REGULATORY REFORM OF TELECOMMUNICATIONS IN DEVELOPING COUNTRIES: A CASE STUDY OF THE FIXED-LINE TELEPHONE NETWORK IN THAILAND

by

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Corrections

page 49, lines 2 and 9: Replace 'dramatically' with 'rapidly'

page 51, footnote 16: Replace 'terminal equipment' with 'customer premises equipment'

page 56, Figure 3-3: Replace 'The Length of Lines in Lists' with 'The Number of People on Waiting Lists'

page 84, line 2: Replace 'percent' with 'per cent'

page 95, third last sentence and page 100, second last line and page 106, middle box: Replace 'common costs' with 'specific costs'

page 108, end of first full paragraph: Replace 'a_i is the coefficient on the input variables' with 'a_i is the coefficient on the input variables i '

page 111, line 1: Replace 'early research' with 'previous research'

page 115, middle and page ix: Replace 'consumer access network' with 'customer access network'

page 138, sixth last line: Replace 'number observation' with 'number of observation'

page 177, line 6: Replace 'cost of access network' with 'cost of customer access network'

page 191, line 8: Replace 'bath' with 'baht'

page 197, fifth last line: Replace the s in 'labours' with a comma

page 198, line 5: Replace 'entry' with 'involvement'

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ACRONYMS

AIS	Advanced Info System
AJRC	Australia-Japan Research Centre
APT	Asia-Pacific Telecommunity
AT&T	American Telephone & Telegraph
ATM	Asynchronous Transfer Mode
B-ISDN	Broadband Integrated Service Digital Network
BLT	Build-Lease-Transfer
BMA	Bangkok Metropolitan Areas
BOI	Board of Investment
BOT	Build-Operate-Transfer
BT	Build-Transfer
BTO	Build-Transfer-Operate
CAN	Consumer Access Network
CAT	Communications Authority of Thailand
CI	Condition Index
CTIN	Centre for Telecommunications Information Networking
ESCAP	Economic and Social Commission for Asia and the Pacific
FCC	Federal Communications Commission
FDM	Frequency Division Multiplexing
FTI	Federation of Thai Industries
GATS	General Agreement on Trade in Services
GDP	Gross Domestic Product

GOS	Grade of Service
ICC	Interstate Commerce Commission
IDN	Integrated Digital Network
IEAT	Industrial Estate Authority of Thailand
ISDN	Integrated Services Digital Network
ITM	Intercity Telecommunications Market
ITU	International Telecommunication Union
LECs	Local Exchange Carriers
MOF	Ministry of Finance
MOTC	Ministry of Transport and Communications
MTA	Metropolitan Telecommunications Areas
NECTEC	National Electronics and Computer Technology Center
NESD	National Economic and Social Development
NESDB	National Economic and Social Development Board
NIRA	National Institute for Research Advancement
NITC	National Information Technology Committee
OECD	Organisation for Economic Co-operation and Development
PA	Provincial Areas
PCM	Pulse Code Modulation
PSTN	Public Switched Telephone Network
PSTNs	Public Switched Telephone Networks
PTA	Provincial Telecommunications Areas
PTD	Post and Telegraph Department
PTO	Public Telecommunications Operator

RDI	Research Development and Innovation
RSAs	Revenue Sharing Arrangements
RSU	Remote Switching Unit
SPC	Stored Program Control
STD	Science and Technology Development
TA	TelecomAsia
TAC	Total Access Communication
TAT	Tourism Authority of Thailand
TDM	Time Division Multiplexing
TDRI	Thailand Development Research Institute Foundation
TOT	Telephone Organisation of Thailand
TT&T	Thai Telephone and Telecommunication
US	United States
WTO	World Trade Organisation
X-bar	Cross Bar System

ABSTRACT

Recent research suggests that the presence of a single operator in the telecommunications market would lead to the inefficient utilisation of resources. Deregulation is argued to be a method to overcome such a shortcoming. Liberalisation, privatisation and build-transfer (BT) regimes are examples of regulatory reforms emerging in many countries. These reforms include free entry in domestic long-distance services in the United States, a competitive market in international calls in Japan, privatisation in Argentina and the application of BT regimes in many developing countries such as China, Vietnam and Thailand.

A build-transfer-operate (BTO) arrangement is one form of BT regime. In recent years, without an investigation of whether such a change is justified, BTO arrangements have been applied to the telecommunications sector in Thailand. This thesis, therefore, sets out to examine whether Thailand's BTO arrangements are worthwhile. Three issues are examined. (1) What is the market structure of the telephone industry in Thailand - is it still a natural monopoly? (2) Are there significant cost savings from the introduction of BTO regimes? (3) What is the impact of BTO regimes on social welfare?

The results of a study of costs of construction of fixed-line capacity indicate that (1) the local telephone market both before and after the introduction of BTO regimes is unlikely to be a natural monopoly, (2) other things being equal, operators gain cost savings not only from the adoption of digital switches but also from the introduction of BTO regimes.

The impact of BTO regimes on welfare is evaluated in terms of its impact on total surplus. The results indicate that (1) BTO regimes provide not only cost savings

adding to producer surplus but also add to consumer surplus, (2) the size of total welfare gains increases as the number of lines increases, and (3) BTO regimes are not capable of removing all the deadweight loss associate with the current regulatory environment.

The implications of this study is that although BTO regimes provide efficiency gains in terms of cost savings and welfare improvements, the presence of a remaining deadweight loss even after the introduction of BTO regimes implies that further reform should be considered. These include policies designed to promote free entry into the fixed-line market.

RESEARCH DECLARATION

This thesis contains no material which has been accepted for the award of any other degree in any university and, to the best of my knowledge and belief, it contains no material previously published or written by another person, except where due reference has been made in the text.

I give consent to this copy of my thesis, when deposited in the University Library, being available for loan and photocopying.

4 December 1998

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND AND MOTIVATION OF THE STUDY

Traditionally, telecommunications has been regarded as a natural monopoly.[1] In particular, economies of scale are the most important factor leading telecommunications to a natural monopoly market. As Kahn (1971) states:

> '... *a natural monopoly is an industry in which the economies of scale - that is, the tendency for average costs to decrease the larger the producing firm - are continuous up to the point that one company supplies the entire demand* ...' (pp.123-4).

When the above condition exists in the production process an operator can achieve a significant saving on production costs.[2] More importantly, total production

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[1] Natural monopoly refers to a situation where a single firm is observed to provide goods and services at lower cost than two or more firms.

[2] A specific name of an operator in telecommunications is called a public telecommunications operator (PTO) (ITU, 1997).

cost of aggregate supply would be cheapest when there is a single producer in the industry. Telecommunications in the United States (US) is a classic case to explain this circumstance. In the early nineteenth century, the structure of the intercity telecommunications market (ITM) in the US was considered to be a natural monopoly as stated by American Telephone and Telegraph Company (AT&T) (1980):

> '*... a single interactive and interdependent network [is] the most efficient means for providing all of this Nation's telecommunications services... [S]uch a network can be planned, constructed, and managed most efficiently by an integrated enterprise that owns the major piece-parts of the facilities network...*' (p.35).

The above statement was supported by several arguments. First, it was argued that the performance of AT&T's competitors would be inefficient. In the ITM the competitors of AT&T could survive if, and only if, the rates charged by AT&T exceeded their costs. Second, breaking up the Bell System would bring about management inefficiency in controlling the overall telephone system (Evans and Heckman, 1983). As a result, the Interstate Commerce Commissions (ICC), which had been responsible for providing licences and regulating incumbent firms in providing interstate telephone services, allowed only AT&T to be a public telecommunications operator (PTO) (Viscusi et al, 1994).[3]

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[3] ICC was established under the Mann-Elkins Act of 1910. With the Communications Act of 1934 the power of the ICC has been transferred to the Federal Communications Commission (FCC). The FCC has control over most aspects of competition, that is prices, the number of operators and interconnection (Viscusi et al, 1994).

In later years, it has been recognised in the United States that the telecommunications market may not be a natural monopoly. This conclusion was derived by a number of scholars, for example Evans and Heckman (1984), Shin and Ying (1992) and Shin and Ying (1994). Thus, deregulation was recommended to bring about an efficient resource utilisation. For example, Evans and Heckman (1984) stated that the centralisation of the Bell System caused higher production costs. Shin and Ying (1994) found that allowing free entry would gain over 20 per cent cost savings. To transform the market structure from a monopoly to competition the deregulation of the telecommunications market was required.

Recently, several forms of deregulation, for example liberalisation, privatisation, and build-transfer (BT), have been applied internationally. Privatisation has been usually applied to solve a budgetary shortfall (Smith and Staple, 1994). Argentina and Malaysia are examples of countries using this regime (Herrera, 1992 and Abu, 1993). Liberalisation has been introduced, for example in the United States and the United Kingdom, where the telecommunications structures in those countries are believed not to be natural monopolies (Evans and Heckman, 1984, Shin and Ying, 1992 and Shin and Ying, 1994). BT agreements are one of the structural transformations introduced to circumvent the problem of a supply shortage, in particular in the public utility industries (Smith and Staple, 1994). China, Indonesia, Vietnam and Thailand are example countries using BT regimes (Yoonaidharma, 1993, Scale, 1994, Smith and Staple, 1994 and Foster and Knight, 1997).

The motivation of this study is that while the experiences of privatisation and liberalisation have been often studied (for example, Imai (1994) assessed the gains from allowing free entry in the Japanese international telecommunications industry, and Herrera (1992) tested the impact of the privatisation of the Argentine telephone system.), no one has studied whether BT arrangements are justified and what is the impact of the introduction of BT regimes in the telecommunications sector. This is, therefore, the focus of this study. Before proceeding to the discussion of the objectives, methodology and organisation of this study, the characteristics of BT regimes are described below.

A precise definition of BT arrangements implies the delegation of the franchise of a monopoly to new investors (Smith and Staple, 1994). As illustrated in Table 1-1, different countries have applied BT regimes in different forms. Build-transfer-operate (BTO) regimes refer to the contracts by which governments have allowed private firms to build up the network but all assets must be transferred to public ownership before operating (ITU, 1997). An example of a country applying this regime is Thailand (Yoonaidharma, 1993). Another type of BT regime which will be discussed briefly here is build-operate-transfer (BOT). Unlike BTO, private firms under BOT regimes can operate and provide services to consumers after the communications network has been built up. Then all assets will be transferred to public ownership at the end of the concession period (ITU, 1997). In recent years, BOT regimes have been introduced into many developing countries, for example Indonesia, China and Vietnam (Smith and Staple, 1994, Scale, 1994 and Foster and Knight, 1997).

In this thesis the introduction of BT regimes in Thailand is selected as a case study. While a supply shortage of the communications network, which will be detailed in Chapter 3, has been considered as a major problem in economic development, the Thai Government has also aimed to become a telecommunications centre in Southeast Asia (NITC, 1995). To circumvent the supply shortage and to increase the number of networks the private sector has been allowed to participate in providing several types of communications services under BTO agreements (Yoonaidharma, 1993). Therefore, a number of concessions, as illustrated in Table 1-2, have been granted to private firms. For example, the Telephone Organisation of Thailand (TOT) granted concessions to two private firms to operate and to provide fixed-line telephones.[4] TOT and the Communications Authority of Thailand (CAT) granted four licences to two private firms to operate cellular mobile phones. While such regulatory reforms have never been studied as to whether they are justified, BTO regimes have been widely applied in Thai telecommunications. Consequently, Thailand has been counted as a leader of BT arrangements (ITU, 1997). Thus, there is an interest in investigating whether BTO agreements are efficient in Thai telecommunications.

In addition, the fixed-line concessions granted to TelecomAsia (TA) and the Thai Telephone and Telecommunication (TT&T) are highlighted in this thesis for two reasons. First, like other countries, fixed-lines are important networks for providing basic communications services, for example local and long-distance calls. More importantly, the contribution of a telephone system was demonstrated by Hardy (1983, cited in William and Jequier, 1983) to provide a great influence on economic development, in particular in developing countries. Therefore this study, it is hoped, will provide some policy implications for countries using BT regimes. Second, a qualitative analysis by the Thailand Development Research Institute (TDRI, 1997a) concluded that the use of the BTO mechanism is not an appropriate regime. Reform in that direction probably brings about inefficient resource utilisation. For this reason, it would be interesting to quantify whether BTO regimes in the provision of fixed-lines provide any contributions to society.

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[4] TOT is a state-owned enterprise, established under the Telephone Organisation of Thailand Act of 1954. Details are discussed in Chapter 3.

TABLE 1-1

Build Transfer Arrangements

Type	Description	Examples
BTO	**Build-Transfer-Operate** The private partner constructs the network and transfers ownership to the public upon completion. The private partner then operates the network until the end of the concession period.	**Thailand** The Telephone Organisation of Thailand (TOT) and the Communications Authority of Thailand (CAT) have granted several concessions, as illustrated in Table 1-2, to the private sector.
BOT	**Build-Operate-Transfer** The private partner constructs and operates the network during the concession period. The assets will be transferred to the public at the end of the concession period.	**Indonesia** PT Telekom signed contracts in several projects building local networks and cellular systems with different investor groups under revenue sharing arrangements (RSAs).
BLT	**Build-Lease-Transfer** The private partner builds the network and leases it to the public partner. The assets will be transferred to the public partner at the end of the contract period.	**Lithuania** US West built an international gateway, which is being operated by Lithuanian Telecom.

Source: Smith and Staple (1994) and ITU (1997)

TABLE 1-2

Examples of BTO Projects in Thai Telecommunications

Types of Services	Concessionaires	Year	Carrier
Fixed-line telephone	TelecomAsia (TA)	1991	TOT
	Thai Telephone and Telecommunication (TT&T)	1992	TOT
Cellular mobile phone			
Analogue	Advanced Info System (AIS)	1990	TOT
	Total Access Communication (TAC)	1990	CAT
Digital	TAC	1993	CAT
	AIS	1994	TOT
Paging service	Pacific Telesis/ Percom Service	1990	CAT
	Shinnawatra Paging	1989	TOT
	Hutchison Telecommunications	1990	TOT
	Matrix (Thailand)	1990	TOT
	Samart Corporation	1995	PTD
Trunk mobile	Radio Phone	1992	TOT
	TAC	1992	CAT
Data communications	Shinnawatra Datacom	1989	TOT
Videotex	Line Technology (Thailand)	1992	TOT

Note: TOT = The Telephone Organisation of Thailand

CAT = The Communications Authority of Thailand

PTD = Post and Telegraph Department

Source: ITU (1997)

1.2 OBJECTIVES OF THE STUDY

The main objective of this thesis is to examine whether BTO arrangements are justified. In this study an improvement in efficiency, in particular in terms of cost savings from the construction of fixed-line networks, is a key indicator to evaluate BTO regimes. To meet the objective of this study the following three questions must be examined.

First, what is the actual market structure of the fixed-line networks in Thailand? Theoretically, a natural monopoly industry requires a single firm to achieve cost minimisation in production. If this thesis can show that the structure of the Thai telephone system is no longer a natural monopoly, at this stage, it provides an initial indicator to point out that BTO regimes are not justified. This is because BTO arrangements are the licence granted to a certain number of private firms. There is no free entry or exit under BTO regimes so they are not strategies towards a competitive market. In this case, BTO regimes undoubtedly would not be an appropriate approach in reforming the telecommunications industry in Thailand. Other types of deregulation, for example an opening up to free entry, should be considered.

However if there is the presence of a natural monopoly in the Thai fixed-line market a further investigation is required to see whether BTO arrangements improve the efficiency of the system. This is the second issue to be tackled in this thesis. If BTO regimes achieve a significant saving in production costs a comparative study between the use of BTO regimes and other types of deregulation is required for further study, thus society can gain maximum profit from the use of an appropriate methodology in reforming the fixed-line market.

