecoms services in the country. In its history the industry has undergone through series of development programs in light of technological shocks over the world.

Notwithstanding the apparent positive moves by the corporation in recent years, the sector registered poor performance in every measure of development indicators as compared to other developing countries. According to Tilahun (2005) the sector's poor performance is mainly owing to the telecommunication policy adopted by the government and the inefficiencies inherent in monopoly service provider. The following stylized facts to some extent depict a picture of the current status of telecoms sector in the country.

2.1 Some Stylized Facts of the Sector

Currently ETC provides national and international telecoms services using communication media ranging from a radio transmission to an optical fiber network. In the year 2006/07 there were 919 public stations in the country, of the total stations 51.67% are digital automatic telephone exchanges, 38.33% are pay stations & rural

radio communication and the rest 10% are manual exchanges. In the same year, total installed exchange capacity of fixed telephone reached 1,123,281, out of the total capacity 99.71% are digital where as 0.29% are manual exchange lines.

According to ETC's 2006/07 annual statistical bulletin, the country's telecoms penetration (teledensity or number of telephone subscribers per 100 inhabitants) has increased from 0.53 in 2001/02 to 1.16 in 2006/07. The increment ranges from 0.59 to 2.73 if mobile telephone subscription is included in the last five years.

In the year 2006/07 the total number of main telephone line subscriber is 880,088 increased on average by 30% per annum from what it was five years ago. The figure for waiting list for fixed telephone line showed the reverse trend with telephone line subscribers. The former comes down to 13,579 in 2006/07 from 139,095 in the year 2001/02, showing an average decrement of 18% per annum in the last five years. The declining trends of waiting list for main telephone line might be due to efforts exerted by the company in achieving the objective of universal access in basic telecoms services besides the expansion of wireless telephone services.

Since the introduction of mobile telephone service in 1999, the number of mobile telephone subscribers rises at an alarming rate. It was 6,740 in the first year and increased to 42,910 and then to 1,208,498 in 2001/02 and 2006/07, respectively. For the last five years, the average rate of growth of mobile telephone subscribers was 543% per annum. The high growth rate is a direct reflection of the fact that mobile telephone service is a fast technology that readily disseminates in a given geographical

area. Besides the existence of huge unmet demand in fixed telephone line would also contribute for such tempo. Qualitatively, value added services such as Roaming, Satellite mobile, call diverting, call waiting, call barring, voice mail service (VMS) and short message service (SMS) are being delivered. The Internet service is also expanding over the country since it has been brought in 1996/97. The total number of internet subscribers reached 31,400 in 2006/07.

The overall expansion of telecoms services in line with the installation of digital exchange capacities resulted in a boost to the country's metered telephone traffic. For the year ended 2006/07 the estimated figure for metered traffic call was 2,714.31 millions of metered pulses.

E. Viani as referred by Tilahu (2005) pointed out that there are three possible methods in measuring productive efficiency of labor in a telecommunications industry: real sales per employ, real earnings per employ and fixed lines per employ. When we measure Labor productivity by main telephone line per employ, we get 75.58 in the year 2006/07. Therefore, on average one employee is currently responsible for 76 customers of the firm.

In the year 2005/06 the gross revenue and expenditure of the company was 2,155.04 and 1,499.60 million Birr, respectively. In the last four years revenue and expenditure have been increasing by 34% and 55% per annum, respectively. Gross profit of the company for the year ended 2005/06 was 655.44 million Birr while it was 446.42 million Birr in the year 2001/02.

2.2 Regulation of the Industry

In the last three decades, many countries have experienced a change in policy paradigm as their public utilities have been liberalized and most of the publicly owned incumbent monopolies have been privatized. The privatization and liberalization schemes coupled with effective regulation of such markets pave the way to emergence of competition.

In Ethiopia, as opposed to many countries of the world, public utilities are still operating in a monopoly market structure. The Ethiopian Telecommunications Corporation in its hundred plus years of existence remains on the hands of the government having an exclusive right in provision of telecoms services in the country. Up until now, neither the incumbent operator is not privatized nor is the telecoms sector liberalized. Thus the alleged benefits of competition in terms of an optimal mix of lower price with higher supply of services couldn't be reaped.

The corporation enjoying legal protection from the government runs the sector without being efficient. Thanks to its market power, ETC has been profitably providing the services over the country. From the point of view of social welfare, however, persistence inefficiencies were recorded. As per the study made by Abdulsemed (1998) the telecommunication's tariff are significantly distorted and resulted in inefficient resource allocation in the economy. As is noted in the earlier section the telecommunications sector is at a rudimentary stage of ICT development judged against ages of the industry.

The government initiated various reform schemes acknowledging the problem emanating from the structure of the market. On top of that a sector specific regulatory authority, Ethiopian Telecommunications Agency (ETA), is inaugurated in 1999 under the proclamation number 49/1996 (as amended). Whereas the then Ethiopian Telecommunications Authority which had been responsible for dual objectives of regulation and provision of telecoms services was transformed into a national operator named as Ethiopian Telecommunication Corporation (ETC).

As per the Telecommunications Proclamation No 49/1996 the objectives of ETA are directed towards promoting the development of high quality, efficient, reliable and affordable telecommunications Services in the Country. The same proclamation bestowed the following powers and duties to the regulator:

- Ensuring the telecoms services are operated in a manner that best serve and contribute to the country's economic and social development.
- Ensuring that telecoms services conform to the specified standards of quality.
- Authorizing and supervising the use of frequencies allotted to Ethiopia.
- Specifying technical standards and procedures for the provision of telecoms services.
- Regulating tariffs related to basic telecoms services.
- Regulating types of telecom equipment, which may be connected to a telecom system.
- Licensing and supervising operators of telecom services.

As part of its duty, ETA licensed the Ethiopian Telecommunication Corporation in 2002 to be a sole provider of the following four telecom services over the country.

1. Public Switched Telecommunication Service
2. GSM 900 Mhz Mobile Telecommunication Service
3. Internet Service
4. Digital Data Communication

Since establishment of the agency, any activity that is related to provision of telecommunications services require ETA's license. Moreover, tariff rates of basic telephone services began to be regulated.

2.3 Areas Allotted to the Private Sector

ETA noted that the telecommunications sector of the country could not meet the stipulated objectives with out the role of a private sector. However, it is not determined to fully allow and compete them with the incumbent firm in basic telephone services. Instead, the monopoly is continued to dominate the market and the privates are allowed to operate in restricted fashion only at the periphery services of the incumbent operator. The agency's mission is directed to facilitate and regulate the participation of the private sector in the downstream liberalization of and others when government decides on telecommunication services, ETA (2006).

The Agency sequentially issued license directives 'Resale and Telecenter in Telecommunication Services No. 1/2002' and 'Value Added Service Directive No.2/2005' which stipulate the following services permitted to the private:

1. Telephone resale service:
2. Fax resale service,
3. Internet resale service.
4. Telecenters: a center where two or more telecommunication resale services are provided together at the same place.
5. In-house (building) / Outside cable installation service
6. Exchange installation
7. Terminal equipment maintenance:
8. GMPCS services: global mobile personal communication by satellite
9. Value added services: which include,
    i. Virtual Internet Service (V-Internet): provision of dial-up internet access service, web hosting service, e-mail and other similar services to customers by leasing internet bandwidth or internet network equipment of the Corporation

    ii. Call Center Service: information provision service which is useful for a customer or potential customer by the initiation of the person providing the information himself or through a request made by the customer or potential customer by a telephone call or using internet, regarding the business or service the person is providing,

or the business or service of another person, or on other similar issue.

2.4 Evaluating the Regulatory Performance

Even though ETA is a newly established institution, regulation activity is not a recent phenomenon in the country's telecommunications sector. So far the Ethiopian Telecommunications Authority was responsible for dual duties of regulation and service provision. However, the scope and principle of the regulation task was not clear. Moreover, the fact that the industry was made to supervise itself resulted in ineffective outcome. It is to address this problem that the government restructured the industry and created an independent regulatory body, the ETA. Smith (1997), as referred by Afonso and Scaglioni (2006), pointed out three leading features of an independent regulator in telecommunications as:

i. Independence from the operators of the telecommunications sector;

ii. Independence from other interested parties such as industrial interests;

iii. Independence from political actors like ministers for the day-today matters.

As per the above features, ETA in the first place is established so as to meet the first condition. The agency is separated financially as well as in management from the operating firm, ETC. The second feature is an empirical question and may be less vital for us at least in the current situation. The last criterion is crucial for effectiveness of a given regulator. When we come to ours case, the agency is not independent from government ministries. For instance, ETA is established by proclamation to be

accountable to Ministry of Transport & Communications. Under proclamation No. 47/1999 article 57 the Ministry itself is given the power of issuing regulatory directives. Overlapping authorities as such would create a problem and question independence of the regulator. The agency is established in such a way that government subsidy is one source of finance. Such independences would enable the government or specific ministries to impose political objectives. Therefore, the regulator should be an independent and autonomous institution guided by economic efficiency in the economy.

Regulation of prices and tariffs of telecommunications services is a major duty of the Ethiopian Telecommunications Agency. Proclamation No. 47/1999 bounded the scope of price and tariff regulation to basic telephone services of the industry. The same proclamation states that telecommunications pricing is determined by the principles of economic efficiency, public interest and commercial viability of the operating firm. Accordingly the marginal cost and operating system planning approaches are recommended in order to set the prices and tariffs. However, measuring the marginal cost of telecoms services is difficult let alone meeting the multiple objectives at a time. Empirical works of such concepts are not as easy as depicting them in black and white. Until then the agency has not implemented the marginal cost pricing principle. Nor has it revised the prices and tariffs of telecoms services except a flat rate reduction of international call charges. Therefore, the agency should employ an appropriate pricing scheme which readily be applied and result in optimal resource allocation in the telecoms sector. For instance an incremental cost pricing method could be used.[1]

[1] See Abdulsemed (1998) for more on incremental cost.

Ensuring the provision of telecom services in such a way that it best serve and contribute to the country's economic and social development is another objective of the ETA. It also supervises whether telecoms services conform to the specified standards of quality in the country. Otherwise action would be taken by the Agency if any activities of the operating firm don't comply with requirements of the license. Let's say that the services being delivered by the operator is persistently at odd with one or more objectives which ETA aspires. What measure would be taken by the agency? Financial penalty? Revoking the license? or what? Such actions would at best be used had there been competing operators. If the license is revoked or cancelled, there would be no telecoms service in the country. However, in the existing monopoly market structure compelling the operator in order to comply with the licensee condition is too difficult. The incumbent operator is granted a life long exclusive right in provision of the service. It doesn't fear for any actual or potential competition at least in a short period of time. To address such a problem the licensee should be sold or provided in a competitive auction for a limited period of time. This would be a source of fund from the license and the auctioneer would have an incentive of providing quality services with a threat of license termination or revoking.