Third, what is the impact of BTO arrangements on social welfare? Theoretically, deadweight loss is the consequence of the existence of a natural monopoly thus it is interesting to evaluate whether BTO regimes can circumvent this problem.

1.3 METHODOLOGY OF THE STUDY

With respect to the three questions discussed previously, the methodology of this study consists of seven steps.

To answer the first question discussed in the previous section, the cost structure of the fixed-line market in Thailand will be examined. Although much prior research, for example Evans and Heckman (1984), Shin and Ying (1992) and Shin and Ying (1994), has proved that the structure of the telecommunications industry in the US is no longer a natural monopoly, such a conclusion does not necessarily apply to the structure of the telecommunications market in Thailand. This is because the structure of the telecommunications industry in Thailand is different from that considered by past research in many aspects, for example economic regulation, system design in communications networks and market size. The question of whether the Thai telephone network is a natural monopoly, therefore, is still one of the important tasks to be tackled in this thesis.

Theoretically the development of a natural monopoly concept can be classified into two schools, scale economies and subadditivity. Each theory contains both strengths and weaknesses. Therefore the first task of this study is to review the theories of scale effects in both schools. The review also includes past research. The lessons from theoretical and literature reviews will provide a substantial guideline to build up a suitable methodology for this study.

In this thesis a cost function is used as a tool to estimate whether BTO regimes are justified. In addition, the model specification of the cost function will be developed by using both econometric and engineering concepts. Thus it is necessary to have some basic knowledge about a telephony system. The second task of this study, therefore, is to review the components of the telephone system.

With respect to the current definition of a natural monopoly, the application of the concept of subadditivity is one approach to investigating the cost structure of an industry. However, the strengths and weaknesses of subadditivity have to be assessed. If it is not an appropriate approach for this particular study another method will be proposed, and this is the third task of this thesis.

The fourth task is to estimate the cost structure of the fixed-line market in Thailand. In this study a translog cost function is developed from a combination of econometric and engineering concepts. To answer the second question discussed in the previous section dummy variables are included in the cost function to determine the change in the magnitude of the effects of the introduction of BTO arrangements. In other words, the coefficient of dummy variable will indicate the effects of BTO regimes in terms of cost savings.

In Thailand there were 69 provinces in 1992. Because an operator could not install all lines for every province in one year, provinces were given different priorities in installing new networks under a BTO contract. Thus it is interesting to see what factors applied in ranking the investment priorities. This is the fifth task of this study.

The sixth task of this thesis is to investigate the impact of BTO regimes on social welfare. In this study the concept of total surplus is applied. The impact of BTO regimes on social welfare is considered in two aspects: the magnitude of welfare effects after the introduction of BTO regimes and the sensitivity analysis of welfare effects in the presence of externalities.

Because the analysis in this thesis considers only the effects of the introduction of BTO regimes other types of deregulation, which are probably more appropriate than BTO arrangements, will be suggested for further study. This is the last task of this study.

1.4 ORGANISATION OF THE STUDY

As illustrated in Figure 1-1, the rest of this thesis consists of eight chapters and an appendix. Details of each chapter are described below.

The aim of Chapter 2 is to survey prior research on the telecommunications market. The chapter contains two main parts. The first section reviews the theoretical perspective of a natural monopoly. The discussion is reported under two circumstances: a natural monopoly in a single product and a natural monopoly in multiple products. Then, a review of relevant research is presented.

Chapter 3 presents the history of the telecommunications industry in Thailand. The context in this chapter provides four main topics:

(1) the structure of telecommunications regulators and carriers,

(2) the main reasons leading to a monopoly,

(3) the pressures to reform the market, and

(4) the impact of telecommunications legislation on the market mechanism (price allocation, the number of telephone lines and the number of incumbent firms).

Because this thesis incorporates an engineering concept of the telecommunications network into the cost function, the components of the telephone system are described in Chapter 4. This chapter discusses the types of telecommunications network, the innovation in two major telephone components (transmission and switching systems), the development of telephone technologies in Thailand and the relationship between the volume of telephone traffic and the telephone equipment required in the network.

Chapter 5 proposes the method to estimate the structure of the fixed-line market in Thailand. This chapter is divided into two major parts. The first part discusses the appropriate method to investigate the market structure of this particular study. Then the cost function developed from econometrics associated with the engineering concept is proposed.

Chapter 6 presents the empirical results from the estimation of the cost structure of the fixed-line market in Thailand. The first task is to develop a model specification of the cost function for the Thai fixed-line network. Then the specified model is examined using cross section data of selected telephone exchanges in Thailand.

As mentioned in the methodology, in provincial areas the priorities in providing fixed-lines under BTO regimes are ranked differently. Chapter 7, therefore, investigates the factors that influence the priority of investment. To investigate those factors a specified function of logit model is applied. Then the model is tested with the cross section data of 69 provinces in Thailand.

Chapter 8 examines the impact of BTO arrangements on social welfare by using the concept of total surplus. Two issues are discussed in this chapter:

(1) the magnitude of welfare effects after the introduction of BTO regimes, and

(2) the sensitivity analysis of welfare effects in the presence of externalities.

Chapter 9 presents conclusions and interesting issues for further study. The conclusions of this thesis are divided into five sub-sections:

(1) BT regimes and the Thai constitution,

(2) the market structure of local telephone networks in Thailand,

(3) the factors influencing the priority of line installation in provincial areas,

(4) the impact of BTO regimes on social welfare, and

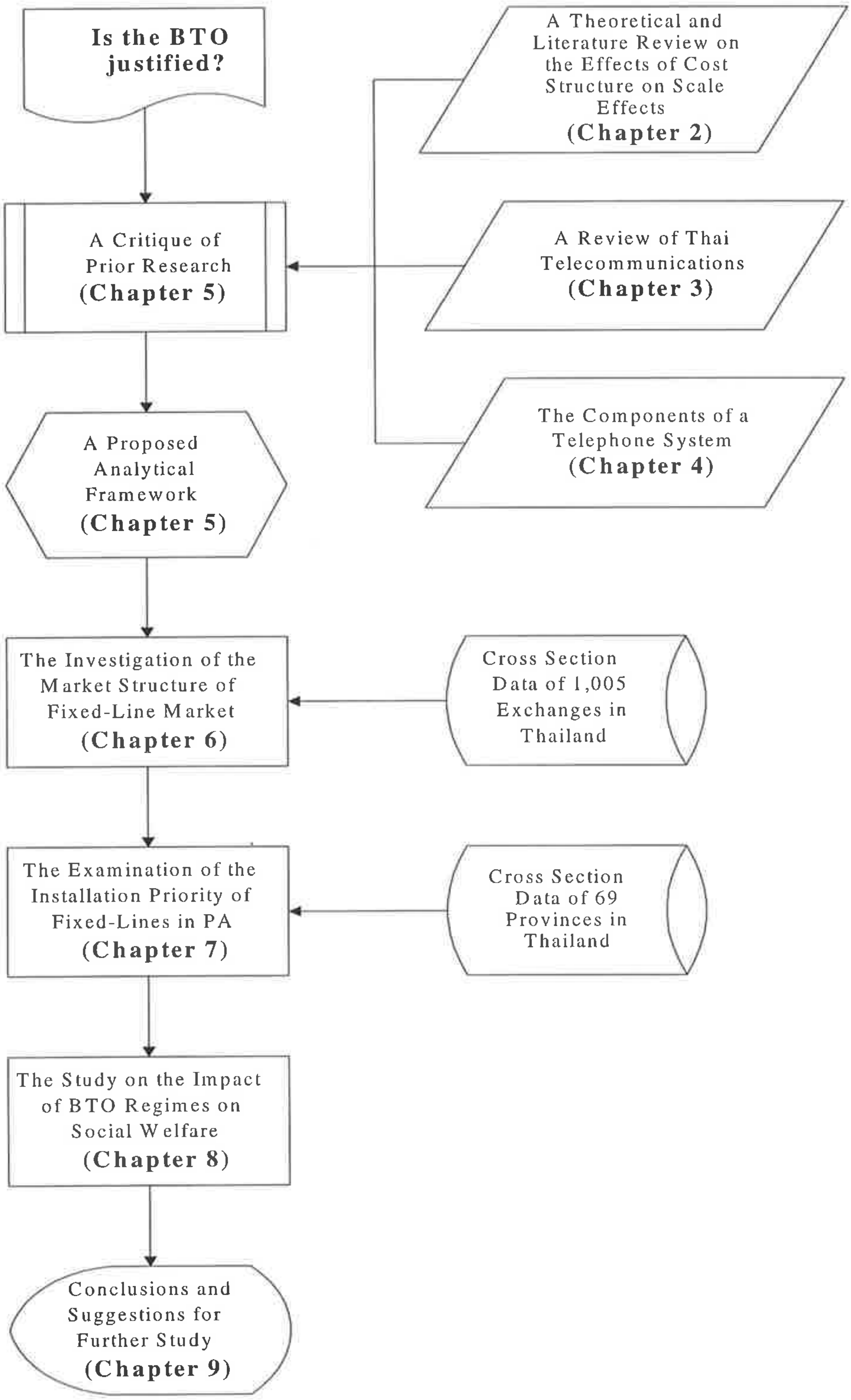
(5) implications of the study.

Then, some interesting issues, which have not been tackled in this thesis, are proposed.

Appendix I provides a definition of key terms used in this thesis.

FIGURE 1-1

Methodology and Organisation of the Study



CHAPTER 2

THE MARKET TEST IN TELECOMMUNICATIONS: THEORETICAL PERSPECTIVE AND A LITERATURE REVIEW

2.1 INTRODUCTION

Scale effects are one of the economic frameworks applied to investigate the structure of markets. In this study the concept is used as a technique to estimate the market structure of the fixed-line telecommunications system in Thailand. This chapter, therefore, overviews the theoretical development of scale effects and past research.

The theoretical development of scale effects can be separated into two periods, scale economies and subadditivity. Before subadditivity was proposed by Baumol et al (1982), the test for scale effects alone was a substantial indicator to determine the type of market structure (Berg and Tschirhart, 1988). In recent years it has been argued that the existence of scale economies alone is not a sufficient economic framework to quantify the structure of an industry. The concept of scope economies and subadditivity were then introduced in 1977 and 1982, respectively. To understand the strengths and weaknesses of these concepts each will be first contrasted in this chapter.

The applications of scale, scope and subadditivity lead to a variety of methodologies estimating the market structure of several public utility industries, for example electricity, gas and telecommunications. Thus, the findings of past research are of great importance to guide the development of an appropriate economic framework for this study. For this reason, a review of the related literature is the second task of this chapter.

This chapter contains three main sections. Before proceeding to a review of prior research in Section 2.3, the development of the core concept in testing the cost structure of an industry is discussed in Section 2.2. In this section, the definition of a natural monopoly and the criteria used to determine a market structure, and whether it is a contestable or a natural monopoly market, are detailed. Section 2.3 reviews past research which is relevant to this study. Concluding remarks are presented in Section 2.4.

2.2 A THEORETICAL PERSPECTIVE OF NATURAL MONOPOLIES

As mentioned in Chapter 1, an investigation into whether the structure of the Thai telecommunications market is still a natural monopoly is the first task of this thesis. The arguments deliberated in this section, therefore, will focus only on the issues related to the techniques required to investigate the structure of an industry. In particular, a non constant return to scale or economy of scale, which is one of the key characteristics determining the presence of a natural monopoly, is highlighted here.

The discussion of scale economies in this section will be separated into two sub-sections relating to the number of outputs, namely a single output and multiple outputs.

2.2.1 A Single Product Firm

With respect to the definition of a natural monopoly stated by Kahn (1971), the natural monopoly exists when economies of scale exist. In other words, an industry is a natural monopoly when the cost of production exhibits a decreasing average cost. To explain this circumstance, consider Figure 2-1. Average cost declines until the output q^* is reached. Following the concept of Kahn, the area showing a decreasing average cost is between $0 - q^*$. This statement can be expressed in mathematics as:

$$C(q^i)/q^i < C(q^j)/q^j \qquad \text{(equation 2.2.1)}$$

for all q^i and q^j, where $0 < q^j < q^i \leq q$

given $C(q)$ is the firm's cost function, where q is the firm's output.

Equation 2.2.1 can be explained that when $C(q^i)/q^i < C(q^j)/q^j$ there is the existence of scale economies, an industry is a natural monopoly. In turn, when $C(q^i)/q^i > C(q^j)/q^j$ diseconomies of scale exist and the industry is no longer a natural monopoly.

It is true that equation 2.2.1 is a necessary condition to indicate that an industry can minimise cost when the levels of production output are ranged between $0 - q^*$. The existence of decreasing average cost alone, however, is not sufficient to indicate clearly whether an industry should be monopolised or contestable. In some cases, although the average cost of producing output more than q^* is increasing, the total production costs of a single firm are still minimised. In this case there still exists a natural monopoly.

The above argument can be explained by Figure 2-2. Suppose there are two firms in the industry. Assume that each firm provides the least cost solution. Let AC_1 represent the average cost of a single firm, and AC_2 is the overall average cost for two firms. Assume further that at a given point on the AC_1 curve, double the output rate, we will obtain a point on the AC_2 curve. Thus, each firm would produce at the same output rate and have the same marginal cost. For example, the minimum average cost of producing q' is equal to c', double the output rate q'', then we obtain a point on the AC_2 at c''. Under this assumption, c' is equal to c''. To produce at q', there is no doubt that a single firm can produce at cheaper cost than by two firms. And to produce at q'', the total production costs of one firm would be more expensive than by two firms. When market demand is between $q' - q^*$, in this case, the industry still requires a monopolist to minimise cost, although the average cost of producing $q' - q^*$ is rising. Thus, the traditional definition of a natural monopoly fails to shed light on this circumstance (Baumol, 1977 and Berg and Tschirhart, 1988).

To circumvent such a shortcoming, subadditivity was proposed by Baumol et al in the early 1980s. Under this concept, an industry is a natural monopoly when a cost function is strictly subadditive (Baumol et al, 1982). In other words, if a single firm can produce more cheaply than two or more firms at all levels of output, there is a presence of natural monopoly in the industry. This can be illustrated in mathematics as follows:

$$C\left(\sum_{i=1}^{m} q^i\right) \leq \sum_{i=1}^{m} C_i\left(q^i\right), \text{ for all quantities of } q^1,\ldots,q^m \qquad \text{(equation 2.2.2)}$$

where m is equal to the number of firms.

When the condition 2.2.2 is met, an industry requires a monopolist. That is, when $C\left(\sum_{i=1}^{m} q^i\right) \leq \sum_{i=1}^{m} C(q^i)$, the investigated industry will achieve some significant savings in the total production cost if there is a single firm in the market. In turn, when $C\left(\sum_{i=1}^{m} q^i\right) > \sum_{i=1}^{m} C(q^i)$, to gain cost savings the industry requires two or more firms in the market.

Nevertheless, the concept of subadditivity also contains a weakness. That is, the condition 2.2.2 can indicate the optimum number of firms in the industry at all ranges of output, but it does not guarantee that the industry will experience a decreasing average cost in every case. Referring to Figure 2.2 again, the subadditivity test tells us that at the range of output between $q' - q^*$, although the average cost is rising, a single firm is required to minimise cost. However, its assessment does not explain the source of cost savings clearly. Cost savings arising in the single firm may come from firm economies of scale or contracting economies rather than production scale economies.[5] As a result, the test for the degree of scale economies is still required to investigate for the sources of the presence of a natural monopoly.

The implications of equation 2.2.1 and equation 2.2.2 can further interpret the degree of natural monopoly whether it is a strong or weak natural monopoly. The industry is a strong natural monopoly when the first condition is met, while it is a weak natural monopoly when only the second condition is found.

[5] Firm economies of scale refer to the gain arising from one management in several plants. Contracting economies are the ability to reduce costs (ie, negotiation power) and risks by organising activities within the firm.

So far, the analysis only refers to a single product. It has been argued that the analysis of a single output firm is not close to reality. A firm would normally produce multiple products, rather than a single product. As Baumol et al (1982) observed:

> *'...although much of received theory focuses on single-product firms, virtually all firms in reality produce and sell more than one good or service. This multiplicity of outputs can take the form of a variety of physically-dissimilar offerings, a wide variety of offerings of similar outputs (such as shoes of different sizes) adapted to demands of individual consumers, or just physically-similar outputs sold at various places or time..'* (p.3).

An operator, in practice, would rather produce multiple products to achieve a significant saving on some joint costs. As a result, the methodology to estimate the natural monopolies in multiple products was further developed. This will be discussed in the following sub-section.

FIGURE 2-1

Average Costs

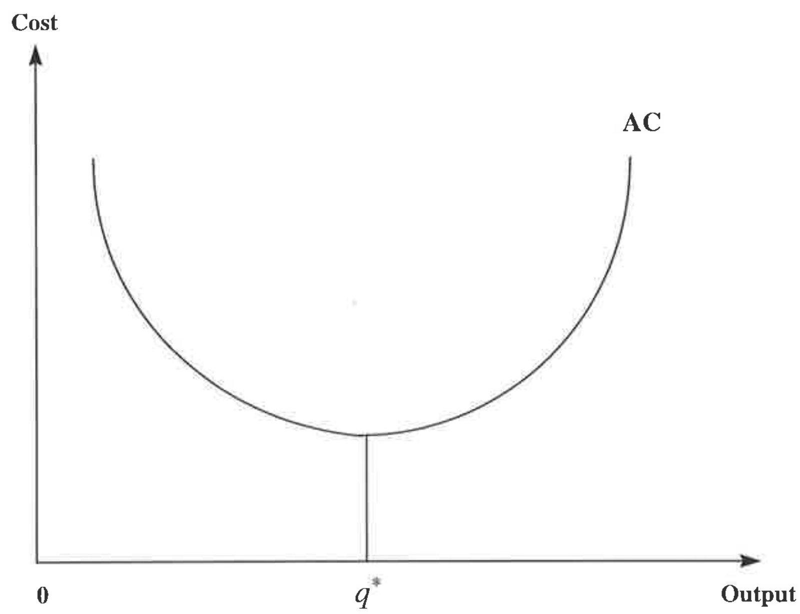
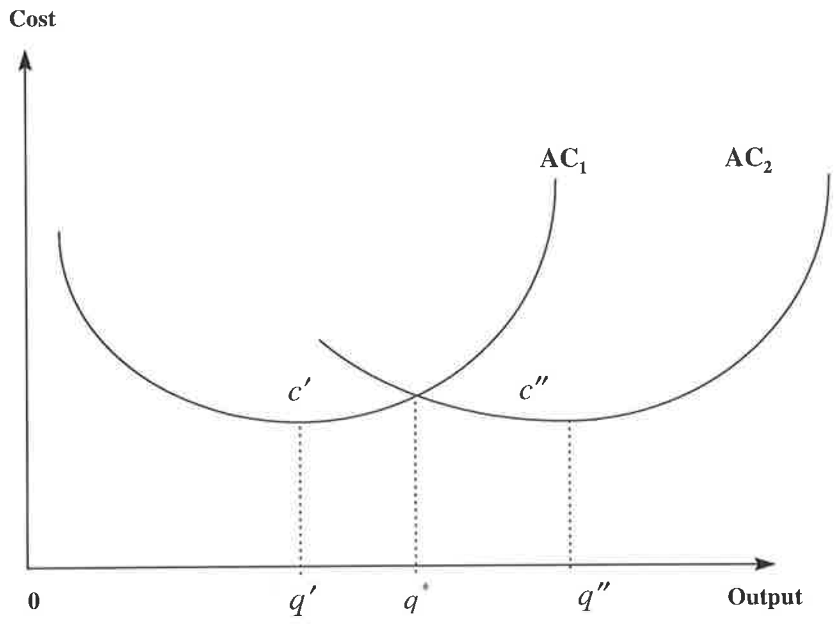


FIGURE 2-2

A Monopoly with Rising Average Costs



2.2.2 A Multiple Product Firm

As discussed previously, scale economies are necessary, but not sufficient, to evaluate the presence of natural monopoly in the case of a single product firm (Baumol, 1977 and Berg and Tschirhart, 1988). In the case of the multiple product industry, Baumol et al (1982) stated that scale economies are neither necessary nor sufficient to ensure the existence of a natural monopoly. This is because economies of scale in the multiple product case may be achieved in one product and not the others. To shed further light on this issue, consider an industry that produces two products as an example. Suppose Firm A initially produces only Product A, at the amount Q_A with the production cost $C(Q_A)$. Suppose further that at this level of output, Firm A enjoys scale economies of producing Product A. Later, Firm A decides to produce Product B for Q_B using the production cost $C(Q_B)$. In this case, the average incremental cost (AIC) of producing Q_B is:

$$AIC_B = \frac{C(Q_A, Q_B) - C(Q_A, 0)}{Q_B} \qquad \text{(equation 2.2.3)}$$

If AIC_B decreases as the numbers of Product B increase, there is an existence of scale economies in Product B at the level of output Q_B, and vice versa. However, the existence of scale economies does not necessarily imply the presence of multiple product natural monopoly. An operator may produce both products, although there are diseconomies of scale in producing Product B, if there are strong economies of scale in Product A. Thus, there still exist scale economies in the whole industry. For this reason, the concept of scope economies associated with scale economies was applied to explain the presence of a natural monopoly in a multiple product industry. Baumol (1977) stated that the existence of scale and scope economies is sufficient to ensure the existence of natural monopoly. As Panzar and Willig stated:

> ' ... *the ideas of economies of scope and overall and product-specific returns to scale are inextricably related...*
>
> ... *economies of scope and decreasing average incremental costs in each product line together imply both overall scale economies and strict subadditivity* ... ' (Panzar and Willig, 1977 and Panzar and Willig, 1979, cited in Baumol et al, 1982, p.xvi).

To explain the concept of scope economies, suppose there are two firms in the market. Firm A produces Product A at Q_A and Firm B produces Product B at Q_B, economies of scope exist when:

$$C_A(Q_A,0)+C_B(0,Q_B)>C(Q_A,Q_B) \qquad \text{(equation 2.2.4)}$$

If condition 2.2.4 is accepted it means there are economies of scope in the market. In this case, a single firm which produces two products exhibits lower costs than two firms producing different products.

In principle, to estimate the scope economies a data set of the production cost of each product is required. Empirically, it is a difficult task to allocate the total production cost into common and joint costs. For this reason Baumol et al (1982) proposed 'strict and global subadditivity' to circumvent the data problem. They stated that strict and global subadditivity is a necessary condition to identify the structure of the industry. To explain the definition of strict and global subadditivity, consider the discussions provided below.

$$C(q_1^1+...+q_n^m) < C_1(q_1^1)+...+C_i(q_n^m) \qquad \text{(equation 2.2.5)}$$

where $q^1,...,q^m$ are all ranges of outputs, and each vector contains n different outputs and there are i firms.

Consider the two product case as an example again. By definition an industry is a natural monopoly when the sum of the production costs to produce, for example q^* by two or more firms, is greater than the production costs of the same units of outputs produced by a single firm. As illustrated in Figure 2-3, suppose there are four sets of output vectors that sum to q^*. That is:

(1) $\bar{q}^1 + \bar{q}^2 = q^*$,

(2) $\hat{q}^1 + \hat{q}^2 = q^*$,

(3) $\tilde{q}^1 + \tilde{q}^2 = q^*$,

(4) $q_1^* + q_2^* = q^*$

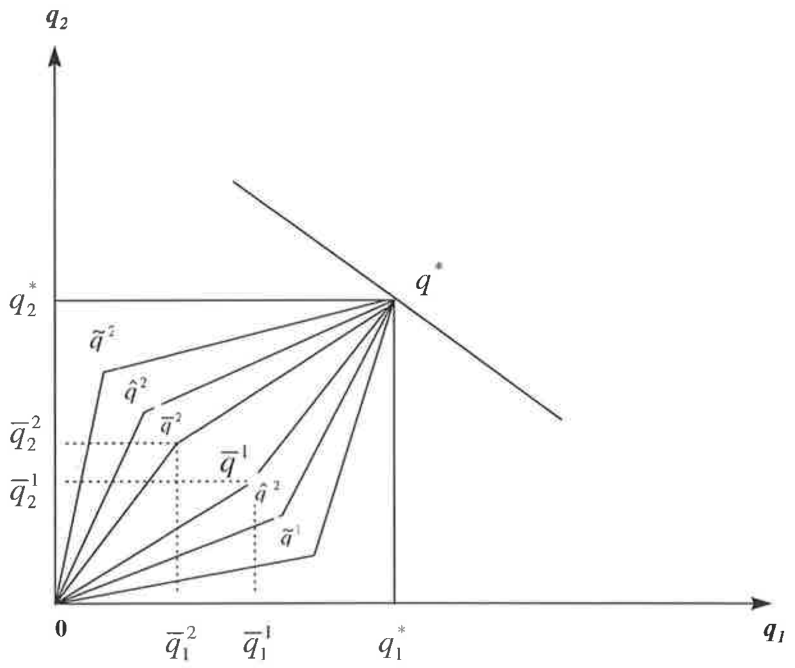
The above can be explained that to produce at q^*, for the cost function to be strictly subadditivity, the sum of the cost of producing any two output vectors by two or more firms must be greater than the cost of producing q^* by a single firm. That is, the total cost of $C(\bar{q}^1)$ and $C(\bar{q}^2)$ produced by a single firm is less than or equal to the total cost of producing by two or more firms. If this is also true in the other three output vectors, it can be said that subadditivity exists. Thus, an industry is a natural monopoly.

When a comparison between subadditivity and economies of scope is scrutinised, scope economies are a less stringent condition than subadditivity (Berg and Tschirhart, 1988). Considering Figure 2-3 again, the condition of the strict and global subadditivity proposed by Baumol et al must hold for all four sets of output vectors as discussed previously, while only the condition $C(q^*) < C(q_1^*) + C(q_2^*)$ is required for the existence of scope economies.

Theoretically, to estimate the market structure with the concept of subadditivity proposed by Baumol et al, global information is required. For example, the evaluation of the above cost function requires four sets of data. Empirically, obtaining such data sets is a difficult task. This problem has been argued as one of the failures of global subadditivity testing (Evans and Heckman, 1984). To circumvent this shortcoming, a regional test was proposed by Evans and Heckman in 1984. Details of this methodology are discussed in the following section.

FIGURE 2-3

Subadditivity and Economies of Scope



2.3 A MARKET TEST OF NATURAL MONOPOLY IN TELECOMMUNICATIONS: A LITERATURE REVIEW

The aim of this section is to survey past research which has applied the concept of non-constant returns to scale in testing the market structure of telecommunications. Two approaches, namely econometric models and the combination between econometrics and engineering, have been applied in association with the theory of the production function to quantify the degree of scale effects. Examples of past studies using econometric models alone in the production function are Fuss and Waverman (1977), Denny and Fuss (1980), Nadiri and Shankerman (1981), Breslaw and Smith (1980, cited in Fuss, 1983), Evans and Heckman (1983), Evans and Heckman (1984), Shin and Ying (1992) and Berg and Tschirhart (1995). Prior research which applied an engineering concept to the production function can be found in the studies of Waverman (1975), Yaged (1975), Ellis (1975), Hall (1975), Gabel and Kennet (1994) and Gasmi et al (1997).

This section presents the major findings of some of these studies and their methodologies.

2.3.1 The Applications of Scale Economies

As discussed in the previous section, the test for scale economies alone regarding the initial definition of a natural monopoly was once regarded as a sufficient and necessary condition to determine the structure of an investigated industry. The study of Waverman is an example of this approach applied in telecommunications.

Waverman (1975) assessed the impact of the Federal Communications Commission (FCC) policies on the growth of intercity telecommunications, in particular in the microwave system.[6] The cost functions using a data set of the 141 microwave systems with varying grades of service, distances and capacities were estimated for the degree of scale effects.[7] Waverman applied the Cobb-Douglas form in his cost function. Four independent variables (the number of circuits available, the number of operating circuits, the number of hops or stations and grade of service) were investigated. Waverman was aware that in his study three parameters, namely year of construction, location and a measure of output, were lacking. He asserted that the absence of such variables might cause error terms in the estimation of the determinants of system costs but the empirical assessments would not bias the estimates of scale economies. In his finding he confirmed an existing scale economy in the microwave industry.

However, the methodology applied in Waverman's study was subsequently argued to contain at least two weaknesses. First, a failure to evaluate the multiple product case was argued to be a major invalidity (Littlechild, 1979). Second, as argued in the previous section, the degree of scale economies alone, even in the case of a single

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[6] A microwave system is a point to point radio transmission system capable of carrying large number of telecommunications circuits, using analogue and digital transmission techniques (Farr, 1988). In this study Waverman classified different types of the microwave system according to the types of users, petroleum and pipelines, power, business, forestry products, maritime, motor carriers, local government, police, highway maintenance and railroads.

[7] Grade of service (GOS) is a measure of the quality provided at each stage throughout a circuit switched telephone or telex network, in terms of sufficiency of circuits or switching centre equipment to carry a given level of telecommunications traffic (Farr, 1988). In the study of Waverman, GOS is ranged between 1 - 150 circuits.

product, is insufficient to quantify the type of market. In this case, the conclusions in his study may be overestimated.

2.3.2 The Applications of Scope Economies

Before the concept of 'strict and global subadditivity' was proposed in 1982, as discussed in the previous section, the degrees of scale and scope economies were considered to be amenable to the formulation of testable hypothesis to ensure subadditivity (Baumol, 1977), in particular in the multiple product case. The study of Fuss and Waverman (1981) and of Gabel and Kennet (1994) are examples following this concept.

Fuss and Waverman (1981) investigated the structure of Canadian telecommunications. The application of a duality approach into the multiple product cost function was used in their study. Data from the operation of Bell Canada between 1952 - 1975 were examined. In their study, three types of outputs were measured, local services, message toll services and competitive services (ie, data transmission). For input data, four variables (cost of materials, indirect taxes, manhour input and capital input) were included in the duality cost function. Fuss and Waverman concluded that the test for overall scale elasticity was not adequate to accept or reject the hypotheses of increasing, constant or decreasing returns to scale. This was because the point estimates showed decreasing returns for the first half of the period and increasing returns in the second half. In addition, they found that economies of scope did not exist in this industry. Fuss and Waverman attributed the presence of such results to the limitation of data. They stated that pooled cross section data were required to obtain robust results.

The weaknesses of the study on scope economies were subsequently claimed to lie in the difficulty in allocating total costs into joint and common costs (Dalton and Mann, 1988). This is presumably a reason why the results in Fuss and Waverman indicated no scope economies in telecommunications in Canada.

Gabel and Kennet (1994) investigated economies of scope between toll switched and exchange switched services in local telephone exchange markets in the United States (US).[8] In this study, an engineering optimisation model was applied to test whether scope economies existed in these markets. They stated that such a model would allow them to compare the cost of a single network with the costs of various combinations of networks. In their study, four outputs (exchange switched service, toll switched service, local private line service and toll private line service) and four input variables (the cost of switches, the cost of trunk exchanges, the cost of feeder and distribution cost) were examined.[9] Gabel and Kennet concluded that economies of scope did not exist in the telephone exchanges.

In addition, Gabel and Kennet attributed the shortcomings of other studies, for example Shin and Ying (1992) and Shin and Ying (1994), to the lack of data on costs in situations where there were two or more firms operating in the same market. In addition, they also attributed the inconsistent results of past research, which will be discussed further, to the data problems in input variables represented by input prices. Gabel and Kennet claimed that testing the cost structure of telephone exchanges with an engineering data set would circumvent the shortcomings of prior research.