Since telecommunications technology is one of a dynamic industry the regulator has to adapt and well equip itself to the changing conditions. It should also be capable of predicting market changes and disseminate any information to stakeholders over the economy. Such a potential would be build up through continued research and

development activities. And any development should be made public on regular basis. However, ETA is unable to issue annual report let alone catch up the dynamic globe.

In many developed countries liberalization and privatization reforms to the telecommunications sector has made competition to emerge bringing higher benefits in terms of price, quality and innovative services to consumers. For instance, in the United States the former big monopoly operator, AT & T (the American Telephone and Telegraph Company) divested of itself in 1983 into 22 local Bell Operating Companies (BOCs). The divestiture created intense competition not only in the long distance telephone operators of the country, but also resulted a positive spillover effect to the perceived natural monopoly segment of urban telephone services, Beesley (1997). In Ethiopia a radical reform in favor of competition hasn't been made in the telecom sector. Rather policies have been designed in order to galvanize the incumbent firm from potential entrants. Competition does not emerge as manna at a certain point in time. It, however, develops through series of policy reforms which might be taken as a facilitating condition for competition.

CHAPTER THREE

LITERATURE REVIEW

3.1 Theoretical Literature

Currently researches dealing with viability of competition in infrastructural industries are flourishing. Especially the very existence of a natural monopoly is evaluated by studying its cost function using devices of scale and scope economies. As a result many countries are reforming their market structure towards tighten regulation or liberalization schemes to an incumbent monopoly in a way to a market led outcome. However, the issue is still controversial in public utilities like telecommunications due to their unique nature of inhibiting entry of multiple firms. Researchers are debating on public utility matters whether we ought to rely on a market condition by allowing competitive suppliers or there to be a legal monopoly subject to government regulation of prices, quantity, entry, investment, service quality and other aspects of firm behavior. This chapter presents a review of selected literatures in light of the debates.

3.1.1 A Public Utility Theory

Infrastructural industries such as telecommunications, electricity, postal, water and sewage have been labeled as public utilities since they provide essential goods and services in an economy. Nevertheless the market for such industries does not accommodate multiple suppliers efficiently from economic point of view. Accordingly the incumbent industry would be considered as a natural monopoly without a threat of competitive entry in the market.

Miller (1995) in his paper "Is the public utility concept obsolete?" provides a list of barrier to entry that impedes development of competition in public utilities:

1. The industries are characterized by high threshold levels of investment, mandated at a minimum by the necessity to connect and/or interconnect all customers. They, thus, also will have as distinguishing features substantial sunk costs and a high fixed to variable cost ratio.

2. The assets of public utilities are substantially non-fungible.

3. Incumbent firms control over essential bottleneck facilities, and uniquely are granted the power of eminent domain.

4. Public utilities typically serve a number of distinct markets, with differing demand elasticity.

5. The requirement that networks are constructed in advance of demand almost ensures the existence of economies of scale.

6. Public utilities also are distinguished by the substantial utilization of joint assets. The use of joint assets for the production and distribution of multiple services ensures that joint costs comprise a significant proportion of total costs, and is a source of significant economies of scope.

7. Public utility industries also are distinguished by essential interdependencies, including the requirement to coordinate across markets.

8. Public utility industries also historically have been characterized by the presence of significant externalities. For instance, in telecommunications the benefit of the service to all consumers is enhanced by the interconnectivity of the network

9. Customer inertia and loyalty to incumbent providers and established brands discourage new entrants.

Such types of conditions, in varying combinations, inhibit establishment of competition in utility markets by generating significant structural barrier to enter and exit, even without a legally imposed impediments. As far as these conditions are real phenomenon, the public utility concept is indeed undying.

Mansfield (1970) as quoted by Isaac and Smith (1984) argued that:

> *…a firm may become a monopolist because the average cost of producing the product reaches a minimum at an output level that is big enough to satisfy the entire market at a price that is profitable. In a situation of this sort, if there is more than one firm producing the product, each must be producing at a higher-than minimum level of average cost. Each may be inclined to cut the price to increase its output rate and reduce its average costs. The result is likely to be economic warfare and the survival of a single victory, the monopolist. Through time the single survivor of price cutting firm in a scale-economies environment operates as a true monopolist because it gains the protection of alleged barriers to entry*

Joskow and Noll (1984) stated that public utilities like telecommunications industries have elements that arguably are natural monopolies in two senses. First, some specific components of the underlying technology exhibit economies of scale over a range of output or capacity that is comparable to the magnitude of demand. Second, as networks, these industries require some standardizations and coordination through out the entire interconnected system in order to operate efficiently. However the fact that components of the network have natural monopoly characteristics doesn't imply that any part of the industry ought to be a monopoly. He further contends that, with respect to scale economies, the physical links that exhibit declining average costs per unit of capacity may not be the most important part of cost of providing the service. Moreover, if customers desire different qualitative attributes in their service (such as speed, reliability, or specific service features), they may prefer two or more product-differentiated firms with somewhat higher costs and prices than one firm offers a homogeneous product that is not the most desirable service for anyone. With regard to standards and coordination, the alternative to monopoly ownership might be some sort of industry-coordination organization.

As opposed to a public utility theory, however, several advocates of a contestable market hypothesis argue that it is not the economies of scale per se that pose an entry barrier (Baumol W., 1982). He argued that only if the cost curves reflect large sunk costs already borne by the incumbent can the incumbent firm even be assumed to be advantaged over potential entrants. Apparently the same is true with the telecom sector in developing countries which require substantial initial investment of capital and

significant proportion of it turns out to be a sunk cost. As per Coursey et al (1984), potential entry or competition in a contestable market disciplines behavior almost as effectively as would actual competition within the market. Thus, even if operated by a single firm, a market that can be readily contested performs in a competitive fashion. In line with this Shepherd (1995) maintained that perfect contestability nullifies the impacts of a monopoly. So that public policy makers should concentrate on promoting contestability of the market how much concentrated is it.

3.1.2 Analysis of a Multiproduct Firm Cost Function

The problem with public utilities is that there would be a likelihood of abuses if the market depends on a single supplier. In order to address this problem policy makers have struggling in searching for an optimal market structure that would maximize the social welfare. Evans & Heckman (1984) refereeing Elizabeth & Friedlander (1982) argued that when all firms (actual or potential) have access to the same technology, properties of the firm cost functions reveal the most efficient industry structure

So far studies were focusing on a singleproduct firm, or different outputs of a firm were aggregates to come up with a single composite product. This is because of heterogeneity of output was not given due emphasis in analyzing a cost function so as to justify the feasible market structure in an industry. Therefore, results of such studies have to be taken with cautious. Currently heterogeneities of an industry outputs are acknowledge and thus literatures on a multiproduct firm production and cost function are accumulating.

Mester (1987) argued that optimal firm size and product mix of a multiproduct firm can be determined once structure of the cost function is identified. The latter might be studied based on concepts of scale and scope economies. The presence of scale economies would imply that smaller firms (potential entrants) that operate at a small scale would be at a cost disadvantage compared with larger established firms. A finding of economics of scope (i.e., economies of joint production) would imply that firms that were specialized would be at a cost disadvantage and may lead to inefficient production as compared with joint production of outputs.

Scherer and Ross, (1990) pointed out that economies of scale are best analyzed in terms of three categories: product-specific economies, associated with the volume of any single product made and sold; plant specific economies, associated with the total output (possibly encompassing many products) of an entire plant or plant complex; and multi-plant economies, associated with a firm's operation of multiple plants.

In this country telecommunication services are delivered by a single operator and analysis of scale economies is made from the point of view of multi-plant and product specific economies of scale.

Accurate information about the presence or absence of economies of scale and scope would be of particular interest for regulators of supposed natural monopolies. Given such information, regulators could in principle proscribe the set of products to be produced by a regulated firm, as well as the scale of its operations, in order to enhance productive efficiency, Chappell & Wilder (1986). In line with this Kim (1987) argued that,

> *…evidence of scale economies is central to the continuing debate over the existence of natural monopoly, the applicability of marginal cost pricing and the possible advantages of increased competition in public and regulated industries. Therefore, the direction of public policy towards an industry depends heavily on the nature and existence of scale economies in this industry. If economies of scale actually exist in the provision of services, then a valid policy argument can be made for the establishment of a large firm in order to gain the benefits of these economies.*

However, it is an outdated view to give due emphasis merely to scale economies as a justification to natural monopolies. This is owing to the classical analysis of scale economies in a single product firm by considering every outputs of an industry as homogeneous. Since heterogeneities of outputs are being recognized the traditional methodologies of cost analysis should be modified in line with a multiproduct firm framework. Hence, it is subadditivity of the cost function rather than the economies of scale that matters in determining an efficient market structure.

As per Evans and Hekman (1984), cost function is said to be subadditiue if (with given input prices) one firm can produce a given output vector, Q, more cheaply than it can be produced by two or more firms, each of them with the same cost function, C(q).

Formally, cost subadditivity implies that:

$$\sum C(q_i) > C(Q), \text{ where } Q = \sum q_i$$

Subadditivity is obviously the basic criterion which must be satisfied if cost savings are to be achieved by combining firms so as to achieve an efficient market structure, Baumol and Braunstein (1977).

According to Evans and Hekman (1984), the presence of economies of scope is a necessary condition for a subadditive cost function. Whereas cost complementarities defined as economies of scope coupled with a declining average incremental cost for each product is a sufficient condition for subadditivity. As to Sing (1987), cost complementarities are present when the marginal cost of producing one product decreases when the quantity of the other product is increased.

Scope economies exist if the cost of producing each product separately exceeds the cost of producing all products jointly. In line with this, Bailey and Friedlander (1982) suggest three sources of scope economies: sharable inputs, networking of activities within an industry and sharable intangible assets.

To Evans and Hekman (1984) and Sing (1987), subadditivity of the firm cost function is a necessary and sufficient condition for natural monopoly to be an efficient market structure, provided that all firms have access to the same technology and market coordination between separate firms is unable to achieve the same economies (say by networking or pooling arrangements) as internal coordination within a single firm.

3.1.3 Regulation

Infrastructural industries in many parts of the world have been dominated by a single or few suppliers dictated by optimal resource allocation in the economy. Since competition can not emerge without being cost inefficient there has to be a check to potential market abuses in such instances of industry configuration. Accordingly, involvement of the government in the form of regulation is inevitable to discipline the market conduct and performance so as to maximize economic welfare.

According to Bailey (1995), regulation refers to government's direct control of an industry's structure, conduct and/or performance. For Crew (1982), regulation means control over the actions of private individuals and business over what they may do, and sometimes how they may perform certain activities.