[8] Toll switched exchange is called a trunk switched exchange in the United Kingdom.

[9] Feeder is one type of equipment associated with the telecommunications network.

2.3.3 The Applications of Subadditivity

Following Baumol et al (1982), 'strict and global subadditivity' was proposed as both sufficient and necessary conditions for the estimation of a market structure. However, the investigation for the global subadditivity requires global information. This requirement is a major constraint in applying the concept of subadditivity suggested by Baumol et al. Such a restriction leads to a number of modifications in the cost function and the methodologies used in many studies, for example Evans and Heckman (1984), Roller (1990), Charnes et al (1988), Guldmann (1990), Shin and Ying (1992), Shin and Ying (1994) and Berg and Tschirhart (1995). Each of these studies presented a variety of interesting findings whose implications provide guidelines for the development of the new analytical framework used in this thesis. For this reason, it is important to review these research studies in some detail.

As discussed above, the requirement of global information is an obligation of subadditivity concept proposed by Baumol et al (Evans and Heckman, 1984). To circumvent this shortcoming Evans and Heckman introduced in 1984 a 'regional test' as a substitute technique in testing subadditivity.

Figure 2-4 shows an 'admissible region', which is an area to evaluate the existence of subadditivity (Evans and Heckman, 1984). Under this concept only the range of output $\tilde{q}_t$ is tested for subadditivity. In their study Evans and Heckman assumed R_L is the lowest ratio of output 1 to output 2, and R_U is the highest ratio of output 1 to output 2. To accept the existence of subadditivity the hypothetical firm must have output ratios between the vectors R_L and R_U. If the hypothesis is rejected, it indicates a global subadditivity is also rejected. In other words, an industry is not a natural monopoly. Evans and Heckman claimed that the results of such a regional test are sufficient to indicate whether the global region is subadditivity.

The concept of a regional test was first applied by Evans and Heckman (1984) to test for the cost structure of the Bell System in the US. Time series data over the period between 1947 and 1977 were examined. A transcendental logarithmic (translog) cost function was used to ensure the presence of subadditivity. Two types of outputs (local and toll telephone services) and three input vectors (capital, labour and materials) were investigated. The major finding of their study indicated that subadditivity was rejected in the period between 1958 and 1977. This implied that telecommunications in the US after 1958 were no longer a natural monopoly and that society would gain more benefits if there were more than one incumbent firm. Evans and Heckman stated further that the centralisation of the Bell System after 1958 caused high costs through an inefficient operation.

Charnes et al (1988) tested for the subadditivity of the Bell System by using the same data set as Evans and Heckman (1984). In contrast to the study of Evans and Heckman, 'a goal programming/ constrained regression' was the technique applied in their study.[10] Charnes et all included the concept of the goal programming into the same functional form of the translog cost function that was used in Evans and Heckman (1984). They attributed the major advantage of the goal programming method to the fact that it circumvented the problems of data deficiencies. Charnes et al claimed that goal programming would check any systematic errors in the data set and then eliminate the ones with error terms. Opposed to Evans and Heckman, Charnes et al concluded that the

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[10] A goal programming/ constrained regression refers to a type of sensitivity analysis used to examine some variations in the investigated observations. It is also applied to evaluate an increase or decrease in the total deviation between regression values and observations.

structure of telecommunications in the US during the period of their study was still a natural monopoly.

Like Charnes et al (1988), Roller (1990) tested for subadditivity of the US Bell System. The same data set as used in the study of Evans and Heckman (1984) was tested. The difference in the methodology between the two studies is in the cost function estimated. In Roller's study, a quadratic, instead of a translog, cost function was used. Roller claimed that the use of a quadratic cost function would provide two advantages, compared with a translog cost function. First, it has been believed that the analysis of multiple product case with a quadratic cost function would provide better results than a simple translog cost function, in particular when economies of scope and subadditivity are investigated (Evans and Heckman, 1983). Second, Roller claimed that the quadratic cost function would reduce the constraints posed by data problems.

However, Roller was also aware that the use of a quadratic cost function contains a weakness. That is, although the function exhibits a negative sign in independent variables, the assessment results are still the same.[11] This bias may lead to a loss in functional flexibility which is required for a global test. Roller stated further that the areas of such a loss are too small and they would not cause the biased results.

Compared with the findings of Evans and Heckman (1984), Roller concluded that economies of scale still existed and there were strong economies of scope in the Bell System. He concluded further that divestiture in any year between 1947 and 1977 would have led to an increase in costs. In other words, the telecommunications market, prior to the break-up of the Bell System, was a natural monopoly. Consistent with the

[11] A proper cost function must be nonnegative and linearly homogeneous, concave and nondecreasing in input prices (Baulmol et al, 1982).

findings of Charnes et al, the evidence in the study of Roller supported that the Bell System during the period of study remained a natural monopoly.

Guldmann (1990) studied the production structure of the local exchange networks in New York. The aim of his paper was to investigate the cost structure of local exchange carriers (LECs) to see whether they were natural monopolies. Cross section data for 44 local exchange companies in 1980 were tested using a translog cost function. In his study two multiple outputs (the number of telephone stations and the locations of each exchange) and two input prices (labour costs and capital costs) were examined. Guldmann found that an increase in firm size resulted in decreasing economies of scale. As a result smaller firms were considered to be more efficient than medium or larger sized firms.

In 1992 Shin and Ying tested the structure of the Bell System by using pooled cross section data. Shin and Ying attributed the inconsistent results of past research to the use of time series data as well as to the small number of observations. They claimed that time series data would provide biased estimates of scale elasticity since there is high correlation between output and technological change variables. Shin and Ying stated further that using pooled cross section data would offer more precise and plausible estimation parameters, while the estimates of time series data produce a cost function with high economies of scale.

For the above reason, pooled cross section data of 58 local telephone networks between 1976 and 1983 in the United States were tested in their study. Three outputs (the number of telephone lines, the number of local calls and the number of toll calls) and three input variables (labour costs, capital costs and the prices of other inputs) were included in a cost function. They found that LECs in the US were no longer natural monopolies.

In 1994, Shin and Ying retested the same model with a different data set. In this study pooled cross section data for the period 1984 - 1991 were tested. Their finding was the same as in their previous research. In this study they also examined two other issues, the relationship between the existence of small size LECs and the cost of production and the percentage of cost saving when there was more than a single firm. They found that, at the same level of output, small LECs can produce at lower costs by 22 per cent. More importantly, the monopoly output which is produced by two or more firms could potentially result in over 20 per cent cost savings.

Berg and Tschirhart (1995) investigated the market structure of seven LECs in the United States. Compared with other studies, rather than estimating the cost structure of telephone exchanges Berg and Tschirhart examined whether sunk costs are the barrier to entry in LECs, and whether the market is sustainable.[12,13] They asserted that these two questions must be asked to see whether regulation is justified.

The findings in the Berg and Tschirhart's paper showed that, with respect to the current services provided in the US market, the LECs were neither sustainable nor had subadditivity. That is, allowing more firms to participate in the LECs market leads to

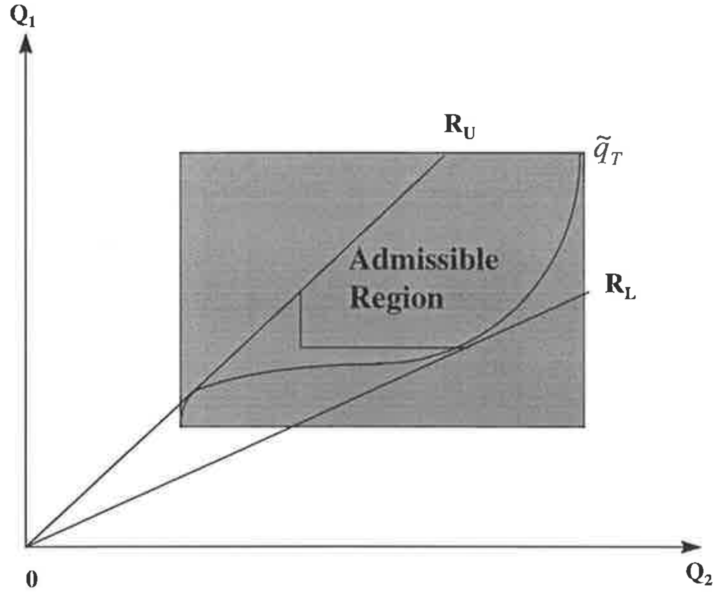
[12] In the production process, inputs can be classified into two broad categories, fixed costs and variable costs. The fixed costs refer to the costs which do not vary with the amount of output, while the variable costs tend to vary directly with the level of output. For sunk costs, they refer to the expenditures on production inputs, for example plant and machinery which once incurred cannot be used for other purposes or resold. All sunk costs, once incurred, are fixed costs but not all fixed costs are sunk. A natural monopoly generally requires a large amount of fixed costs, and frequently most of them are sunk costs (ie, specific machinery). Such a capital expenditure, therefore, becomes a key barrier to entry for weaker firms.

[13] A sustainable natural monopoly refers to the situation that a monopolist will charge prices that thwart the entrance of competitors. If an industry is sustainable, it indicates the industry is a natural monopoly.

more cost savings. More importantly, the assessment of results indicates that the LECs market is not sustainable. This can be interpreted to mean that the monopolist cannot find a set of prices that would thwart an entry. Berg and Tschirhart concluded further that whether or not the telecommunications structure is a natural monopoly, telecommunications regulations are required to control the incumbent firms in order to achieve a cost saving from economies of scope.

FIGURE 2-4

Test for Subadditivity using the Concept of Evans and Heckman



Source: Evans and Heckman (1984)

2.4 CONCLUSION

Lessons from the theoretical and literature reviews in this chapter can be summarised as follows:

First, with respect to the traditional definition of a natural monopoly, natural monopoly exists when economies of scale exist. Such a definition indicates the need to test for scale economies to determine whether an industry is a natural monopoly. In later years it has been demonstrated that the degree of scale economies alone is not sufficient to indicate the market structure. This is because in some cases while the average cost is rising, a single firm is still needed in the market to minimise cost. That is, a single firm may be able to produce at the lowest cost when the average cost is rising.

In recent years a natural monopoly has been redefined. In the single product case, the presence of the natural monopoly exists when the cost function satisfies subadditivity. That is, a singular firm can produce a good or service supplying the entire demand at a lower cost than two or more firms. In the multiple product case, the industry is the natural monopoly when a single firm can produce multiple goods or services at a cheaper cost than two or more firms.

Second, a review of past research has provided the following interesting issues.

(1) A translog cost function is not an appropriate technique to investigate the cost structure in the case of the multiple outputs.

(2) If technological change is rapid and large the estimates of a cost function with time series data probably lead to biased results.

(3) In providing telephone services small firms in the United States have been shown that they can gain more benefits from economies of scale than medium and large firms.

(4) The use of admission region technique suggested by Evans and Heckman to test for subadditivity can circumvent the problem of data shortage. This method, however, is applicable only when an investigated industry is not a natural monopoly.

(5) The use of an engineering concept in a cost function to estimate the market structure can circumvent the shortcomings of a data set.

(6) There are, at least, two methods to estimate the market structure of an industry: the test for degree of scale effects (scale economies and subadditivity) and the test whether sunk costs are barriers to entry.

However, the nature of scale effects is the methodology applied in this study. The reason for selecting this method is because, apart from sunk costs which are normally barriers to entry in this industry, the presence of telecommunications laws in Thailand, which will be reviewed in the next chapter, is a more important barrier deterring private firms participating in this market than is sunk costs. Thus the test of sunk costs may suggest biased results. For this reason, the estimation of the cost structure and the nature of scale economies is the focus of this study.

All previous research reviewed in this chapter has examined market structures which contain different characteristics from the telecommunications industry in Thailand. Therefore, before proceeding to the method used to test the cost structure of the telephone industry in Thailand a review of its telephone industry will be presented in the following chapters.

CHAPTER 3

THE TELEPHONE INDUSTRY IN THAILAND

3.1 INTRODUCTION

As in other countries, the telephone industry in Thailand plays a substantial role in economic and social development. A telephone system was first introduced into Thailand in 1875. Its networks have been gradually expanded over the whole nation. Under the Telegraph and Telephone Act of 1934, only the Telephone Organisation of Thailand (TOT) has the right to build and expand telephone networks for the whole country. In 1991, the Thai Government decided to reform the telecommunications market under build-transfer-operate (BTO) regimes. Such a transformation has considerable impact on the existing economic regulations.

Accordingly, reference in this chapter is made to three issues. First, what are the reasons leading the telephone industry in Thailand to be a monopoly? Next, what are the pressures influencing regulatory reform? Third, what impact does the presence of telecommunications laws have on prices, number of telephone lines and the number of incumbent firms?

This chapter is divided into five sections. Before proceeding to the discussion of why the telephone industry in Thailand is a monopoly in Section 3.3, the next section provides some background about telecommunications in Thailand, the areas of telecommunications services, the presence of Telecommunications Acts and the structure of the regulatory body in Thailand. Section 3.4 describes the pressures leading to regulatory reform under BTO regimes. Section 3.5 discusses the impact of two Telecommunications Acts in Thailand (The Telegraph and Telephone Act of 1934 and The TOT Act of 1954) on the pricing system, the number of fixed-line firms and the number of telephone lines. Concluding remarks are presented in Section 3.6.

3.2 AN OVERVIEW OF TELECOMMUNICATIONS IN THAILAND

In Thailand, telecommunications services, as illustrated in Figure 3-1, have been divided into two main areas - Bangkok Metropolitan areas (BMA) or Metropolitan Telecommunications Areas (MTA) and provincial areas (PA) (areas 1-9) or Provincial Telecommunications Areas (PTA). BMA consists of four provinces, Bangkok (the capital city) and three peripheral provinces (Pathumthani, Nontaburi and Samutprakarn). In 1992, PTA consisted of 69 provinces divided into nine telecommunications zones.

According to Thai jurisprudence the Government reserves rights to provide and manage all communications services (Yoonaidharma, 1993). Figure 3-2 draws a diagram of the regulatory body structure in Thailand. The administration of the telecommunications sector has been managed and controlled by four government organisations, namely the Ministry of Transport and Communications (MOTC), the Post and Telegraph Department (PTD), TOT, and the Communications Authority of Thailand (CAT).

As illustrated in Table 3-1, there are five pieces of legislation that relate to the administration of the Thai telecommunications industry. These are The Telephone and Telegraph Act of 1934, The Post Act of 1934, The TOT Act of 1954, Radio Broadcasting and Television Act of 1955 and The CAT Act of 1976. The Telegraph and Telephone Act of 1934 and The Post Act of 1934 are the key pieces of legislation determining the structure of telecommunications. As stated in Article 6 of The Telegraph and Telephone Act, the Thai Constitution reserves rights to TOT to be the sole network provider and service provider of fixed-lines (TDRI, 1997a). The TOT Act of 1954 and The CAT Act of 1976 are the key Telecommunications Acts establishing the TOT and the CAT, respectively.

The TOT Act of 1954 also indicates the responsibilities and duties of the TOT. According to this law, the TOT can provide the public switched telephone networks (PSTNs), long-distance toll fee services, regional calls (Laos and Malaysia) and multi-access radio telephones to the public.

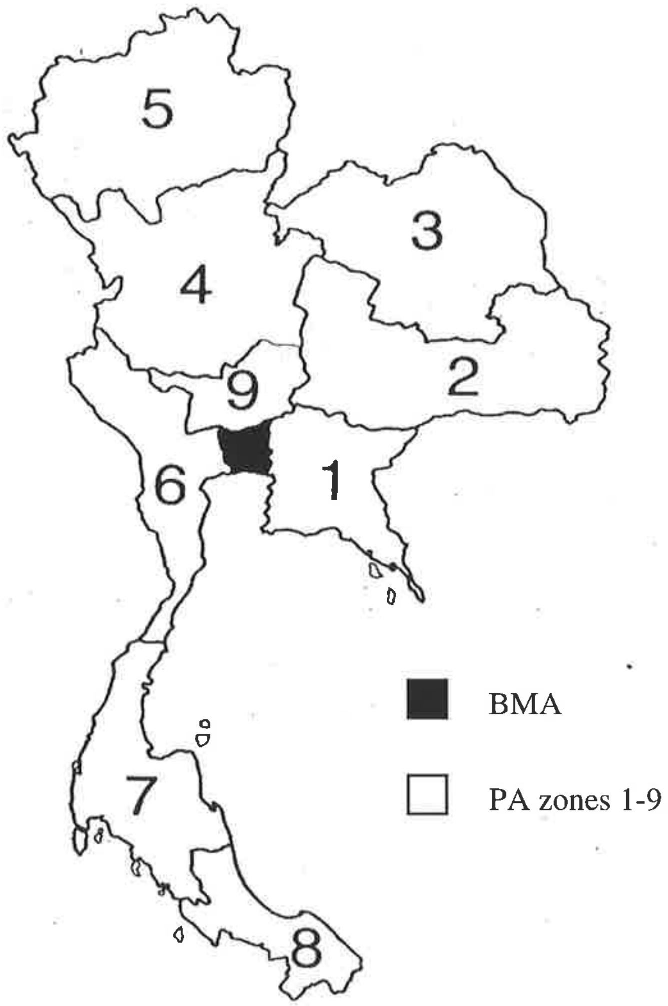
In the context of The CAT Act of 1976, CAT has been responsible for two main types of communications services, namely international call services and non-voice services (ie, postal, monetary and telex).

The Radio Broadcasting and Television Act of 1955 reserves rights for PTD to regulate radio spectrum frequency allocations, and manage wireless communications. In recent years, the PTD has also manipulated domestic satellite communications.

The historical survey so far has provided an overview of the telecommunications sector in Thailand. Before proceeding to a discussion of regulatory reform in the telephone system, the main factors leading to a monopoly in the telephone industry will be discussed in the next section.

FIGURE 3-1

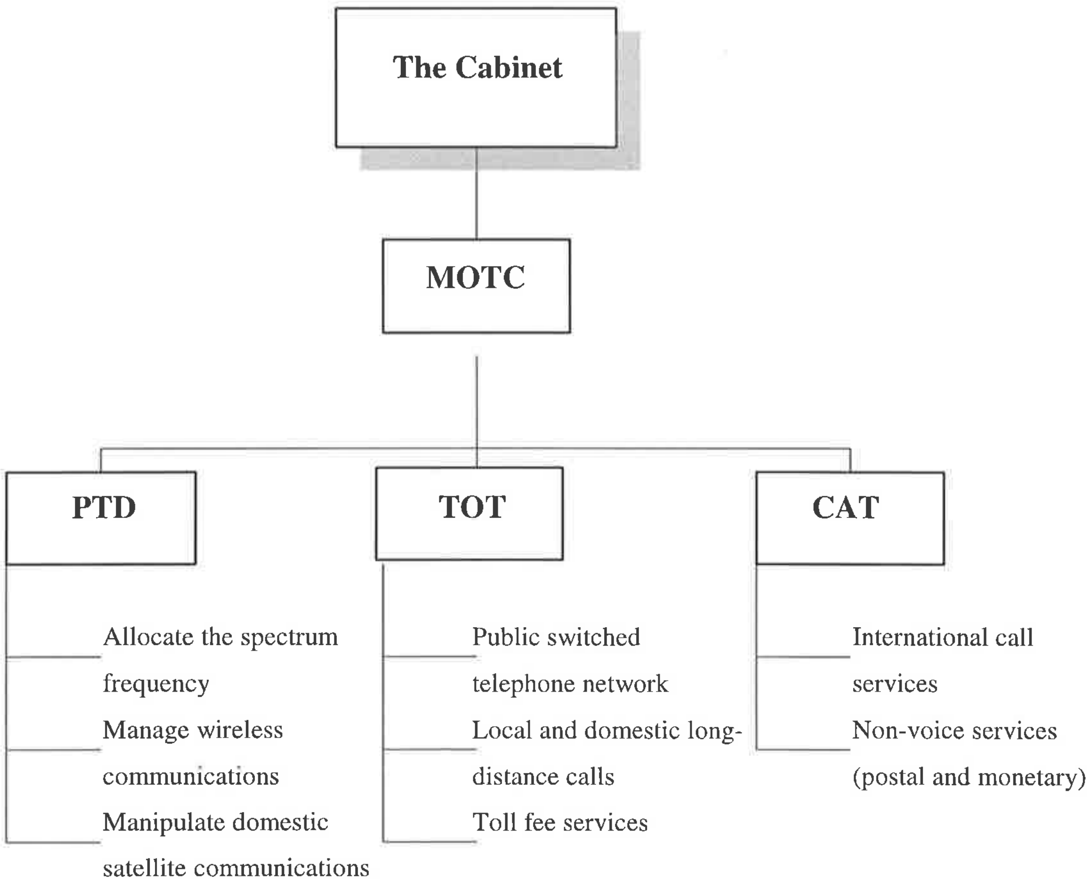
Telecommunications Areas in Thailand



Source: TT&T (1994a)

FIGURE 3-2

The Structure of Regulatory Body in Thailand



Note: MOTC = Ministry of Transport and Communications

PTD = Post and Telegraph Department

TOT = The Telephone Organisation of Thailand

CAT = The Communications Authority of Thailand

TABLE 3-1

Telecommunications Acts in Thailand

Telecommunications Legislation	The Main Context
The Telegraph and Telephone Act of 1934 and The Post Act of 1934	This legislation empowers the state to monopolise the provision, maintenance and operation all of telegraph and telephone services.
The Telephone Organisation of Thailand Act of 1954	TOT was established under this legislation. This legislation reserves rights to TOT in providing and promoting telephone activities.
Radio Broadcasting and Television Act of 1955	This legislation authorises PTD to manage the use of radio spectrum.
The Communication Authority of Thailand Act of 1976	CAT was established under this Act. This legislation delegates CAT the responsibility for the provision of international telecommunications services and non voice services (monetary and postal services).

Source: Soonthonsiripong (1996) and BOI (1996)

3.3 REASONS FOR MONOPOLY STRUCTURE

As discussed in the previous chapter, scale effects, generally, are important factors determining the structure of a telecommunications market. In particular, a monopolist, it was believed, would minimise production cost. The telecommunications industry, therefore, is monopolised. Apart from this reason, there are two other factors which are of great importance in determining the structure of the telecommunications market in Thailand. These are national security and the context of the Thai Constitution.

Initially, national security was the most significant reason to direct the structure of the telecommunications sector (TDRI, 1997a). In the early 20th century, there was the colonial power-conflict between French and British Governments in laying telegraph cables in Thailand. During that period, no particular telecommunications law had been set up. Therefore, there was no restriction on who could be a telecommunications operator. The French at that time wanted to lay cable westward from Vietnam to Cambodia, while the British planned to lay telegraph cable from India to Thailand. However, the French wanted to block out the British influence in Indochina. The French, therefore, asked for an exclusive right from the Thai Government in order to lay telegraph cable in Thailand. To circumvent such a conflict the Thai government reserved rights for itself to establish and to operate the telegraph system. Before the establishment of TOT in 1954, PTD was delegated to be responsible for laying communications networks and providing services (Boonyawinaikul, 1995). The right to install networks and to operate telephone services has gradually been transferred from PTD to TOT since 1954. All responsibilities were transferred to TOT in 1969 (TOT, 1991).

Although there has been no problem as to who could be a telecommunications operator or in laying the network in recent years, the national security reason still prevails. As stated in Article 4 of The Telephone and Telegraph Act of 1934:

> *'representatives from the Ministry of Defence, National Security Council and the Ministry of Interior shall sit in the National Telecommunications Commission'* (quoted by Yoonaidharma, 1993, p. A-7).

The Thai Constitution is the second context that determines the structure of the telecommunications market. As telecommunications is seen as a natural monopoly, a monopolist, without regulation and government intervention, would charge higher prices and produce lesser quantities than those preferred by society as a whole (TDRI, 1997a). In contrast, it is assumed that the State would protect the public interest and provide sufficient goods at reasonable prices. For this reason, the Thai Government limits rights for providing public utilities to the state owned enterprises, with Yoonaidharma (1993) stating that:

> *'... Article 64 paragraph 1 of the 1968 Constitution, Article 48, Article 85 paragraph 1 of 1974 Constitution and Article 68 paragraph 1 of the 1978 Constitution encourage only a state to have rights in providing public services ...'* (p. A-3).

Apart from granting rights to provide public services, The TOT Act of 1954 allows the state-owned enterprises to have rights to grant licences and to engage in joint ventures with the private sector. This determination results in granting concessions, which will be discussed in the following section.

3.4 MARKET PRESSURES FOR REGULATORY REFORM

3.4.1 Internal Pressures

During the 1980s the Thai economy experienced rapid growth. Gross Domestic Product (GDP) of Thailand has grown dramatically from US$61,668 million in 1988 to US$124,862 million in 1993. GDP per capita has grown from US$1,154.83 in 1988 to US$ 2,150.42 in 1993 (World Bank, 1995). The telecommunications sector also showed two digit growth rates, that is 33.80 per cent in 1988 and 14.58 per cent in 1993 (TDRI, 1997b). As GDP grew demands for telecommunications, in particular telephone lines, also increased rapidly. During the same period demand for telephones was increasing at an average 19.33 per cent annually.[14] Although the size of telecommunications investment has increased dramatically, for example from 1,000 to 4,000 million baht in the Sixth National Economic and Social Development (NESD) plan (1987-1991) (TDRI, 1997a), there were small percentage increases in new fixed-lines in each year.[15] Consequently, the number of people on waiting lists, as illustrated in Figure 3-3, increased.

Unmet demands for fixed-lines were attributed to three weaknesses in TOT, insufficient budget, inefficient management and deficient skilled labour (Soonthonsiripong, 1996). Each will be discussed below.

First, the problem of insufficient budget. Basically, the installation of telecommunications networks requires large amounts of investment, the government

[14] Computed from TOT's data (1988, 1992b, 1993a).

[15] Telecommunications have been included in the NESD plan since the first plan (1961-1966).

expenditure to this sector, however, is a small proportion compared with investment in other sectors. For example, in 1998 government expenditure on the telecommunications sector was 9.3 per cent of total government budget, while it was 25.4 in the educational sector and 11.3 in the maintenance of national security (Bureau of the Budget, 1998). To increase the capital investment, foreign loans are therefore the major sources of funds of TOT (TOT, 1988 and TOT, 1994a). But with respect to the loan ceiling, the tight budget problem still exists and it becomes one of the weaknesses of TOT (Chanya, 1989).

The inefficient management of TOT has been attributed to two factors; bureaucracy and government orientation. First, because there are too many departments in TOT the working process, then, is slow (TDRI, 1993a). Second, the management style still has a government orientation. That is, the Board of Directors in TOT, as illustrated in Figure 3-4, consists of representatives from several government organisations and the private sector (Boonyawinaikul, 1995). More importantly, due to The TOT Act of 1954, TOT is under the control of the MOTC and the Cabinet. Therefore all investment plans must be approved by the Board of Directors and finalised by the MOTC and the Cabinet. Such a management process, undoubtedly, would take a longer time compared with the management style of private firms.

Lack of skilled labour, in particular engineers and telecommunications specialists, is another weakness of TOT. It was noted that most of the employees in TOT have been responsible for administration, while there is only 28 per cent of total employees who operate in the department of network constructions (TDRI, 1997a).

With respect to the supply shortage of fixed-lines, a need to deregulate the telecommunications sector has been taken into account since the Fifth NESD plan (1982-1986) (Yoonaidharma, 1993). In 1984 Canadian investors were offered the rights to develop a digital network by Prime Minister Prem Tinnasulanon. The contract, however, was subsequently cancelled. This was because this proposal contradicted Articles 5 and 6 of The Telephone and Telegraph Act of 1934, as under this legislation the private sector or any third parties are allowed to operate communications services only for their own use (Yoonaidharma, 1993). They are prohibited from operating communications services for the public. Although the Article 9(6) of The TOT Act of 1954 allows private firms to be part of a joint venture, a joint operation can be made only in terminal equipment (Yoonaidharma, 1993).[16]

Attempts to deregulate the telecommunications market were found again in the Sixth NESD Plan (1987-1991) (Yoonaidharma, 1993). Telecommunications laws were reconsidered to see whether allowing private firms to participate in this market is possible. Consequently, with regard to the context of The TOT Act of 1954, the participation of private firms is feasible through granting concessions or licences to private firms under BTO regimes. The introduction of BTO arrangements was first introduced in the Thai telecommunications market in 1986. Pacific Telesis was the first private company granted a 10 year concession by CAT to provide a paging service.[17] Since then, as shown in Table 1-2 in Chapter 1, the number of concessions granted to private firms has gradually increased.

In the fixed-line networks, concessions were granted to the private sector when the unmet demand during the mid 1990s, as presented in Figure 3-5, showed an increasing trend. The TOT considered that without cooperation by the private sector the

[16] Terminal equipment refers to hardware used in telecommunications, for example telephone sets, switches and cables.

[17] Paging service sends messages to a beeper carried by the person who is to be paged.

aggregate forecasted demand in 1996 would increase to double the supply of the fixed-lines (Chanrojanakij et al, 1994).[18] That is, TOT could supply a total of three million telephone lines, whilst total demand was six million lines. Thus, TOT decided to circumvent such a problem by granting a concession for the 'Three Million Telephone Lines Expansion' project in 1990. A private firm, which won the bid, would be allowed to operate two million lines in BMA and one million lines in PA for 25 years.[19]

In February 1991, TelecomAsia (TA) won the bid in the 'Three Million Telephone Lines Expansion' project.[20] However the contract was subsequently cancelled. The Thai Government, headed by Prime Minister Anand Panyarachun, claimed the weaknesses of the Three Million Lines Project related to two problems, the possibility of a monopoly occurring and the problem of cross-subsidisation (Yoonaidharma, 1993 and Chanrojanakij et al, 1994). Each will be explained in more detail below.

Consider the occurrence of a monopoly. As mentioned previously, TOT acknowledged that TOT could not supply another three million lines to meet market demand. So it was planned to grant a licence for the Three Million Lines Project to a single private firm which would undoubtedly lead to a monopoly market. It was expected that social loss would be present, as there was a single firm in the market (Chanrojanakij et al, 1994).

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[18] Aggregate demand for telephone lines is forecast from the existence of telephone lines, the number of people on the waiting list, GDP per capita, the size of household (TOT, 1993a).

[19] There were five private firms proposing an interest to invest in this project. These were Alcatel CIT, Telefonaktiebolaget L.M. Ericsson, CP Telecom, Toyo Menka Kaisha and Consortium of Mitsui.

[20] At the beginning the company was called 'CP Telecom'.

The second weakness in the Three Million Lines project was attributed to the problem of cross-subsidisation. In the provision of telephone services the prices of long-distance calls have been frequently claimed to be overcharged. Then extra profit from long distance calls will offset loss from the provision of local calls, which is frequently undercharged (Chanrojanakij et al, 1994). Therefore, if the licence to install three million lines was granted to a single firm it was presumed that, without well-defined regulation, the prices of long distance calls might be overcharged.

To circumvent these problems the Three Million Lines Project was divided into two projects, one for two million lines in BMA and one for one million lines in PA. Consequently, TA and Thai Telephone and Telecommunication (TT&T),[21] as illustrated in Table 3-2, were granted licences to build up two million lines in BMA and one million lines in PA, respectively.[22]

3.4.2 External Pressures

As mentioned earlier the right to provide communications services, with regard to the Telegraph and Telephone Act of 1934, is reserved to state-owned enterprises. However, unilateral agreements with trade counterparts, for example the United States and Organisation for Economic Co-operation and Development (OECD) countries, and,

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[21] TT&T is a consortium of Loxley Bangkok, Jasmine International, Ital-Thai Development Corporation and Phatra Thanakit.