Government intervention in terms of regulation brings into play a monopoly in line with a socially acceptable track. It takes place on the one hand to capture the least cost scale of technology only available with the monopoly, and on the other hand, to attempt to control the abuses of monopoly power that would be there in the absence of regulation, Crew (1982). For Mayo (1984**),** regulation of public utilities prevents monopolistic pricing while still permitting the most cost efficient industrial structure

Crew (1982), however, stated that regulation limits the ability of monopolist to charge monopoly prices, but not in a way that leads to optimal prices for its services, competitive returns on investment, static and dynamic cost minimization, and optimal service quality. Because regulation constrains prices, regulated monopolies cannot

exercise all of their market power simply by setting monopoly prices. Moreover, Mayo (1984) confirmed that regulation generally does not guarantee that regulated firm's costs are held at the lowest possible level for a given amount of output. It seems then that regulation results in a tradeoff between cost savings from efficient industrial organization and cost inefficiencies, generically known as x-inefficiencies. It is therefore an empirical question for effectiveness of regulatory outcomes and is up to policymakers in this regard to weigh the pros and cons of alternative policies.

Basically, there are two main forms of regulation, Price-cap and Rate of Return Regulation. Notwithstanding differences between them, both are aimed at enabling effective provision of utility services in line with a perceived competitive outcome. However, there is a general preference to a price cap regime by many regulatory bodies.

3.1.3.1 Rate of Return Regulation (RRR)

RRR is a form of price regulation whereby regulatory authorities set the maximum rate of return on employed capital that the regulated company may exploit. Prices are set at a level that the company is assured of a certain return on its investment after recouping its operating costs, with a periodic adjustment of rates in line with cost changes. Beesly (1997) characterized the RRR as:

The regulated company files a tariff when it wishes to revise it prices. For an agreed test period (usually the latest 12 months) the company calculates operating costs, capital employed and cost of capital. The regulator audits these calculations and determines a fair rate or return on capital employed. These data plus the assumptions about demand are used to calculate the total revenue requirement. This determines the level of tariff…An approved tariff generally stands until the company files to change it, usually on the grounds that the achieved rate of return has become inadequate.

RRR was more practiced in U.S.A. Nowadays RRR is less employed due to its apparent drawbacks and regulatory bodies in many countries are shifting to a price cap regime. Bailey (1995) figured out the main disadvantages of RRR as:

1. Lack of incentive to regulated firms in reducing costs, since any increased profits would lead to the company breaching its rate of return ceiling with the result that prices would have to be reduced.

2. The bias towards capital-intensive production methods ('the Averch-Johnson effect').This cost-plus inefficiencies and over capitalization expand the rate base (i.e. the value of capital employed) against which the rate of return is measured and so allows a higher absolute level of profits for a given relative rate of return.

3. The extremely detailed nature of regulation in terms of defining the rate base and monitoring the rates of return actually achieved.

Majumdar (1997) corroborates to the above points by contending that the sources of misgivings with RRR arise from x-inefficiencies entailed in the method. It is intuitive that, if a firm is allowed to charge a price that will cover all its costs, the firm has little incentive either to reduce costs or to look for innovative ways of reducing such costs. The firm does not, in any way, suffer from being x-inefficient, and x-inefficiencies are passed on to customers.

3.1.3.2 Price Cap Regulation

This involves setting a maximum price ('price cap'), either individual price cap, a ceiling being set on each individual output, or a tariff-basket price cap, a ceiling set on the average of prices for a specified range ('basket') of services, Bailey (1995). He further argues that

> *Individual price caps provide more guarantee for consumers in controlling the prices of individual services; the tariff basket price cap cannot do this. However, individual price caps are more complex to administer. They require much greater information about the costs of individual services and become out of date more quickly as service-specific costs change. They may also restrict the action of companies in terms of their ability to rebalance costs and tariffs or respond to market developments. Put simply, individual price caps lack the basic*

simplicity of the tariff basket price cap. However a tariff basket price cap allows the regulated company to alter its relative prices as it wishes. It may afford the company too much freedom to manipulate prices.

As per Bailey (1995) the advantages of a price cap regulation is that it addresses the drawbacks of a ROR. Specifically,

1. Companies have an incentive to reduce costs because they retain any profits arising from improved internal efficiency.

2. There is no bias towards capital investment or recruitment of labor since there is no rate base against which rates of return are judged.

3. A price cap is simple to administer, market prices being much more salient than costs of production.

The following formula is used by many regulatory bodies in line with a price cap regulation:

$$P = RPI - \chi$$

Where RPI = Growth rate of retail price index (analogous to consumer price index)

χ = the productivity offset.

As per Loube (1995), the productivity offset measures the difference between the productivity of the regulated industry and the productivity of all industries in the economy. He further contends that, the formula is designed to reflect the average cost

change experienced by a representative competitive firm in the industry. If an individual company performs better than average, it is allowed to retain its surplus earnings. If its performance is worse than average, stockholders are penalized with lower profits.

A Price cap plan differs according to how measures of inflation and the productivity offset are determined in the formula. According to Loube (1995), the measure of the productivity offset can be derived from:

1. Productivity change of a specific company,
2. Industry average productivity change,
3. Industry average productivity change less the national productivity change, or
4. Productivity change that represents the best practices of the industry.

In a multi-product company, the price cap formula focuses on price cap indices rather than an individual price. The former is a weighted average of allowed rates for a basket of services delivered by a company. Then the actual price index of services in the basket would fluctuate within the upper and lower limits. However, a price cap regulation is not without a problem. The counter arguments are, ibid:

1. The maximum price may become the minimum price. In other words, the regulated company may view the maximum price as a right and fully exploit the price cap.

2. It creates considerable uncertainty regarding the actual outcome of regulation. Uncertainty becomes greater the longer the price cap is in place. Profit levels could be much higher or much lower than those envisaged when the price cap was set, depending on changes in both costs and volume of sales.

3. Quality and universality of services may be reduced, contrary to public policy objectives, because the price cap creates a great incentive to reduce costs (in facilitating increased profits).

Moreover, the experience of price cap regulation reveals that it does not protect monopoly customers, it allows utilities to engage in cross subsidization, and it does not establish a level playing field that would nurture the development of competitive markets, ibid.

3.2 Empirical Literature

So far public utilities like telecommunications were simply taken as a natural monopoly and governments prevented development of competition by precluding entry of firms into the market. Writers have been figuring out various features of such industries which set barrier to entry of multiple firms. Industries which were perceived to be natural monopoly have been regulated. Economists then began to question arguments of the public utility theory in general and legitimacy of the supposed natural monopolies in particular. This section provides some empirical researches done in order to evaluate the best market structure from the angle of cost savings.

In 1984 Evans & Hekman presented an influential paper entitled "A Test for Subadditivity a Cost Function with an Application to the Bell System". Their work pioneered a new test of cost subadditivity in a multiproduct firm setting which doesn't require global information on firm cost function. So far, analysis of a natural monopoly requires extrapolation of estimated cost function outside the range of the available data in deriving the necessary and sufficient condition for subadditivity. It also provides an easily computed rejection criterion for the hypothesis of additive cost function.

The test is performed in such a way that a monopoly output (the Bell System) is divided into two hypothetically competing firms. Then a subadditivity test would be applied to a pair of firms constructed by satisfying certain conditions. Since the test would be made on the actual data of the monopoly, the result is more robust than the traditional method. They estimated a trans-log cost function for the U.S. Bell system and applied the test using time series data of the firm from 1947-77 by assuming that it produces local and toll telephone services with capital, labor and material are taken as inputs of production. A maximum likelihood technique was used in joint estimation of the cost function with the two factor share equations. Finally, they rejected the hypothesis that the Bell System's cost function is subadditive implying that it was not optimally decentralized itself during the sample period and was therefore operating inefficiently.

Sung and Gort (2000) investigated cost subadditivity of the U.S. local telephone industries by using the Evans & Hekman method. Eight LECs (telecom companies) have been selected for the study using pooled, cross-sectional and time-series data. They estimated a trans-log cost function by incorporating differences in input qualities. They found regions of monopoly gain and cost subadditivity for the sample period. However, both have a decreasing trend with firm size, as the largest firms turned to have no cost savings from the monopoly. Negligible economies of scale were found which declines with firm size. They, therefore, concluded that entry and rising competition in the local and regional markets are unlikely to have adverse effects on costs and monopoly is not necessary for efficiency.

Sing (1987), examined scope and scale economies to determine whether gas and electric utilities are more efficiently supplied by a combination or separate utilities. The cost function for the gas and electric utilities were estimated by a multiproduct hybrid trans-log cost function. Unlike the Evans and Hekman , Sing made a Box-Cox transformation on the output variables which permits inclusion of zero value of outputs. The estimated cost function indicates diseconomies of scope at the mean combination utility output vector. He concluded that at the mean output levels a combination gas-electric utility is not a natural monopoly and suggested that factors other than cost savings are responsible for the existence of combination utilities.

Chappell & Wilder (1986) presented an article to analyze the multiproduct cost functions of gas-electric utilities in the United States using the 1980 data. The

quadratic cost function was specified and estimated using ordinary least squares. They found remarkable economies of scale and scope over most of the relevant range of outputs leading to a conclusion that electric-gas utilities could be a natural monopoly. They also recommended that regulators should not limit the size of utilities or restrict them to production of either gas or electricity exclusively since such policies are potentially damaging to productive efficiency.

Hunter et al (1990) using a multiproduct cost function approach examined subadditivity of costs in a sample of 311 largest commercial Banks in the United States. They extended the Evans and Heckman approach of grid subadditivity to fit with the Banking industry. Their findings indicate no evidence of significant scale economies or cost subadditivity and thus cost complementarities were not the main reason for a multiproduct setting for the largest banks. So that it would pay for the large banks to break up production into hands of several firms. They further argue that the existence of these larger multiproduct banks is consistent with their offering product mixes and branch configurations that minimize both bank costs and the transactions costs incurred by consumers in the acquisition of financial services or with a diversification motive.

Mester (1987) in his paper entitled ‘A Multiproduct Cost Study of Savings and Loans’ investigated the cost structure of California Savings and Loans for the year 1982 using a multiproduct firm approach. A maximum likelihood technique was employed in estimating the cost function of the company. The findings indicated that savings and loans exhibit neither global nor product-specific economies of scope and that no two

outputs have been cost complements. So no evidence of a natural monopoly was found in the study period. Non-production (cost) motivations such as customer convenience and diversification to reduce risk may explain why savings and loans provide these outputs jointly.