[22] In 1995, TA and TT&T amended their agreement for joint operation and joint investment of telephone services. This amended agreement involved the addition of six hundred thousand numbers and five hundred thousand numbers, respectively. Therefore, TA held responsibility for building up 2.6 million lines in BMA, and TT&T for building up 1.5 million lines in PA.

in particular, the impact of multilateral agreements on the General Agreement on Trade in Services (GATS) and the World Trade Organisation (WTO) also have pressured the Thai Government to open up the telecommunications sectors.

Following the Uruguay Round negotiations, the Thai Government has allowed foreign investors to participate in the provision of communications services under BTO agreements. However, the investment and management are restricted under three conditions. First, foreign investors cannot establish their own communications networks. They have to lease circuits from the state-owned enterprises. Second, the company should be a Thai registered company with foreign equity participation not exceeding 20 per cent of the registered capital and the number of foreign shareholders must not exceed 20 per cent of the total number of shareholders of the company. The rest must be invested by the Thai partners. Third, foreign investors must have professional skills (TDRI, 1997a).

Due to the scope of negotiation in the Belo Horizonte Meeting in May 1997 investment restrictions have been gradually eliminated.[23] According to the previous negotiation, as mentioned above, the proportions of foreign shareholders have been expanded. Currently the foreign partners in the telecommunications sector can hold a maximum of up to 40 per cent of the total investment.[24]

In addition, it has been stated in the WTO agreement, in particular in the telecommunications sector, that:

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[23] Http://www.sice.oas.org/ftaa/belo/forum/workshop/syno9%5Fe.st

[24] In other sectors the foreign investors can hold a maximum of 49 per cent of the total investment (TDRI, 1997a).

'Member countries should commit to a certain date for full liberalisation. Those which are not able to liberalise immediately, must commit themselves to a schedule of progressive reduction' (p.9).[25]

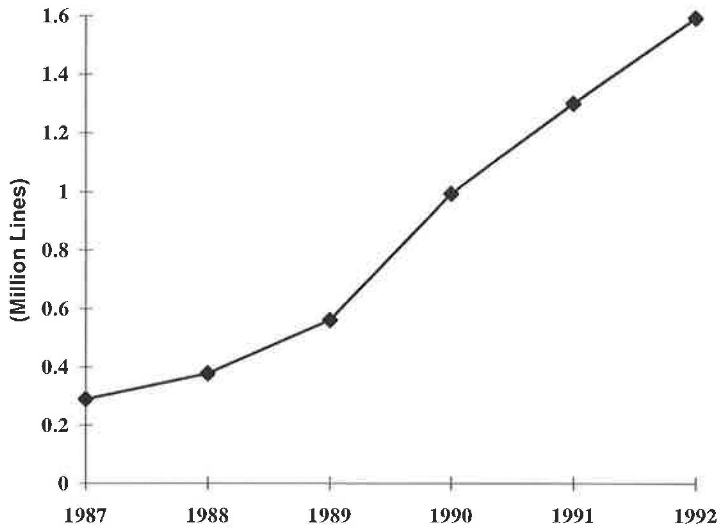
For the above reason, some sectors in the telecommunications industry, such as telecommunications equipment sales service and telecommunications consulting services have already opened up free entry, while other sectors, for example data base access services and teleconferencing have still been restricted under the above conditions (TDRI, 1997a). In 1997, the Thai Government has committed itself to liberalise fully the telecommunications market in 2006 (TDRI, 1997a).

There is no doubt that the plan to liberalise the telecommunications market would have many effects, for example change in a pricing system and innovation in communications technologies. However because this is beyond the scope of this study estimation of its impact is an area suggested for further study.

[25] Http://www.sice.oas.org/ftaa/belo/forum/workshop/syno9%5Fe.st

FIGURE 3-3

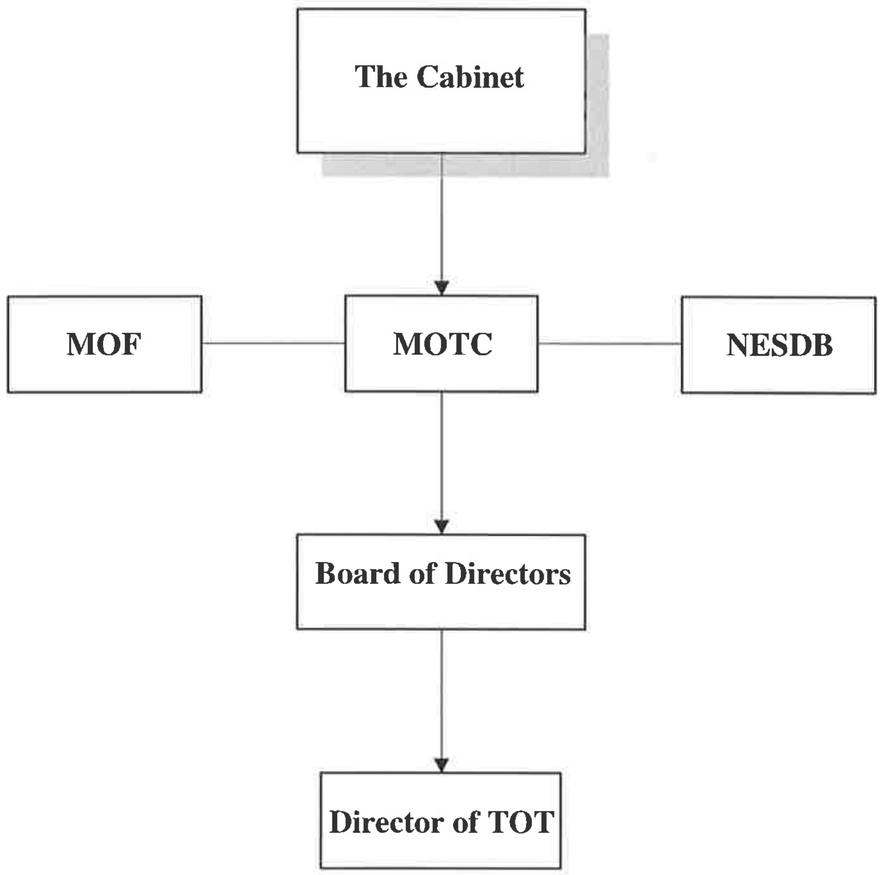
The Length of Lines in Lists



Source: ITU (1994)

FIGURE 3-4

Board of Directors of TOT



Note: MOTC = Ministry of Transport and Communications

MOF = Ministry of Finance

NESDB = National Economic and Social Development Board

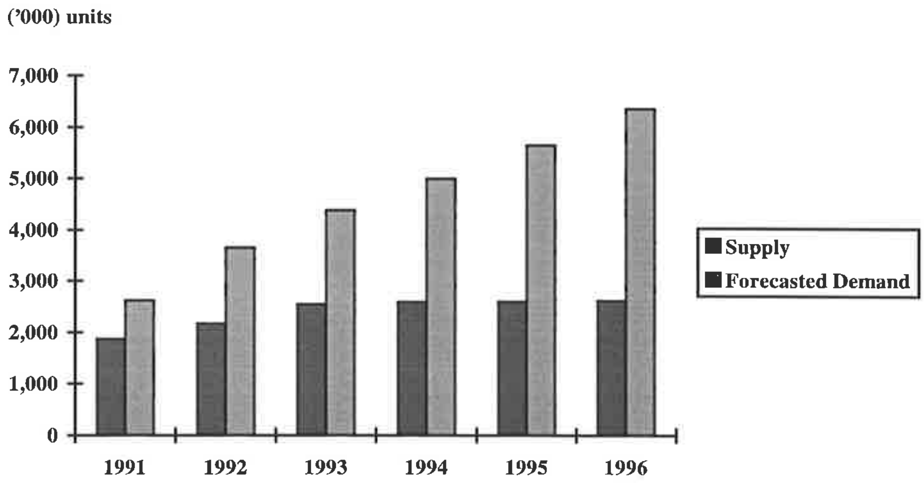
TOT = The Telephone Organisation of Thailand

Source: Boonyawinaikul (1995)

FIGURE 3-5

Demand for and Supply of Fixed-Lines

(Under an Absence of a Regulatory Reform)



Source: TOT (1993a), TOT (1994a) and TOT (1996)

TABLE 3-2

Concessions in the Fixed-Line Telephony in Thailand

Concessionaire	Period	Description
TA	1991-2016	• TOT initially granted a 25 year concession to TA to install and to operate 2 million fixed-lines in BMA areas • Began operation in 1992
TT&T	1992-2017	• TOT granted a 25 year concession to TT&T to install and operate 1 million fixed-lines in 71 provincial areas • Began operation in 1993

Note: TA = TelecomAsia

TOT = The Telephone Organisation of Thailand

TT&T = Thai Telephone and Telecommunication

Source: TT&T (1994a) and TOT (1996)

3.5 ECONOMIC REGULATION IN TELECOMMUNICATIONS

As discussed previously, the development of telecommunications has been determined by the Thai Constitution and the Telecommunications Acts. In particular, The Telegraph and Telephone Act of 1934 and The TOT Act of 1954 have effects on the allocation of prices, quantities and market structure. The impact of this legislation will be discussed in this section.

3.5.1 Before the Introduction of BTO Regimes

The discussion of a market structure of the telecommunications sector in this part will be separated into two sub-sectors, the network provider and the service provider market. In the network provider market the mechanisms of a monopoly market exist because of the context of The Telegraph and Telephone Act of 1934 and The TOT Act of 1954. That is, before reform, due to The Telegraph and Telephone Act, the right to lay communications cables in Thailand had been reserved for TOT alone. As a result TOT was a sole operator in providing fixed-lines.

The context of The TOT Act of 1954 identifies TOT to be a price maker for the access charges of a telephone line.[26] Two-part tariffs are the pricing strategy applied for

[26] In this thesis, access charges means a fee where a user or customer registers as a subscriber to a communication service.

fixed-line telephones. As illustrated in Table 3-3 the access charges of a fixed-line consist of three parts: installation (first time), bond (refundable), and connection fee (monthly payment) (TOT, 1997a).

In the service provider market, it can be separated into two sub-markets, the local and domestic long-distance call market and the international call market. The TOT Act of 1954 reserves the right to TOT to be responsible for the provision of local and domestic long-distance call services as well as to be a price maker for domestic calls. A local measured service has been applied for local calls, while time zone metering has been used for domestic long distance calls. Under the local measured service the subscriber pays a fixed monthly fee, which is the connection fee in Table 3-3, and then pays for local calling on a usage basis. Under the time zone metering the user pays service charges according to distance and the period of usage. In addition, as illustrated in Table 3-4, peak and off-peak pricing are also applied in the basket of domestic long-distance calls. Currently, the tariffs of domestic long-distance calls have been classified into 6 zones (0-50 kms, 51-100, 101-200, 201-350, 351-500 and from 500 kms.).

Consider the international call market. The CAT Act of 1976 reserves the right to CAT to be a sole service provider and a price maker for the international call services. Like domestic long-distance calls, time zone metering has been applied in the charges for international calls. Table 3-5 shows international call charges, which have been classified into 11 zones (Africa, ASEAN, Singapore, Asia, Burma and Cambodia, Australia, Europe, Middle East, North America, Pacific Ocean and South and Central America).

Although The TOT Act of 1954 and The CAT Act of 1976 offer TOT and CAT to be the price makers for all telecommunications prices and tariffs, the text in the same

Acts, however, identifies further that all pricing strategies have to be approved by the MOTC and finalised by the Cabinet.

3.5.2 After the Introduction of BTO Regimes

In this specific context the introduction of BTO regimes affects only the number of operators in the network provider of fixed-lines and the service provider for domestic-calls market. More details are presented below.

As illustrated in Figure 3-6 and Figure 3-7, after the regulatory reform of a fixed-line market TA and TT&T are so far the only two private firms that have been allowed to be network providers as well as service providers for domestic calls in this sector. However, an increase in the number of operators does not result in the existence of a competitive market. The mechanisms of the competitive market do not work. That is, entering to and exiting from this market is not free. In addition, private operators have to follow all prices and tariffs allocated by TOT. Although the private firms can propose new price regimes the final decisions depend on the Government (TT&T, 1994a). For this reason, it can be said that the introduction of the BTO regimes is only the introduction of an illusory competitive market. The private firms are most likely subcontractors to expand the communications networks which are determined by the Thai Government.

Because BTO regimes have never been introduced to the international call market, as illustrated in Figure 3-7, CAT so far is still a sole service provider in this market.

TABLE 3-3

Access Charges for a Fixed-Line

(between 1989-present)

Types of Surcharge	Charge Rate (baht per line)
1. Installation surcharge	3,350
2. Bond	3,000
3. Connection fee	100 per month

Source : TOT (1997a)

TABLE 3-4

Usage Charges for Domestic Long-Distance Calls

(between 1989 - present)

Distance	Usage Charges (baht per minute)		
	07.00-18.00	18.00-22.00	22.00-07.00
from 0-50 kms	3.00	1.50	1.00
from 51-100 kms	6.00	3.00	2.00
from 101-200 kms	9.00	4.50	3.00
from 201-350 kms	12.00	6.00	4.00
from 351-500 kms	15.00	7.50	5.00
from 501 kms	18.00	9.00	6.00

Source: TOT (1997a)

TABLE 3-5

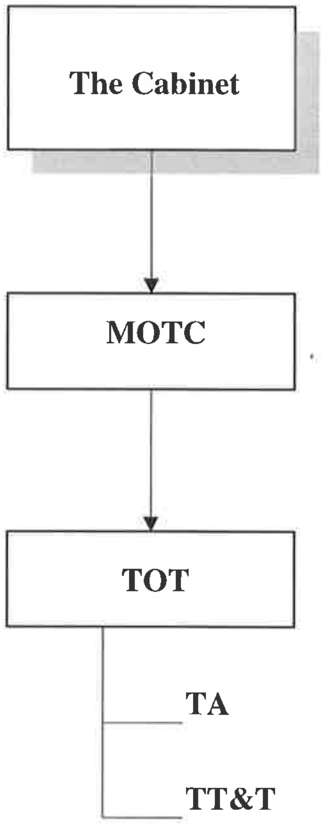
Usage Charges for International Calls

Zone	Commence Date	Usage Charges (baht per minute)		
		07.00-21.00	21.00-24.00 05.00-07.00	00.00-05.00
Africa	Before 01Jan 96	61	49	43
	1-Jan-96	58	46	41
ASEAN	Before 01Jan 96	34	27	27
	1-Jan-96	34	27	27
Singapore	Before 01Jan 96	30	24	24
	1-Jan-96	30	24	24
Asia	Before 01Jan 96	43	34	30
	1-Jan-96	40	32	28
Burma, Cambodia	Before 01Jan 96	30	24	24
	1-Jan-96	30	24	24
Australia	Before 01Jan 96	46	37	32
	1-Jan-96	43	34	30
Europe	Before 01Jan 96	54	43	38
	1-Jan-96	51	41	36
Middle East	Before 01Jan 96	54	43	38
	1-Jan-96	51	41	36
North America	Before 01Jan 96	46	37	32
	1-Jan-96	43	34	30
Pacific Ocean	Before 01Jan 96	54	43	38
	1-Jan-96	51	41	36
South and Central America	Before 01Jan 96	61	49	43
	1-Jan-96	58	46	41

Source: CAT (1997)