CHAPTER FOUR

METHODOLOGICAL FRAMEWORK

4.1. Analysis of a Multiproduct Firm Cost Function

It is imperative to analyze cost function of a multi-product firm so as to determine an optimal size and product mix of a firm in a given market that would result in optimal resource allocation in the economy. Scholars are inquiring validity of a public utility theory, particularly the existence of a natural monopoly, from economic efficiency point of view. This chapter deals with the methodologies that would be used in analyzing cost structure of the Ethiopian Telecommunication Corporation viewing it as a multiproduct firm offering a variety telecoms services.

4.1.1 Economies of Scale

Scale economies or returns to scale are usually defined in terms of the relative increase in output resulting from a proportionate increase in all inputs of production. Hanoch as referred by Kim (1986), indicated that it is more appropriate to represent scale economies by the relationship between cost and output along the expansion path where input prices are held fixed and costs are minimized at every level of output.

In a single product industry Scale economies (SE) are measured by the relationship of

average cost (AC) to marginal cost (MC) at a certain level output, for a given level of input prices:

$$SE = AC / MC = \{C(Q) / Q\} / \{\partial C / \partial Q\} = 1 / \sum \varepsilon$$

Where ε is an elasticity of cost with respect to output Q,

SE >, < or = 1, as production of Q revealed increasing, decreasing or constant returns to scale, respectively.

The concept of scale economies can be customized to a multiproduct firm framework by considering two related concepts: Ray Scale Economies and Product Specific Scale Economies.

Ray scale economies (RSE) are a straightforward extension of the classical scale economies (SE) in a single product firm. It indicates the behavior of cost as the production level of a given bundle of output changes proportionally while the composition of output is kept constant:

$$RSE = [\sum_j C(Q) / Q_j] / [\sum_j MC_j] = 1 / \sum \varepsilon_j$$

Where MC_j = the marginal cost of output j,

ε_j = elasticity of cost with respect to output j.

RSE >, < or = 1, as the estimated cost function exhibits increasing, decreasing, constant returns to scale , respectively, in production of an output bundle given by Q.

While RSE describes the behavior of cost as output is varied along a given ray, it does not describe the full behavior of costs when compositions of output change. An additional dimension of this behavior can be measured by product specific scale economies (PSE) which provides the citrus paribus degrees of scale economies attributable to a particular output. In line with this, it is imperative to define a related cost concept so as to shed light to the analysis of product-specific economies of scale in a multiproduct firm setting. This is given by an incremental cost (IC_j) of each output which is defined as the addition to total cost when output j is produced in positive quantity. As per Kim (1987), IC_j is given by:

$$IC_j = C\ (Q_N) - C\ (Q_{N-j})$$

Then an average incremental cost (AIC) of output j would be,

$$AIC_j = IC_j\ /\ Q_j$$

Product-specific returns to scale to output 'j' (PSE_j) are measured by, ibid:

$$PSE_j = AIC_j\ /\ MC_j = IC_j\ /\ (Q_j \times MC_j) = IC_j\ /\ (C\ (Q_N) \times \varepsilon_j)$$

PSE_j >, < or = 1, as the cost function exhibits increasing, decreasing or constant returns to scale with respect to output j, respectively.

Analysis of product-specific scale economies requires knowledge of the multi-product cost functions with and without output j, C (Q_N) and C (Q_{N-j}). To derive the latter, it is necessary to evaluate the cost function at zero level of output j. A problem would be encountered when a translog structure is used in estimating a cost function. This is because such a cost function doesn't allow a zero value of output since every parameter would be converted into logarithm. As per Kim (1987) and Mester (1987), a solution to this problem is to estimate fixed costs at an arbitrarily small level of output; experimental analysis suggests defining the minimum level of output at 10% of output at the sample mean. A rationale for this approach is that a substantial percentage of total cost remains even when output levels are zero.[2]

However, we have to be cautious in interpreting the result in that an incremental cost of a product in such setup depicts differences in fixed costs rather than differences in individual total costs of each output.

4.1.2 Economies of Scope

Product specific scale economies reflect the partial returns to scale as they measure the effect on costs of a ceteris paribus change in one type of output. To capture fully the effects of changes in bundle of output on cost a measure of scope economies should be employed. Scope Economies (SCOP) are defined as the fraction of cost that is saved by joint production of various outputs as compared to specializing in a single output,

$$SCOP = [\sum C(Q_j) - C(Q)] \; / \; C(Q)$$

[2] See also Cowing and Holtmann (1983)

Where C (Q_j) is the standalone production cost output j.

A positive (negative) value of SCOP signals cost savings (dissavings) in a monopoly market structure against multiple specialty firms for the same level of output. The problem here is how to find a standalone cost for each output of the firm. If the firm under the study has specialized in either product, a zero level of that product might be extrapolated to arrive at the standalone cost of production for each output. If a translog cost function is specified similar problem would be encountered as the case in measuring an incremental cost of a product. Therefore, a similar mechanism would be used as stated in the previous section to a zero level of output.

4.1.3 Cost Complementarities

Cost complementarities are present when the marginal cost of producing one product decreases while the quantity of the other product is increased. Unlike scope economies which compare cost efficiencies of a monopoly versus multiple single-product firms, cost complementarities provide an insight to potential cost savings associated to joint production of two outputs. For a twice continuously differentiable cost function, cost complementarities are present if,

$$\partial^2 C\ (Q)\ /\ \partial Q_i\, \partial Q_j \leq 0, \text{ for } i \neq j$$

On the other hand Q_i and Q_j are cost discomplemented when the above inequality is reversed.

4.1.4 Cost Subadditivity

As per Evans & Heckman (1984), the cost function of a multiproduct firm is said to be subadditive if for an output vector Q:

$$C(Q) < \sum_i C(Q_j)$$

Where $\sum Q_i = Q$, with a constraint that the Q_i output vectors are nonnegative and have at least two nonzero elements**.** The cost function is superadditive (additive) if the above inequality is replaced by '>' (=).

It is imperative to know the degree of cost subadditivity of a firm in order to come up with a reasonable regulatory setup in an industry. In a multiproduct firm, economies of scope are a necessary condition for cost subadditivity; whereas the presences of cost complementarities (scope economies) besides product specific economies scales are a sufficient condition. A finding of cost subadditivity for all relevant range of output vectors of a firm is sufficient for the existence of a natural monopoly. Consequently, economic efficiency calls for a single player in the supply side of the market with an appropriate policy to galvanize the incumbent firm from competitive entry. According to Evans and Heckman (1984), the relevant output vectors are those which are consistence with industry equilibrium given demand and cost conditions for alternative possible organization patterns of the industry (for example, multi-firm vs. single-firm).

The study extends the Evans and Heckman (1984) 'grid subadditivity test' in examining cost structure of the ETC. It necessitates selecting an admissible region for each output vector of the firm in lieu of excessive extrapolation of estimated cost function well beyond the range of observed data in measuring the standalone cost of production. Nor does it requires an arbitrarily formulation of a minimum output level in place of a zero output.

The test is commenced in such a way that an observed output vector of the incumbent firm is divided into two and cost comparison is made between a monopoly versus duopoly market configuration. Although the monopoly outputs are partitioned among two hypothetically competing firms, all other variables in the cost function are left unchanged. Such comparison makes product-mix-cost comparisons more realistic as it is based on actually observed product mixes. A vector of output which is within an admissible region of output combination is divided between the two competing firms satisfying two constraints:

1. Each hypothetical firm must produce at least the lowest output level that the incumbent monopoly produces. If the lowest level of an output 'j' observed in the sample is '$\min Q_j$', then:

Firm 1 produces: $Q^1_j = \gamma\, {}_{var}Qj + {}_{min}Q_j$

Firm 2 produces: $Q^2_j = (1-\gamma)\, {}_{var}Qj + {}_{min}Q_j$

$$0 \leq \gamma \leq 1$$

Where, ${}_{min}Qj$ = minimum level of output j,

$_{var}Qj$ = variable level of output j (the increment to $_{min}Q_j$), and

Q^1_j & Q^2_j = output j of the first and the second competing firms,

When we aggregate outputs across firms,

$$Q_j = {}_{var}Q_j + 2_{min}Q_j$$

Thus,

$$_{var}Q_j = Q_j - 2_{min}Q_j$$

For a non-negative $_{var}Qj$, $Q_j \geq 2minQ_j$. Therefore subadditivity test would be restricted to admissible regions of output vectors which are at least twice the lowest output level in the sample.

2. The second constraint implies that the vector of variable quantity, $_{var}Qj$, for each competing hypothetical firm should satisfy:

$$_LR_j \leq (_{var}Q_j + {}_{min}Q_j) \;/\; \sum_j [(_{var}Q_j + {}_{min}Q_j)] \leq {}_UR_j$$

Where $_LR_j$ and $_UR_j$ are the lower and the upper product mix ratios obtained from the range of ratios observed in the data. The second constraint precludes the hypothetical firms from specializing in either output than the firm for which data is available i.e. the incumbent operator.

Possible pairs of multiproduct firm configurations which lie within the admissible region are constructed by varying γ over a grid given by $\gamma = m, n$; m, n = 0, 1, 2, 3…, g where g is the grid size.

For each cell within the grid, the degree of subadditivity is measured by:

$$\text{Sub}\gamma = [C(Q) - C(Q_\gamma)] \;/\; C(Q)$$

It measures cost differences between a single versus a pair of competing firms producing the vector of output, Q. If Subγ <, =, or > 0, the cost function is subadditive, additive or superadditive, respectively, with output pattern determined by 'γ'.

4.2 Specification of a Cost Function

A multiproduct firm cost function can be specified in the form of quadratic, standard translog, hybrid (generalized) translog or a constant elasticity of factor substitution cost structure. However, there is a general preference to an ordinary translog approximation to multiproduct technologies owing to its flexibility in testing specific features of technology (like returns to scale or homotheticity) by examining the estimated model parameters, Ray (1982).