FIGURE 3-6

The Current Market Structure of Fixed-Line Network Provider



Note: MOTC = Ministry of Transport and Communications

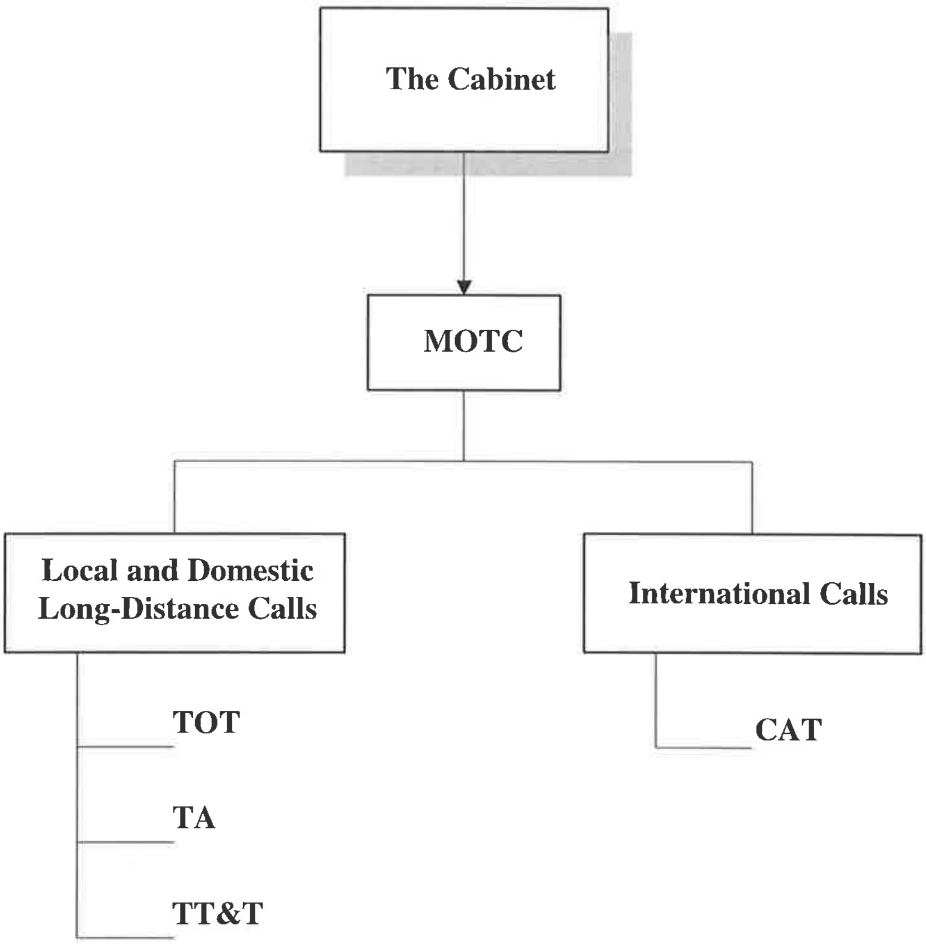
TOT = The Telephone Organisation of Thailand

TA = TelecomAsia

TT&T = Thai Telephone and Telecommunication

FIGURE 3-7

The Current Market Structure of Fixed-Line Service Provider



Note: MOTC = Ministry of Transport and Communications

TOT = The Telephone Organisation of Thailand

TA = TelecomAsia

TT&T = Thai Telephone and Telecommunication

CAT = The Communication Authority of Thailand

3.6 CONCLUSION

The TOT was established in 1954 under The TOT Act of 1954. Under this legislation the TOT has been granted the right to be the sole network provider, to provide communications services and to grant licences or to operate joint ventures with the private sector.

The weaknesses of TOT and international trade agreements are important pressures leading to the need for reform in the Thai telecommunications structure. As a result of tight budget constraints, inefficient management and deficiency of skilled labour, the capability of TOT in providing a telecommunications network and telephone lines was low. This problem became more serious when the Thai economy experienced a two-digit growth rate during the mid 1980s. While the supply of telephone lines increased slowly, demand for telecommunications facilities, in turn, increased dramatically. BTO regimes have been introduced with the hope that the participation of private firms would circumvent this problem. As a result two private companies, TA and TT&T, were permitted to operate 2.6 million lines in BMA in 1991, and 1.5 million lines for provincial areas in 1992, respectively.

The review of the Thai telecommunications industry in this chapter provides two interesting observations. First, granting concessions to the private sector does not introduce a free market in the telecommunications industry. This can be explained by three reasons. First, all the ownership of telecommunications networks has to be transferred to TOT before operating and providing services. Second, due to The Telegraph and Telephone Act of 1934, entry to the telecommunications market is not free. More importantly, the legislation has ensured that the market structure is a monopoly. Third, regarding The TOT Act of 1954, the rights to allocate prices and quantities are reserved to TOT. It is true that private firms can propose new price regimes but final decisions, however, depend on the Thai Government. In this case the mechanisms of a competitive market are not workable. For these reasons such a market transformation under BTO arrangements is the introduction of illusory competition.

Second, the weaknesses of TOT result in the supply shortage of fixed-lines. In circumventing such a problem BTO regimes have been introduced. The number of fixed-lines increased due to the licence granted by TOT. Hence, there is an interest to investigate whether BTO arrangements can reduce the amount of deadweight loss. This issue will be further discussed in Chapter 8.

CHAPTER 4

THE COMPONENTS OF A TELEPHONE SYSTEM

4.1 INTRODUCTION

The application of production theory is one of the techniques used to examine the structure of an industry. A cost or a production function can be derived from either an econometric or engineering approach. To develop an engineering cost function, an understanding of the telecommunications network and the telephone components, which are the areas of interest in this thesis, is required. In this chapter, the discussion of communications technologies is divided into three parts. To understand a telecommunications system, the next section explains how telecommunications users can be connected from one place to another under different types of telecommunications networks.[27] Three common types of networks, namely, a star, a mesh and a hierarchy are contrasted.[28]

This chapter also discusses the transmission systems and switching equipment - the components of a telephone system. In addition, because the reduction of average cost in telephony has been attributed to technological revolutions from an analogue to a digital system, this innovation is also reviewed. The advantages of different technologies are then contrasted.

The adoption of telephone technologies normally differs from one country to another. In this thesis the evaluation of BTO regimes is based on the structure of the fixed-line market in Thailand, so the development of the telephone system in Thailand will be discussed in this chapter as well.

The plan for this chapter is as follows. The next section begins by discussing the development of telecommunications systems. The types of communications network are described. Then, the structure of the telephone system is explained. Section 4.3 examines innovation in transmission systems, including the advantages of digital transmissions, and the relationship between the change in capital costs of a telephone

[27] Communications networks can be categorised in different ways. For example, when the classes of users are considered, the networks are distinguished as public switched telephone network (PSTN) and private network. If they are categorised on the basis of the physical distance between devices and the networks, the networks can be classified into four areas, namely, local, regional, wide and international (Stair, 1996). Because regulatory reform in Thailand occurred in the PSTN, only PSTN is highlighted in this thesis.

[28] A star network is one in which telecommunications or computer users are each connected to a central hub. Each message is passed to the central hub before sending to other users. For a mesh network central switches are not required, since each user is directly linked to others. A hierarchical network is the telecommunications network in which the switching centres are organised in hierarchical tiers.

system and the changes in the number of transmissions or cables. In this section, the development of the transmission system in the telephone network in Thailand is also described. Section 4.4 presents the development of switching systems and the advantages of digital switches. The development of a switching system in the fixed network in Thailand is also discussed. Then the relationship between telephone traffic and equipment required in the telephone system is explained in Section 4.5. Concluding remarks are presented in Section 4.6.

4.2 THE TELECOMMUNICATIONS SYSTEM

4.2.1 An Overview of Telecommunications Development

The revolution in telephone technology can be broadly separated into two periods, namely the analogue and digital telephone networks. The former refers to the flow of information which is transmitted continuously. Such a process is a so-called 'analogue signal'. The transmission path of the analogue signal involves the use of analogue transmissions and analogue switch technologies.[29] For the digital telephone network, the signals are transmitted at regular intervals. The transmission path of the digital signal involves the application of digital cables. Details of each item will be explained in the following sections.

[29] Analogue transmissions and analogue switches refer to the devices used to transmit data or messages with analogue signal. An example of an analogue transmission is copper wire cables. An example of an analogue switch is the step-by-step switch.

Since the early twentieth century, communications technologies have been developed from an analogue to a digital signal. Digital technologies emerged in the late 1950s. In particular, a rapid change in communications technologies started in the early 1960s, with innovations in the form of digital transmissions and switches being attributed to the development of pulse code modulation (PCM) techniques.[30]

As a result of the rapid development in the electronic and computer industries, together with an increase in customer demands for new communications services, for example video-on-demand and teleconferencing, communications technologies in recent years have been gone through the restructuring process of integrated systems, such as an integrated digital network (IDN).[31] Particularly during this decade, a broadband integrated services digital network (B-ISDN) has been replacing an analogue

[30] PCM is one of the coded pulses originating in the late 1960s. It is a transmission process by which an analogue electrical waveform is substituted by coded pulses to enable digital transmissions. It can travel on a line with other kinds of digital information simultaneously. The PCM provides at least two advantages over a traditional analogue transmission. First, the messages transmitted over the PCM system are free from surface line noise (Farr, 1988). Second, the PCM transmission offers a lower cost than that of an analogue transmission using a frequency division multiplexing (FDM) (Farr, 1988).

[31] Video on demand refers to a service that allows the users to order a program for viewing in the home. Subscribers can choose the channel that they want and then obtain services or order products through telephone lines. Teleconferencing is a communications service that enables more than two people who are in different places to participate in a conversation. IDN is a telephone network in which all switching centres and interconnecting transmission links use digital transmission techniques, analogue transmission being retained only on local circuits (Farr, 1988).

wire network.[32] This is because the new technologies can carry a greater bandwidth, and can provide a greater capacity and operate at higher speed.[33]

The benefits of telephone innovation depend on the technologies that have been applied. Better service quality and a greater capacity will be achieved when the entire network is fully digital. For example, the digital network upgraded with an asynchronous transfer mode (ATM) would provide greater bandwidth of fibre optic cables at greater speed, and offer more capabilities and better quality of service than the digital system using twisted-pair copper wires.[34] In other words, a whole network equipped with all digital equipment would be able to carry more capacity and provide a better service quality than a semi-digital system.[35]

In addition, technological development, in practice, varies from one country to another and from one period to another as well. With respect to the scope of this study and the characteristics of the telephone system in Thailand in recent years, a review of telephone development will focus on the terrestrial technologies alone.[36] In particular, the discussion of network technologies highlights the period of technological development from an analogue to analogue SPC.

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[32] B-ISDN refers to a very high speed telecommunications service. The operation of B-ISDN has to run over digital transmissions (Morse, 1996).

[33] Bandwidth is the range of signal frequencies or the amount of data (Morse, 1996).

[34] ATM is a fast packet switching which is used on networks to fit with digital cables.

[35] A digital network using some digital and some analogue equipment is called here a 'semi-digital system'. For example, a telephone network equipped with a digital SPC switch and analogue cables is called an analogue stored program control (analogue SPC).

[36] It refers to the technologies equipped on land, for example, copper wires and fibre optics. Non - terrestrial technologies are, for example, satellites.

The above is an overview of the development of telecommunications technologies. The next step is to explain the flow of a telephone system through different types of communications networks.

4.2.2 The Structure of a Telephone System

The discussion about the flow of a telephone system will start from when the messages from a subscriber or telephone user are transmitted from one local exchange to another. The flow of information varies on the type of network structure. Basically, there are three different types of telephone network structure: a star network (Figure 4-1), a mesh connected network (Figure 4-2) and a hierarchical network (Figure 4-3). Each network would supply different levels of reliability (quality of service) and capacity. The reason for choosing an appropriate network for a particular telephone system depends on several criteria such as the number of subscribers, the number of calls and capital investment. Each will be contrasted as follows.

Consider a star and a mesh network. In the star network, as illustrated in Figure 4-1, each telephone user will be connected to a central hub. Every communications message will be transmitted to the hub before being retransmitted to the end users. With this structure, an operator would know the exact amount of equipment required in the system. In this case, the problem of underestimated or overestimated investment does not exist. In contrast to the star network, each user under the mesh network is connected to each other directly. Such a network architecture, on the one hand, has more flexibility in increasing additional users. However, on the other hand, because an operator does not know the amount of equipment required in the system, a shortage or a surplus of circuits is the major problem in the mesh network (Pollard, 1975).

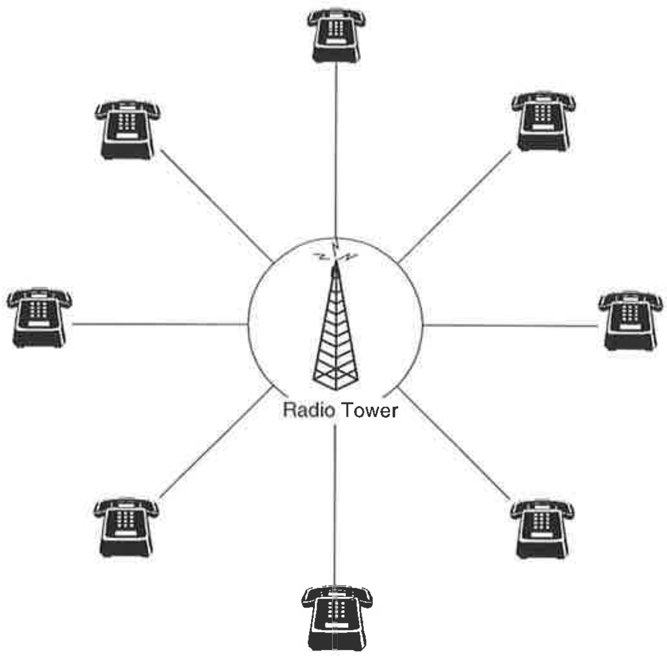
Consider a hierarchical network in Figure 4-3. This type of network is classified into five different levels, namely international gateway, tertiary trunk, secondary trunk, primary trunk, and local telephone exchange (Littlechild, 1979 and Pollard, 1975).[37] Under this network architecture the messages are transmitted to a switching centre at the nearest local exchange. If the destination is in the same local area, the signals would be connected directly between two local exchanges in the same level of the hierarchy. If the circuits in the same level are fully occupied, the interconnections from the lower level to the next higher rank of the network, for example from the local exchange to primary trunk, are applied. For this reason such a system design can provide more communications routes, compared with a star and a mesh network.

In addition, because there are more levels in the hierarchical network such an architecture, therefore, can provide more telephone lines. For this reason the network hierarchy has been widely used, in particular, in the public switched telephone network (PSTN), and in areas with a high population density or a high volume of traffic. However, because it consists of several ranks, more equipment, for example cables and switches, are required. In this case there is no doubt that the cost of investment for this network architecture would be relatively expensive (Tikaput, 1996).

[37] The names of each level are named differently in each country. For example, the switching centres connected to end users are called local exchanges in the United Kingdom, and end offices in North America (Littlechild, 1979).