A hybrid translog cost function is an extension to the standard translog function in such a way that some or all parameters of the cost function are Box-Cox transformed so as to admit a zero level of outputs.[3] Mester (1987), however, argued that a hybrid translog function is more difficult to analyze its results because many of its cost

[3] As per Pulley & Braunstein (1992), a Box-Cox transformation to an output vector Q in a hybrid translog cost function for a box metric λ implies:

$Q^{(\lambda)} = (Q^{\lambda} - 1) / \lambda$ for $\lambda \neq 0$

$= \ln Q$ for $\lambda = 0$. So that zero values for individual outputs are allowed for $\lambda > 0$, and

The standard translog cost function results when $\lambda = 0$.

properties cannot be represented as tractable functions of its parameters. Moreover, from an empirical standpoint the apparent advantages of the generalized translog form in multiproduct studies may be illusory and comparable results might be obtained as an ordinary translog form and is apt to create similar problems in modeling the costs of specialized production, Pulley & Braunstein (1992). Therefore, the study utilizes the standard translog approximation to the true technologies of the ETC specified as follows:

$$\ln TC = \alpha_0 + \sum_m \alpha_m \ln P_m + 1/2 \sum_m \sum_n \alpha_{m,n} \ln P_m \ln P_n + \sum_i \beta_i \ln Q_i + 1/2 \sum_i \sum_j \beta_{i,j} \ln Q_i \ln Q_j + \sum_i \sum_m \theta_{i,m} \ln Q_i \ln P_m + \upsilon$$

m, n = inputs l, k & o

i, j = outputs UT, TT & DS

Where, TC = Total cost,

UT = Urban telephone services

TT = Toll telephone services (Long distance and international telephone services)

DS = Data telephone services

P_l = Price of labor

P_k = Price of capital

P_o = price of 'other'

υ = random error term

Any cost function ought to satisfy certain regulatory conditions for it to be a result of cost minimization process. Varian (1992) summarized the following properties of the cost function:

1. Non-decreasing in input price, P;

- If $P_a \geq P_b$, then $C(P_a, Q) \geq C(P_b, Q)$

2. Homogeneous of degree one in P (linear homogeneity);

- $C(tP_a, Q) = tC(P_a, Q)$, for $t > 0$

For the translog cost function specified earlier homogeneity implies:

a. $\sum_m \alpha_m = 1$

b. $\sum \alpha_{m,\,n} = \sum \alpha_{n,\,m} = 0$

c. $\sum_m \theta_{i,\,m} = 0$

3. Concave in P;

- $C(tP_a + (1-t)P_b, Q) \geq tC(P_a, Q) + (1-t)C(P_b, Q)$

4. Continuous in P;

- $C(P, Q)$ is continuous as a function of P, for $P \gg 0$.

Ahead of estimating the cost function, restriction for symmetry and homogeneity conditions would be imposed. Symmetry implies the following:

1- $\alpha_{m,\, n} = \alpha_{n,\, m}$

2- $\beta_{i,\, j} = \beta_{j,\, i.}$

To enhance efficiency of estimation, the full dual system (i.e., cost and share equations) is simultaneously estimated using Zellner's seemingly unrelated regressions procedure. Since the coefficients in the share equation are subsets of those in the cost function, such joint estimation compensates the information inadequacy in the cost function alone, Ray (1982).

From the translog cost function and Shepherd's lemma (derivative property), we derive the factor share equations, i.e. the share of the total cost accruing to input m, as:

$$\partial \ln C / \partial \ln P_m = [\partial C / \partial P_m] \times [P_m / C] = P_m . \chi_m / C$$

Where χ_m is quantity of input 'm'; in the dual system, however, prices of inputs as opposed to the quantity are used. Therefore, from the translog cost function (Pp. 48) the factor share equation (S_m) would be computed as:

$$S_m = \alpha_m + 1/2 \sum_n \alpha_{m,\, n} \ln P_n + \sum_i \Phi_{i,\, m} \ln Q_i$$

The assumption of linear homogeneity in input prices implies the sum of share equations to be unity. Hence one of the share equations should be dropped while estimating the cost function so as to avoid a problem of singularity.

4.3 Source of Data

The study is based on a secondary time series data collected for 1977/78-2006/07. The sources of the data are mainly Ethiopian Telecommunications Corporation (ETC) annual report and annual statistical bulletin (various years), World Telecommunication Indicators Database 2006, World Telecommunication Development report 2006 and Ethiopian Telecommunication Agency's (ETA's) annual report.

4.4 Measurement of Variables

The intention of the study is directed to assess efficiencies of the telecommunication sector in Ethiopia and evaluate whether it is preeminent to be a single operator of telecom services in the country. Currently ETC provides a variety of services ranging from fixed telephone services to modern data communication services. When it is viewed as a multiproduct firm, optimal disaggregation of output is needed so as to shed light to heterogeneity of output rather than studying in a single product firm framework. However it is impossible, or quite difficult, to incorporate each service of the operator in the study as distinct output given that limited number of observation or absence of data at all for some variable would handicap the econometric process.

In line with this, output of the operating firm is disaggregated as services of urban telephone, toll telephone (long-distance & international telephone services), and Data telephone services. However, the study couldn't take services of internet and mobile services as distinctive outputs. This is because these services are relatively a recent phenomenon and the few observation period would result incompatible sample years

for the econometric analysis. Hence the internet services is aggregated with fax and telegraph services and named as ‘data telephone services’ whereas mobile telephone service is added to urban telephone services. Long distance and international telephone services are named as toll telephone services. An amount of revenue obtained from particular services for each fiscal years ended is used as a proxy to the respective quantity of outputs.

Total cost of the operator equals total expenditure made to inputs of labor, capital, and the ‘other’ factor. The assumption here is that these inputs are weakly separable from other inputs, such as material costs. The ‘other’ factor denotes residual expenses from total cost over and above the expenses of labor and capital. The price of labor equals annual salaries, training and other administrative expenses divided by the number of employees in each fiscal year. Difficulties are encountered in measuring total capital cost of the operator as no data is available in this regard. Hence, capital costs are approximated by annual maintenance and depreciation expenses of equipments. A crude price of capital is obtained by dividing annual capital cost by the number of subscribed telephone lines in each year. The ‘Other’ cost is in turn divided by the number of subscribed telephone lines in each year to arrive at the price of the ‘other’ factor. The factor shares are computed by dividing a cost attributable to each input by the total cost, where the cost shares sum to one.

CHAPTER FIVE

ESTIMATION AND EMPIRICAL RESULTS

5.1 Descriptive Statistics of Variables

In this chapter the translog cost function specified in the previous chapter (Pp. 48) is estimated and its parameters are used in testing cost subadditivity of the Ethiopian Telecommunication Corporation. Its outputs are disaggregated into urban telephone call, tall telephone call and data telephone services. Labor, capital and the composite 'other' factors are employed as inputs of the operator. Thus total cost of the operating firm is a sum of expenditures allocated to each input. Descriptive statistics of the cost function variables are summarized in the following table.

Table -1 Summary Statistics of the Variables

	variable	Notation	Mean	Minimum value	Maximum value	Std. dev.
1	Total cost	TC	$7.19x10^8$	$1.2x10^8$	$2.63x10^9$	$7.04x10^8$
2	Capital share	S_K	0.6347427	0.4671858	0.7339186	0.0469331
3	Other share	S_O	0.2950784	0.1967247	0.474537	0.0492443
4	Labor share	S_L	0.0696358	0.0495744	0.0868942	0.0094826
5	Price of capital	P_K	1217.681	252.5992	252.5992	3880.199
6	Price of other	P_O	647.2095	92.4152	2472.559	682.4678
7	Price of labor	P_L	6841.085	2121.36	14526.36	3661.519
8	Urban telephone	UT	283,908,108	30,254,147	1,532,563,654	$4.29x10^8$
9	Toll telephone	TT	213,017,899	14,521,478	675,425,623	$1.98x10^8$
10	Data services	DS	24,152,595	8,514,256	85,262,145	$3.58x10^7$

Where, TC is measured in Birr;

P_L in Birr per employee per annum;

P_K & P_O in Birr per number of fixed telephone lines per annum;

UT, TT & DS in minutes.

As can be seen from Table 5.1, the maximum and minimum amounts of total cost are $2.63x10^9$ Birr and $1.2x10^8$ Birr, respectively. Capital expenditure accounts for significant proportion of the total cost followed by 'other' factor expenses for the whole sample point. The mean values of the cost shares are 63.5%, 29.5% and 7% respectively for capital, the 'other' and labor inputs. This implies that ETC has been employing a capital intensive production technique. It also implies that labor is a relatively cheap factor of production as the reward to it is relatively low. Urban telephone call leads in terms of quantity of delivery followed by toll telephone call and Data Services. For the sample period, ETC's telecoms services on average constitutes 54%, 41% and 5% of urban telephone, toll telephone and data services, respectively.

5.2 Estimation of the Cost Function

The cost function is estimated together with two cost share equations using Zellner's Seemingly Unrelated Regression (SUR) technique, while the right-hand variables are expanded about their mean. Since the share equations sum to one, one of them should be dropped so as to avoid a problem of singularity. Thus the labor cost share is dropped and the cost function is estimated jointly with the capital and 'other' cost share equations by imposing symmetry and homogeneity restrictions on the cost

function. Estimated parameters appearing in both the cost function and the share equations are unique and indifferent whichever share equation is being dropped.

In order to provide a good approximation to the true cost function, the estimated cost function must satisfy certain regularity conditions. That is, the cost function should be positively linear homogeneous, monotonically increasing and concave in input prices. Sing (1987), however, stated that flexible functional forms such as a trans-log cost function do not satisfy the regularity conditions globally, so that it is necessary to check local properties at each observation point.

Linear homogeneity is satisfied as it was a priori imposed in the estimation course of action. In order to test monotonicity, the cost function and the three input share equations are fitted. The fitted values of the cost and the other share equations turned to be positive for the whole sample point, while 80% of fitted capital and 75% of fitted labor share equations turned to be positive. Therefore, we can maintain that the estimated cost function is monotonically increasing in factor prices.

The local concavity is checked by computing eigen values of the Hessian Matrix for the estimated cost function. The Hessian Matrix is found to be negative, implying negative definiteness of the cost function with respect to input prices. Since each regulatory condition is fulfilled, the estimated cost function can be said to be well behaved. Table-2 (next page) depicts estimated coefficients of the cost function parameters.

Table-2: Estimated Coefficients of the Cost Function

Parameter	Variable	Value	Standard Error
α_0	constant	20.37981	.0053582
α_l	$\ln P_l$	.1090062**	.0565359
α_2	$\ln P_k$	.4888776*	.0844812
α_3	$\ln P_o$	.4021162*	.0720862
$\alpha_{l,l}$	$\ln P_l \ln P_l$	-.9191711*	.2513629
$\alpha_{1,2}$	$\ln P_l \ln P_k$	-.3934162	.4096683
$\alpha_{1,3}$	$\ln P_l \ln P_o$	.3988022***	.2457443
$\alpha_{2,2}$	$\ln P_k \ln P_k$	1.922966*	.4496837
$\alpha_{2,3}$	$\ln P_k \ln P_o$	-1.16057*	.2364976
$\alpha_{3,3}$	$\ln P_o \ln P_o$	.1513895	.1161306
β_l	lnUT	.3687594*	.0783455
β_2	lnTT	.2385451*	.0479218
β_3	lnDS	.2775764*	.061118
$\beta_{1,1}$	lnUTlnUT	-.3899315*	.0807872
$\beta_{2,2}$	lnTTlnTT	-.3180802*	.0513231
$\beta_{3,3}$	lnDSlnDS	-.4538534*	.0782195
$\beta_{l,2}$	lnUTlnTT	.8819138*	.1691354
$\beta_{l,3}$	lnUTlnDS	.6658057*	.1372472
$\beta_{2,3}$	lnTTlnDS	-.5925035*	.128476
$\theta_{1,1}$	$\ln UT \ln P_l$	-.0193887	.1181741
$\theta_{1,2}$	$\ln UT \ln P_k$	-1.003625*	.2258364
$\theta_{1,3}$	$\ln UT \ln P_o$	.1030635*	.1455313
$\theta_{2,1}$	$\ln TT \ln P_l$	.8003025	.2219489
$\theta_{2,2}$	$\ln TT \ln P_k$	-.6967964*	.2313424
$\theta_{2,3}$	$\ln TT \ln P_o$	.2640662***	.164429
$\theta_{3,1}$	$\ln DS \ln P_l$	-.4251798*	.2050402
$\theta_{3,2}$	$\ln DS \ln P_k$	.9956441*	.1944454
$\theta_{3,3}$	$\ln DS \ln P_o$	-.018086	.1410705

* significant at 1%, **significant at 5% and ***significant at 10%, R^2=99.12%

Out of 28 parameters of the estimated cost function, 19 are significant at 1%, 1 is significant at 5% and 2 are significant at 10%. The model fits well as evident from the high R^2 =99.12%. Moreover, all the first-order parameters are positive and statistically significant at 1% degree of significant except the variable lnPl which is significant at 5%.

5.3 Empirical Results

Building on the rudiments of a multiproduct firm technologies conceptualized in the previous chapters, the next step is to make operational and quantify those concepts. In the following sections, the two approaches to cost subadditivity are dealt.

5.3.1 A Traditional Approach to Subadditivity

The major objective of the study is directed to assessing whether monopoly is indeed a 'raison detre' outcome from the point of view of resource allocation in the telecommunication sector of the country. In this regard cost function of the operator is studied to compute the necessary and sufficient conditions of subadditivity. For that reason, a natural monopoly outcome is scrutinized indirectly by testing cost subadditivity, where the latter is a sufficient condition for the former.

Table-3: The Degrees of RSE, PSE and SCOP

year	Ray Scale Economies (RSE)	Product Specific Economies of Scale			Economies of scope (SCOP)
		PSE_{UT}	PSE_{TT}	PSE_{DS}	
1977/78	0.5019018	1.22873	1.492187	0.586309	2.205179
1978/79	0.5047754	1.269877	1.538255	0.541265	2.147734
1979/80	0.5144983	1.28669	1.541803	0.529201	2.084142
1980/81	0.5449339	1.352463	1.586041	0.577955	2.03289
1981/82	0.5641133	1.348707	1.573792	0.455846	1.803825
1982/83	0.5732568	1.41679	1.575136	0.449009	1.762171
1983/84	0.6211381	1.457312	1.603457	0.543374	1.675055
1984/85	0.6072958	1.563806	1.383903	0.46271	1.480977
1985/86	0.6301903	1.578516	1.477258	0.4349	1.576551
1986/87	0.6621749	1.674271	1.495303	0.457866	1.485714
1987/88	0.6998425	1.735155	1.607768	1.345957	1.487417
1988/89	0.6141857	1.959712	1.69588	1.297569	1.631496
1989/90	0.7082015	2.136611	1.601929	0.499578	1.477559
1990/91	0.8255932	2.257597	1.275006	0.943933	1.368425
1991/92	0.7766632	2.059122	1.031669	1.308828	1.653259
1992/93	0.9839474	2.643284	0.615288	1.590118	1.182704
1993/94	1.203216	3.223531	0.227715	2.534372	1.134151
1994/95	1.101664	2.146398	1.685747	2.509249	0.920137
1995/96	1.121205	2.519242	0.685959	1.261833	1.009698
1996/97	0.7248895	3.866513	1.338307	0.652884	1.155214
1997/98	1.039182	2.957184	0.85268	1.245329	1.289063
1998/99	.4479893	0.244275	0.701179	1.963168	1.888904
1999/00	1.286689	0.144555	1.093567	0.903067	0.469718
2000/01	1.448119	1.349214	0.6725	1.165834	0.797722
2001/02	0.753311	3.844474	0.741481	1.828789	0.856969
2002/03	1.408277	1.089327	0.818967	0.602244	1.16526
2003/04	1.067727	1.105382	0.735208	0.557467	1.246595
2004/05	0.775044	1.266486	0.898409	0.732818	0.911849
2005/06	0.688135	1.287708	0.800251	0.967649	0.703978
2006/07	0.664381	1.205369	0.875052	0.969891	0.572005
Average (1977/78-2006/07)	**0.802085**	**1.773943**	**1.174057**	**0.9973**	**1.372545**

In a single-product firm, increasing returns to scale as characterized by a declining average cost of production is a sufficient condition for a subadditive cost function. When multiple outputs are produced, however, scale economies are neither a necessary nor a sufficient condition for subadditivity. Scope economies are the necessary condition whereas ray scale economies coupled with cost complementarities (scope economies) are a sufficient condition for subadditivity.

In line with the traditional method Baumol et al as quoted by Evans and Heckman (1984) recommended testing the necessary and sufficient conditions for subadditivity separately. If the necessary condition is rejected, subadditivity is rejected. Similarly if the sufficient condition is accepted, subadditivity is accepted. A test for each condition is made in henceforth. The approach is called traditional as has been used by scholars over a long period to justify a natural monopoly outcome.

I. Ray Scale Economies (RSE)

So far, economies of scale have been taken as a criterion in identifying optimal market structure of public utilities. This is owing to the fact that almost all literatures were studying cost functions in a single product firm framework. Multiproduct setting of firms was ignored and inappropriate method has been used in aggregating heterogeneous outputs of a firm. Hence, results of such work gave rise to erroneous insight into policies of optimal resource allocation.

Noting the diversity of services being delivered by the firm under the study, ordinary cost concepts should be modified in light of a mutltiproduct technology. Since we cannot construct an unambiguous index of output for a set of heterogeneous products, it is difficult to compute an average cost function. Accordingly a concept analogous to an average cost is developed so as to reflect heterogeneity of outputs. The latter is called ray average cost, which describes the behavior of a cost function as output is expanded proportionately along a ray emanating from the origin. Accordingly, RSE measure the change in total cost when the bundle of output is varied proportionally along a given ray.

In measuring scale economies of the operator, elasticity of cost with respect to each output is measured. An inverse of each elasticity figure gives us the partial scale economy attributable to the respective output. The overall scale economy is obtained by summing the partial scale economy measures. From the translog cost function specified earlier in the study, RSE is computed as:

$$RSE = 1 \,/\, \sum [\partial \ln C \,/\, \partial \ln Q_j] = 1 / [\sum \beta_{i,\,j} + \sum \beta_{i,\,j}\, Q_j + \sum \theta_{i,\,m}\, P_m]$$

As can be seen from Table-3 (Pp. 58), the degrees of RSE exhibit both regions of economies and diseconomies of scale. 73% of observation points turned to be RSE < 1, implying that more decreasing returns to scale points have been obtained for the sample period. The average RSE is 0.80; whereas the minimum and maximum degrees were 0.45 and 1.45, respectively. Therefore, on average the industry has been operating on an increasing portion of ray average cost curve characterizing diseconomies of scale. This implies that there have been resource wastages as the

industry was operating over and above the minimum efficient scale in joint provision of the three telecoms services.

The finding here is in contrast to a traditional view that utilities like the telecommunication industry exhibit considerable scale economies owing to the existence of substantial fixed costs. Since the industry under the study is an old one the fixed costs which were sunk some years ago are well distributed in later years of operation leaving negligible impact to scale of output.

The above finding of diseconomies of scale, however, furnishes nil insight to efficiency justification of the prevailing market structure given that ETC is a multiproduct firm. It merely tells the fact that ETC has over utilized the optimal scale and thus resources have been misallocated as it has been operating on an increasing part of ray average cost curve, for the majority of sample periods.

II. Product Specific Economies of Scale (PSE):

Ray economies of scale in a multi product scenario measure the change in total cost when output is varied proportionally along a given ray. In reality output is not always expanded /contracted proportionally in multiproduct firms. A particular output may change owing to certain market shocks while the rest are unaffected. In such and similar circumstances, measures of ray scale economies cease to be used and product specific economies of scale alleviates such downsides. PSE measures the economies or diseconomies of scale uniquely tied to a single product, given that positive amount of other outputs are produced.

Computation of PSE is a bit difficult since an incremental cost of each output should be known. The latter is defined as an increase in total cost attributable to production of a particular output in positive amount. Since the firm under the study has never specialized in a single service within the sample years, output cannot be extrapolated to a region of zero level in measuring an incremental cost of a given service. Moreover, the structure of the cost function employed in this study, the translog cost function, exacerbates the same problem as it doesn't permit a zero value of output since it would be converted to a logarithmic value. Hence a zero value should be substituted by a certain low level of output. As is done in various literatures the minimum output is arbitrary set to 10% of mean values of each output in the observation period. This is because cost remains high even at zero level of output in a multiproduct framework. In this case an incremental cost of output provides an insight to differences in product specific variable cost of services. When an output is set to zero, or near to zero, it is only a variable cost of that particular product which is put aside. Fixed costs are invariant to the level of output. Thus, we have to be cautious in interpreting an incremental cost of output in multiproduct firm cost analysis. It captures differences in fixed costs arising from joint supply of various outputs, rather than differences in total cost of each output.

Table-1 (Pp. 53) shows that the mean quantities of urban telephone, toll telephone and data telephone calls in the sample are 283,908,108 minutes, 213,017,899 minutes and 24,152,595 minutes, respectively. Then, 10% of each figure is sequentially plugged

into the estimated cost function as a proxy to product specific fixed costs in arriving at an incremental cost of a given output.

As can be seen from Table-3 (Pp. 58), the estimated cost function exhibited different degrees of product specific economies of scale for each service of the operator. The urban telephone service registered quite high economies of scale, as 93% of observation points revealed an increasing returns to scale. The maximum and minimum levels of PSE_{UT} are 3.87 and 0.14, respectively. However, it doesn't have a clear trend in converging to regions of economies or diseconomies of scale attributable to the service. The average degrees of PSE_{UT} is 1.77, implying that ETC has been providing urban telephone service on the declining segment of average incremental cost of urban telephone services and has been far from its minimum efficient scale.

Similarly, the estimated cost function exhibited both economies and diseconomies of scale attributable to the toll telephone service. The maximum and minimum degrees were 1.68 and 0.23, respectively with an average of 1.17. Out of 30 observation points of the study, 18 points turned to reveal an increasing PSE for toll telephone service. Somewhere in the middle of the sample period the firm passed over and above its minimum efficient scale in provision of toll telephone service. However, the degrees of PSE_{TT} show a declining trend for the whole observation point as the firm expands provision of long distance and international call services.

Provision of the data services revealed regions of economies and diseconomies of scale over the sample period with maximum and minimum degrees of 2.53 and 0.43, respectively. Unlike the other outputs of the operator the data service has been, on

average, delivered on an increasing segment of average incremental cost curve of the service. 60% of sample points turned to show $PSE_{DS} < 1$, whereas the average degrees scale economies are 0.93. Not only that data services have been delivered in vicinity of its efficient scale, but also PSE_{DS} shows an increasing trend towards the optimal point over the sample period.

III. Economies of Scope (SCOP)

Product specific economies of scale measure the citrus paribus scale economies attributable to a single product. When the output mix is changed, however, measures of scope economy would be employed so as to compute the relative cost savings/dissavings from the existing multi-product firm versus specialty firms producing each product independently.

It is owing to scope economy or a potential for that matter which justifies the very existence of a multiproduct firm. As per Baumol and Braunstein (1977), economies of scope arise from the sharing or joint utilization of inputs. It arises, for example, if a given factor or input is imperfectly divisible, so that the production of a small set of goods would leave excess capacity in the utilization of that input. Alternatively, the input may have some properties of a public good so that when it is purchased for one production process it will then be freely available to supplementary segments of operation within the industry.

Economies of scope are said to exist when it is cheaper to produce a given outputs in combination rather than separately. In order to make such comparison, however, a

standalone production cost of each output should be known. Since the multiproduct firm under consideration had not specialized in either service, a single product cost function cannot be obtained by extrapolating a respective output to a region of zero output. As noted above the estimated trans-log cost function would not allow a zero level output. Hence similar mechanism is adopted herein as is used earlier in measuring an incremental cost of an output.

As evident from Table-3 (Pp. 58), the estimated cost function did turn out to exhibit considerable economies of scope for the whole sample point. The result is in accord with prior expectation that telecommunications industry is characterized by networking of activities between the different services, which would likely give rise to scope economies. The average degrees of scope economy is 1.37, implying that on average 137% of total cost is saved in joint supply of the three telecom services. Where as the minimum and the maximum degrees are 0.47 and 2.2, respectively. Therefore, ETC has minimized cost in joint provision of the three telecom services. The table also shows that SCOP exhibited a declining trend over the sample period, even though it doesn't turn into diseconomies regions.

IV. Cost Complementarities

Not only does a firm gains from joint supply of multiple outputs, it also achieves cost savings in certain pairs of output within the set of outputs. This feature is termed as cost complementarities. Parameters of the estimated cost function reveal the prevailing inter-product cost savings or dissavings emanating from a given pairs of services.

As can be seen from Table-2 (Pp. 56), the negative coefficient of interaction variable for toll call and data telephone services exhibited significant cost complementarities. Joint provision of these services would save 59% of costs of specialty firms for each service. However, inter-product dis-complementarities are obtained between joint provision of urban telephone service with both data service and toll telephone service. Therefore no pecuniary advantage in terms of cost savings accrue to joint provision of urban telephone service with the rest services of the operating firm.

The overall objective of this section is to test cost subadditivity of the Ethiopian Telecommunication Corporation viewing it as a multiproduct firm. The latter notion implies that the classical scale economies have no value in determining whether there is natural monopoly or not. Rather the sufficient and necessary conditions to cost subadditivity are needed to be tested separately. The necessary condition is satisfied as scope economies are obtained for the entire sample years. The sufficient condition demands the presence of product specific scale economies for each product coupled with cost complementarities (scope economies). Unlike the data telephone service which exhibits nearly constant returns to scale, the other services qualify to the sufficient condition. Scope economy is preferred to cost complementarities as it provides a robust result in cost comparison in a multiproduct firm. We may, thus, maintain that the sufficient condition of a subadditive cost function is satisfied. Therefore, ETC has been a natural monopoly provider of telecom services in the country for the study period.

5.3.2 Grid Subadditivity

The previous section deals with subadditivity test to the cost function of the telecom operator evaluated by the Traditional technique. It was noted that an empirical analysis of a cost function in computing the necessary and sufficient conditions for subadditivity is a bit difficult. Especially the structure of the cost function aggravated the problem by precluding a zero output level in arriving at incremental and standalone costs of a product.

This section employs the subadditivity test presented by Evans and Heckman (1984) in their article 'A test for Subadditivity of a Cost Function with an Application to the Bell System'. It is a new approach in that it provides the necessary condition for cost subadditivity that doesn't require global information on a firm cost function. Since the test is local, extrapolation of the cost function outside the range available data is not needed. It is based on the idea that if subadditivity is rejected in one region, global subadditivity must be rejected. In line with this Hunter et al (1990) argued that the grid approach is more robust than a traditional approach for analyzing subadditivity, since it examines cost characteristics for considerably more points along the multi-product cost manifold.

The test is undertaken in such a way that the observed output of the incumbent operator is divided into two competing firms, and then cost savings / dissavings is compared between a monopoly versus duopoly market structure.

The monopoly (incumbent operator) output is partitioned as follows:

$$Q^1 = [\lambda UT + {}_{min}UT, \eta TT + {}_{min}TT, \delta DS + {}_{min}DS]$$

$$Q^2 = [(1-\lambda)\ UT + {}_{min}UT, (1-\eta)\ TT + {}_{min}TT, (1-\delta)\ DS + {}_{min}DS)]$$

Where, $Q^1 + Q^2 = Q$;

The first exercise in implementation of the test is defining an admissible region for each output of the firm. It is defined by imposing two constraints so as to make the hypothetical industry output configuration in line with the incumbent operator's settings. The first is that each hypothetical firm must produce at least a minimum output level of the firm for which the data is on hand. The second constraint is that the final output mix should be consistence with the actual data, i.e. the two hypothetical firms should not specialize in either product than the existing firm.

In order to satisfy the first constraint we look for a point from the time series data of the incumbent operator where each output level is doubled. When we observe the data, the lowest quantities of the three services were delivered on top of the sample period, i.e., in 1977/78. Then, the minimum quantity that the competing firms should produce is set as follows:

${}_{min}UT$ = 30,254,147 minutes

${}_{min}TT$ = 14,521,478 minutes

${}_{min}DS$ = 8,514,256 minutes

Right from 1977/78 each output level shows an increasing trend and Toll telephone call doubled in 1985/86, whereas Data service and Urban telephone call doubled in 1987/88 and 1989/90, respectively. However, since the year 1989/90 the Data service has been fluctuating and on average declining up until 1998/99 when it again doubled the minimum output level. Since 1998/99 each service rises up and has never fell below two times the minimum output level. Thus, the year 1998/99 would be the first feasible period for the test to be carried out. Accordingly, an admissible region of output for the firm under the study includes services delivered within periods1998/99-2006/07.

The variable quantity ($_{var}Q_j$) which is an increment to the minimum required amount ($_{minr}Q_j$) of each output of the two firms are constructed by varying scalars λ, η and δ over a grid given by:

$$\lambda = i / g, \quad \eta = \mu / g \text{ and } \delta = \nu / g$$

$$i, \mu, \nu = 0,1,2,3\ldots g$$

Where g is the grid size; the grid size determines how many possible combinations of competing operators that could be formed for observation points within the admissible region. The study limits the grid size to 3, so that for each observation point in the grid 16 pairs of competing operators are formed for the experiment. The variable quantity is also determined in such a way that the final output mix produced by competing firms lie within the upper and the lower product mix ratios of the existing firm.

In the sample years the maximum and minimum ratios are UR_j = (0.6915355, 0.6845423, 0.1729837) and LR_j = (0.2955791, 0.2789339 0.00512), respectively for Urban telephone, Toll telephone and Data services.

Once observed outputs of the firm are distributed into the two competing operators, subadditivity test would be made in order to judge cost efficiency of the monopoly against a duopoly market structure. For each cell within the grid, the degree of subadditivity is computed by:

$$Sub_{\lambda, \eta, \delta} = [C(Q) - C(Q^1_{\lambda, \eta, \delta}) - C(Q^2_{\lambda, \eta, \delta})] \; / \; C(Q)$$

$C(Q^1_{\lambda, \eta, \delta})$ and $C(Q^2_{\lambda, \eta, \delta})$ are the respective cost functions of the first and second hypothetical operators of telecom services, whereas C (Q) is the monopoly's counterpart.

Among sixteen candidates of $Sub_{\lambda, \eta, \delta}$ in the grid for each feasible sample point (1998/99-2006/07), the maximum value of $Sub_{\lambda, \eta, \delta}$ is tested against the null hypothesis that the cost function is additive, i.e. $Sub_{\lambda, \eta, \delta}$ = zero. If it is negative and statistically different from zero, we reject the hypothesis that the cost function is additive over the admissible region. Table-4 depicts results of the test.

Table-4: Degrees of Subadditivity

year	Sub $_{\lambda, \eta, \delta}$	λ	η	δ
1998/99	-0.69489	1	0	1
1999/00	-0.63019	1	0	1
2000/01	-0.54251	1	0	1
2001/02	-0.561	1	0	1
2002/03	-0.61947	1	0	1
2003/04	-0.60269	1	0	1
2004/05	-0.50921	0	1	1
2005/06	-0.43921	1	0	1
2006/07	-0.39567	1	0	1

For each observation point lying in the admissible region, sixteen pairs of competing firms are constructed over output configuration given by the parameters λ, η and δ. Then out of the sixteen combinations one with the highest degrees of subadditivity is selected for the test. This is due to the fact that the Evans & Heckman method tests only the necessary condition of subadditivity. A finding of a negative figure for the maximum $Sub_{\lambda, \eta, \delta}$ satisfies the necessary condition and the hypothesis of subadditivity would not be rejected.

As can be seen from the above Table-4, the maximum value of $Sub_{\lambda, \eta, \delta}$ turned to be negative for each test point in the sample period. So that the hypothesis of subadditive cost function is not rejected over the admissible region (1998/99-2006/07) with output

configuration given by λ, η and δ. It is also noted that within the admissible region a relatively cost efficient output mixes are obtained for (λ, η, δ) = (1, 0, 1).

Table-4 reports only the maximum degrees of subadditivity computed for each observation point lying in the feasible region of output configuration of the incumbent operator. Moreover, nowhere in the admissible region a positive value of $Sub_{\lambda, \eta, \delta}$ is obtained. Therefore, the hypothesis of "quasi-global" subadditivity is not rejected.

The overall result implies that the estimated cost function for the ETC has exhibited cost subadditivity and thus the industry has been indeed a natural monopoly for the observed output configuration delivered between 1998/99-2006/07.

5.4 Discussion of the Results

In the previous two sections, a subadditivity test to ETC's cost function was made using two approaches: the Traditional method and an experimental technique of the Evans & Heckman. In the former, the necessary and sufficient conditions for cost subadditivity are separately tested and next the Evans & Heckman approach is a little bit extended in testing the necessary condition. Both methods were surfaced on the principle that cost subadditivity is a basic criteria for existence of a natural monopoly.

The findings in general lead to a conclusion that the telecommunication industry in Ethiopia is a natural monopoly. Both methods confirmed that the incumbent operator has had a subadditive cost function over the sample years. The necessary condition is satisfied as there are economies of scope in providing multiple services as opposed to

specializing in each service. The result is a direct reflection of share ability and public-ness of inputs implying costless transferability factors from one service to the other within the industry. Thus, the corporation's diversification in provision of multiple services and expansion to a great scale is dictated by cost savings.

The fact that a monopoly is an inevitable outcome of market forces would have an implication to policy makers in this regard; an entrant wouldn't operate without being cost inefficient. Existence of multiple providers of telecoms services would result in resource wastage in the economy and the burden would rest on customers in terms of higher price or lower quality of services. So that government intervention is needed to safeguard consumers and achieve in optimal provision of telecoms services. Intervention in terms of regulation to the services of the monopoly would lead to a competitive outcome which would have been realized in non-concentrated or contested market structure.

The finding of significant diseconomies of scale has important policy bearing to the regulatory authority. This has to do with achieving the objective of scale efficiency in the operating firm. Majumdar and Chang (1996) referring Gold defined scale efficiency as measuring the extent to which firms deviate from their most productive scale size, the point on the cost curve where constant returns to scale exist. The firm under the study has, on average, bypassed its most productive size as it has been operating on an increasing portion of a ray average cost curve. The regulator, therefore, has to limit expansion of the firm in order to achieve the minimum efficient scale of operation. This is, however, at odd with the current policy of 'Universal

Access in telecom services' by the incumbent firm. ETC's records of low penetration and huge unmet demand in basic telephone services would not be addressed unless it is allowed to expand further. Nor does the current uneven distribution of telecoms services in the country would be reversed.

There is, therefore, a need for an integrated policy of cost minimization and universal access so as to achieve an optimal resource allocation in the sector. In light of the transforming globe in this regard the industry's technology is not immune from change. So that dynamicity of the scale efficiency has to be noted by the regulator in designing policies. For instance expansion of digital network exchanges unlike the previous analogue technology would result in a boom to firm's optimal capacity without a great impact to its cost of operation.

One advantage of studying cost behaviors in a multiproduct setting is that an insight to scale economies attributable to distinctive products could be substantiated. Significant product specific scale economies have been obtained for the urban telephone services. This implies that its average cost of delivery has been over and above the marginal cost of connecting an individual to urban telephone services. Therefore, an expansionary policy is recommended so as to achieve cost savings and improve scale efficiency for this particular service. The result also provides an insight to price and tariff policies of urban telephone services. As per Table 5.1 (Pp. 52), urban telephone services are the major output of the incumbent firm. Therefore, a marginal pricing principle would not ensure financial solvency of the operator unless it is optimally set by the regulator.

This significant scale economy for the urban telephone service is owing to presence of substantial fixed cost, of which the lions share goes to sunk costs. Costs of local cables, wires and pole are major parts of a public switched telephone services. These costs may also be labeled as commitment costs on part of the operator in delivering telephone services, particularly for urban telephone lines, and thus will contribute to the firm's scale economy and lead to a natural monopoly. Therefore, competition may not emerge in urban telephone call services of the operator in a reasonably short period of time as it entails enormous sunk costs. The regulator should also insulate this service from competition unless there happens to be dramatic technological progress resulting in cost minimization and thus provide a room for competitive suppliers.

On average insignificant degrees of economies and diseconomies of scale has been obtained for toll telephone and data services of the industry, respectively. So that ETC has been operating in vicinity of a horizontal average incremental cost curve of the toll and data services. Hence relative scale efficiency has been achieved in these services in contrast to the urban telephone service. It also signals viability of competition from the point of view of cost savings in toll and data telephone services of the company. Accordingly, the regulator has to further assess the pros and cons of allowing entry and evolution of competition into these services.

As evident from the economies of scope ETC benefits in terms of cost savings from joint provisions of multiple telecoms services. The estimated cost function revealed that on average 137% of total cost of the operator is saved over the sample point. The

industry achieved such savings owing to it ability to pool sharable inputs such as buildings, different materials, idle labor, meter reading, billing services and customer services. The finding of scope economies is a satisfying result to the necessary condition of a natural monopoly. Such a cost savings would not be achieved in specialty firms which provide a single service.

A telecommunication industry is recognized by its dynamic nature where the market and technological conditions constantly change. A finding that an industry is a natural monopoly in one period doesn't mean that it would be so in the next era. Nor does it imply that potential entrants are an evil to optimal resource allocation in the sector. Cost is not the only determining factor of market structure in a given industry. Customers would also benefit from the presence of multiple operators in the market in terms of having differentiated services.

Competition doesn't emerge at one point in time; it is an evolutionary outcome driven by various facilitating conditions. The pros and cons of competition in a market are not invariable with time. It is the task of the regulator to identify appropriate policies and reforms as per the demanding circumstances. It has also to assess whether the sector is smoothly transiting to the desired outcome within a reasonable period of time. The time frame for the process depends on effectiveness of the regulatory setup in an in the economy.

CHAPTER SIX

CONCLUSION AND POLICY SUGGESTION

Infrastructural industries such as telecommunications, electricity, postal, water and sewage have been labeled as public utilities due to their unique nature that set considerable barrier to the emergence of competition. For many years the industries were enjoying considerable market power under an umbrella of a natural monopoly argument. Cost efficiency is the foremost raison detre for natural monopolies. In view of that, entry of firms in the industry is legally prohibited and those monopolies are subject to regulation of their price, quantity and quality of goods and services. To date, however, such credence turned to be obsolete as competition is efficiently developed in many countries following series policy reforms. If not, the industries are restructured so as to delineate boundaries of a natural monopoly against a potentially competitive segment of operation.

Natural monopolies are regulated under the objective of minimizing market abuse and directing the supplier towards a competitive outcome which would have been achieved if there were competing firms. Promoting contestability of concentrated market structures per se is worth equivalently as if there were competing firms in an industry. In a contested market dominant firm(s) couldn't reap monopoly profit fearing that potential entrants would be attracted. In line with this the task of the regulator is directed to facilitating conditions for emergence of competition. Among the two regulatory procedures reviewed in the study, the rate of return regulation has been the overriding regulation principle across the world. Noting its drawbacks and

disincentive nature on the side of the regulated industry, a price cap regime began to be adopted.

In Ethiopia the telecommunications industry has been a statutory monopoly since its existence in 1987. Notwithstanding the positive moves seen in recent years, the sector performed poor in many quality standards judged against the threshold for developing countries. In its effort to develop the sector and satisfy external pressure, the government established a sector specific regulatory body, the Ethiopian Telecommunications Agency, in 1988. Since then the agency has made crucial reforms in telecoms sector. Allowing the private sector in the provision of telecoms services in the form of resell and value added services is the major one among the other. However, it is not yet strong enough to make a radical change in advancing the sector in line with global moves, let alone enhance evolution of competition. Nor is it capable of implementing the major objectives of its existence. ETC is for granted considered as a natural monopoly without any empirical substantiation in this regard.

This research is done to fill the information gap and provide an insight whether monopoly is a natural outcome of market forces in the Ethiopian telecommunications sector. Cost function of the incumbent operator is studied in line with a multiproduct firm setting so as to evaluate the conditions for a natural monopoly operator. Both the traditional and the new test of cost subadditivity are made in light of the idea that a subadditive cost function is a sufficient condition for an industry to be a natural monopoly.

The estimated cost function indicates that there have been, on average, diseconomies of scale as the ray scale economy turned to be less than one in joint provision of urban telephone, toll telephone and data telephone services. The operator has been scale inefficient, as it over utilized its optimal scale of service delivery for many years in the sample period. Policy makers in this regard have to limit expansion of ETC over and above its minimum efficient scale of operation. Besides, efforts should be exerted so as to achieve technological progress in the sector which would in turn expand the optimal scale of the industry. On the other hand, the urban telephone service has had product specific economies of scale while toll service and data telephone services has had near to a constant product specific scale economy. The former is owing to enormous fixed cost incurred in provision of public switched telephone services. Cost complementarities were obtained in joint provision of the toll telephone and data services of the operator. It also gives an insight in that joint provision of toll telephone and data telephone services are relatively viable segments of the industry where competition could efficiently emerge.

The finding of significant scope economy, the necessary condition to cost subadditivity, justifies cost savings in joint delivery of urban telephone, toll telephone and data telephone call services. Apart from cost minimization, the operator has been able to cross subsidize its services across different customers which would have been impossible in a competitive market structure. The result from the experimental test is not at odd with what is obtained from the traditional method since the hypothesis of cost subadditivity is not rejected. The study, therefore, confirms that ETC has exhibited a natural monopoly feature as it achieves cost savings in provision of

multiple telecom services. Since the market cannot sustain multiple providers of telecommunications services without being cost inefficient, the incumbent operator should be subject to regulation to its price, quantity and quality of services.

Therefore, the following policies are suggested so as to improve efficiency of the sector;

1- The finding that monopoly is a preeminent cost efficient market structure in the telecommunications services of the country calls for an effective regulatory institution. Therefore, the existing regulatory authority has to be strengthened in power and resources to be capable of meeting the objectives ranging from assessing compliances to promoting the pace for competition.
2- A price cap regulation should be implemented in regulation of telecommunications services tariff and price. Because the current 'historical cost recovery' principle of pricing doesn't provide an incentive to minimize cost.
3- Entry should be allowed and deregulated to joint provision of toll telephone and data services of the industry. This would also have a spillover effect to regulated segments of a natural monopoly service provider in terms economic efficiency.
4- The pros and cons of privatization of ETC should be studied in depth. A private ownership would have multiple benefits in terms of improved efficiency, a source of finance to the policies of universal access and market demand, unlike political motives, would be the directing force. The regulator would also be more alert in the presence of a private operator.

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Declaration

I, the under signed, declare that this project is my original work and has not been presented for a degree in any other university, and that all sources of materials used for the study have been duly acknowledged.

DECLARED BY:

Name _____

Signature_____

Date_____

CONFIRMED BY ADVISOR:

Name _____

Signature_____

Date_____