FIGURE 4-1

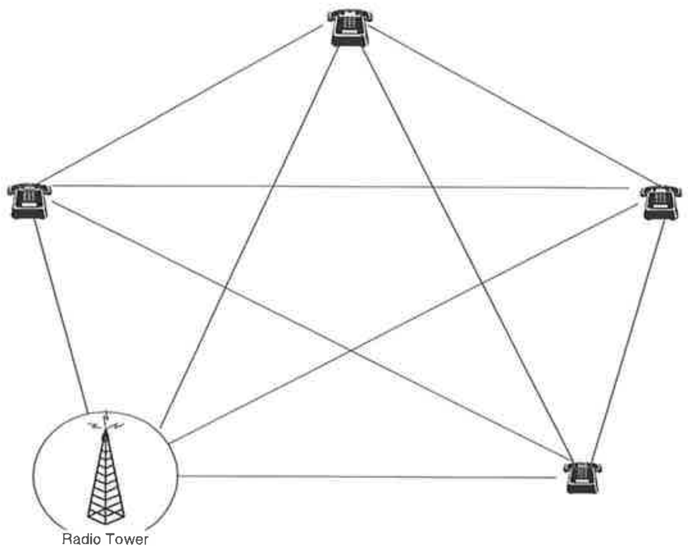
A Star Network



Source: Tikaput (1996)

FIGURE 4-2

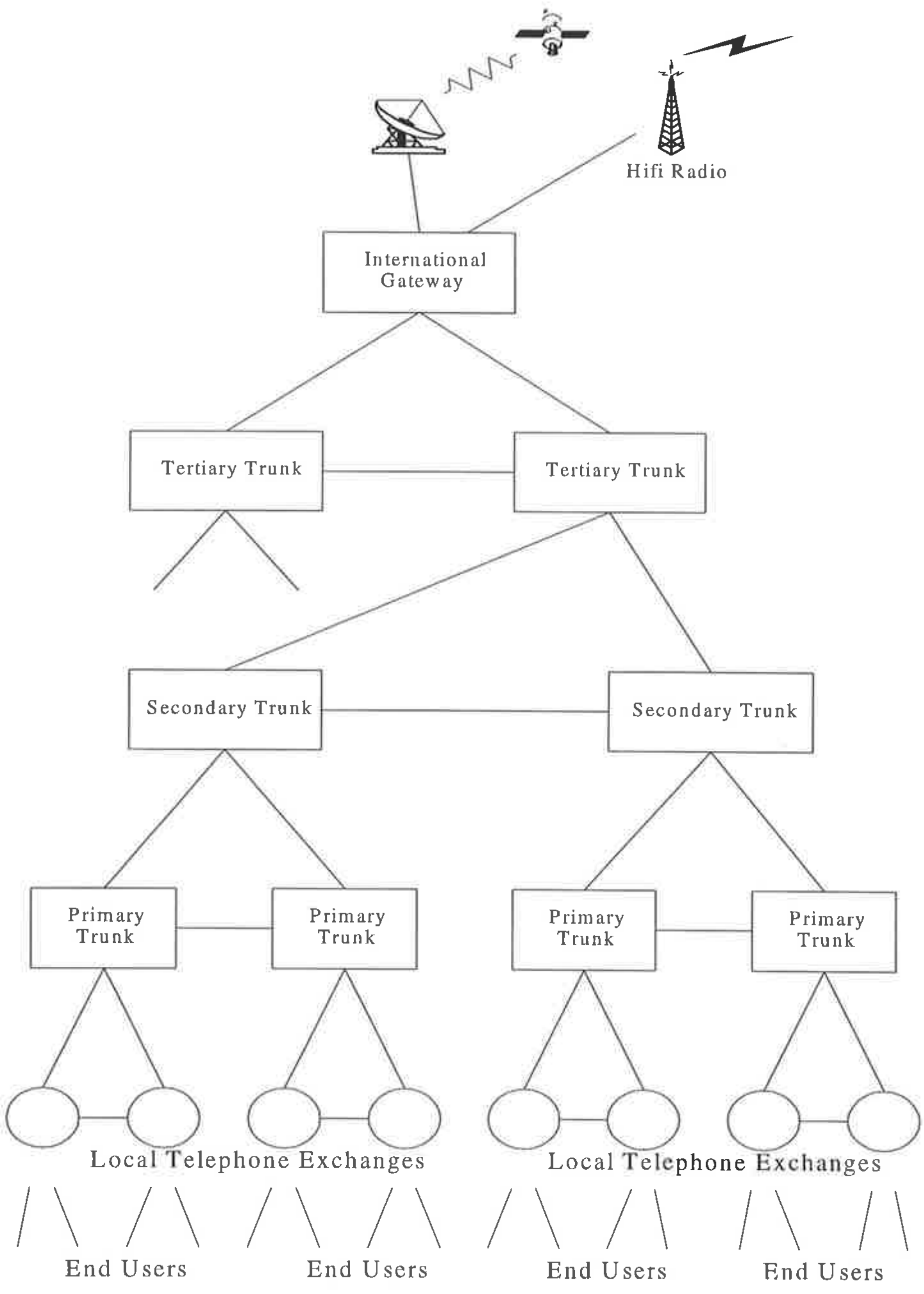
A Mesh Network



Source: Tikaput (1996)

FIGURE 4-3

A Hierarchy Network



Source: Littlechild (1979)

4.3 TRANSMISSION SYSTEMS

A transmission system is the process of moving information from one point to another. It has been invented to carry a fixed maximum number of circuits for transmitting speech and other signals between the nodes of a telecommunications plant.[38] The transmission system requires an interconnection medium or transmission path, such as copper wires or coaxial cables, that allow the atmosphere and space to be used as transmission media.[39] The transmission paths can be classified into two broad classes, analogue and digital. Analogue transmissions involve the use of analogue facilities, such as pairs of wires and coaxial cables. Digital transmissions involve the use of digital facilities, for example microwave and fibre optics. Each system will be detailed here.

4.3.1 Innovation in Transmissions

A good transmission system should consist of, at least, two characteristics. First, it should have a minimal impact on the intelligibility of the message, neither distorting nor attenuating quality (Pearce, 1981). Second, it should be able to provide high capacity or a so-called great 'bandwidth'. Initially twisted-pair copper wires, which refer to bundles of pairs of twisted-insulated copper wires, were developed. Such a network

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[38] A circuit provides for the transmission of these signals in both directions. If the circuit uses a separate transmission path for each direction, then each of these uni-directional paths is called a channel (Flood, 1991).

[39] Cables are the set of insulated wires for carrying electricity or electronic signals. There are many types of cables, for example cables made with fibre glass, cables and copper cables. Fibre optic cables can carry communications signals at higher speeds than copper cables.

architecture can provide a relatively high-quality basic voice service, and hence it was widely adopted in a conventional telephone network. Twisted-pair copper wires are thought to have two disadvantages. First, they cannot support data transfer rates as high as other forms of cabling, such as coaxial cables and fibre optics. Second, compared with other types of cables, because the size of copper wires is bigger, installation of this type of cable will take up more space or land (Albon et al, 1997). Subsequently, coaxial cables were developed during the 1930s (Viscusi et al, 1994). They have a much higher bandwidth to carry more data and offer greater protection from noise and interference, compared with other types of analogue cables (Morse, 1996).

A major milestone in transmission system development occurred in the 60s when digital technology was introduced. Fibre optics and microwave are examples of digital transmission. The optical fibres refer to the technology that uses long, tiny glass or silica fibres to transport messages (Morse, 1996). Microwave refers to a chain of relay stations to receive and retransmit the signals (Farr, 1988).[40] In principle, digital cables provide at least three advantages compared with analogue transmissions. Those are better service quality, more capacity and less equipment required. Each will be explained below.

First, because a digital transmission is not susceptible to interference, the loss of signals per kilometre of optical fibre is less than that of an analogue cable. Messages, therefore, can be delivered more clearly even in the presence of a high level of

[40] Microwave, a point to point radio transmission system, can be modulated in the same way as an electromagnetic wave, and therefore can be applied to a telephone system as well. This communications system can transmit messages over two different frequency ranges, FDM and time division multiplexing (TDM). The FDM is the frequency applied in an analogue telephone system and TDM is the frequency applied in a digital system (Farr, 1988).

disturbance (Flood, 1991). In other words, the adoption of digital transmissions would provide a better service quality.

Second, digital transmission systems can operate at very high frequencies and much wider bandwidth. This allows an operator to provide more products, compared with analogue transmissions. In measuring these benefits the number of circuits is used to indicate the number of production outputs. The digital transmissions, for example, provide high bandwidth, which means more circuits are available compared with analogue transmissions. In other words, given the number of outputs, lesser digital cables are required. Therefore, an average cost per circuit in digital cables, as illustrated in Figure 4-4, is lower than that in the analogue system.

Third, digital transmissions have made possible long-haul repeater sections. That is signals transmitted under digital cables can be sent further. As a result the number of intermediate repeaters, which is the associated equipment used in the transmission systems, is reduced. This indicates that the adoption of digital transmissions would reduce the total capital expenditure of a telephone system.

Although digital transmissions offer several benefits over analogue cables the costs of digital transmissions, initially, were very unattractive. Thus copper based systems were still predominant in telephone systems. Only a few fibre optic and microwave systems were installed in inter-exchange networks (ITU, 1994). New trends in the adoption of digital transmissions have emerged in the 1990s. The introduction of fibre optics has been the most significant radical change in the telecommunications industry (Farr, 1988). However, because the prices of fibre optics in the early 90s were high, to equip the whole network with this type of cable would require high investment. Therefore hybrid transmissions, for example a narrowband network, have been applied to reduce the total capital cost of a telephone system (Tikaput, 1996). That is, copper wires are installed between local exchanges and end users while digital cables, either fibre optics or microwave, are equipped between two trunks, for example from primary to secondary trunk and secondary to tertiary trunk.

4.3.2 The Development of Transmission Systems in the Thai Telephone System

In Thailand a network hierarchy, as discussed previously, is seen as an appropriate network architecture for the telephone system (RDI, 1993). Referring to Figure 4-3, at the end of 1994 the hierarchical network in the Thai telephone system consisted of seven tertiary, 20 secondary and 49 primary trunks and 1,606 telephone exchanges (TT&T, 1994a).

The transmission system of the communications network in Thailand has been developed from an analogue system using copper wires to a hybrid transmission using a narrowband network. That is, the transmission path between local exchanges and end users is equipped with copper wires, but between trunk exchanges or the backbone network there are three types of transmissions (the PCM, fibre optics and microwave cables) (TOT, 1996).[41]

The volume of trunk lines equipped with analogue cables has been gradually surpassed by digital cables using either microwave or fibre optic cables. The use of digital cables has received a major boost from contracts signed between the Telephone Organisation of Thailand (TOT) and two private firms; TelecomAsia (TA) and Thai

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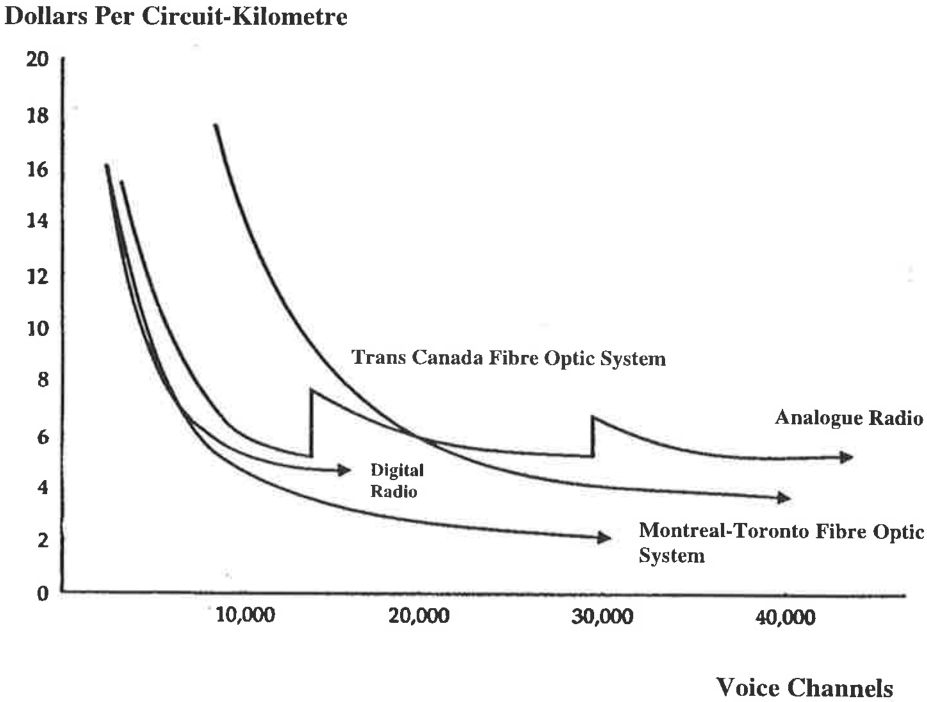
[41] A backbone network is a central high speed communications corridor that connects disparate networks (Morse, 1996).

Telephone and Telecommunication (TT&T) (FTI, 1995). In 1995, the adoption of fibre optics in Thai Telecommunications was increased to 76 percent (APT, 1996).

FIGURE 4-4

Cost Comparison among Different Types of Transmissions



Source: Saunders et al (1994)

4.4 SWITCHING SYSTEMS

In a telephone network, a switching system is needed to connect circuits between desired points. For example, the switching equipment in a local telephone exchange is used to interface the signals between local and trunk transmissions. Like a transmission system, switching equipment has been developed from an analogue to a digital system. The evolution of the switching equipment in communications systems is summarised here.

4.4.1 Innovation in Switching Systems

The evolution of switches can be separated into three periods: a step-by-step, a crossbar and a digital stored program control (SPC). A step-by-step switch uses a 'progressive control' to control the process of dial pulses (Bellamy, 1991). This type of control, on the one hand, is very useful for implementation on a variety of switches. On the other hand it carries a number of limitations. The most significant restriction of the step-by-step switch is that it can select only one route for outgoing trunks, which means less capacity than other types of switch (Pollard, 1975 and Bellamy, 1991).

A crossbar (X-bar) switch uses a common control system. Such a control refers to the ability to assign telephone numbers independently. Before a digital switch was developed the crossbar system, therefore, was used predominantly in metropolitan areas and within a toll network, while the step-by-step switch was carried out only in local exchanges (Bellamy, 1991). The X-bar system has two significant obstacles, namely high cross-talk characteristics and the inability to handle high voltages (Redmil and Valdar, 1994). In other words, the adoption of the crossbar system leads to interference in the reception of picture data, such as audio and video. For this reason a communications network equipped with the crossbar system could offer some types of services which do not require high voltage, for example telephone services, telex and facsimile, while it cannot provide some high speed services, such as video on demand and teleconferencing.

The third generation of switch is a digital switching system. The digital switch, using a SPC system, was first introduced in the early 1960s. Such equipment has been developed to overcome the disadvantages of an analogue system, in particular to reduce the problem of cross-talk as well as to handle high voltages. In addition, the digital SPC offers other advantages over the analogue switch, for example a more reliable system, cheaper cost of investment and ease of maintenance. Each will be described below.

First, an SPC exchange offers greater reliability than the common control crossbar system in function, such as automated record keeping, lower blocking probabilities, generation of traffic statistics, and automated call tracing (Bellamy, 1991). When other things are equal the use of the digital SPC switch requires fewer employees to operate the whole system. Thus operating costs under this system are lower than that of the analogue system.

Second, the installation of a digital SPC switch in a telephone exchange requires smaller space than that required either for the full analogue or the analogue SPC systems. It has been noted that the digital SPC exchange achieves a 25 per cent accommodation saving in the costs of land, compared with the step-by-step or crossbar exchanges, and a 50 per cent cost saving compared with the analogue SPC system (Redmil and Valdar, 1994).

Third, SPC telephone exchanges provide ease of maintenance. It has been noted that the innovation in equipment used in a digital SPC offers a lower fault rate than that used in the analogue system (Redmil and Valdar, 1994). In addition the digital system basically does not require any routine adjustment like the system in the analogue signal (Pollard, 1975). As a result, the lower percentage of technical faults in the SPC telephone exchanges implies lower maintenance costs.

In practice, the advantages of an SPC digital exchange depend on the features of installation, varying from one exchange to another. The full range of advantages as described above cannot be achieved until the digital SPC switch is incorporated into a digital transmission (ie, fibre optics and microwave) and a modern signalling system.[42] However, through using partial digital technology, for example telephone exchanges equipped with digital switches incorporating with analogue transmissions, an operator still gains some benefits. Redmil and Valdar (1994) stated:

[42] A signalling system is the exchange of electrical information specifically concerned with the establishment and control of connections and management. It is applied in the communications network to transmit or to receive coded information. Because there are different communications networks (ie, radio wave, transit traffic, international connection), the signalling systems are designed into different standards to use for a specific purpose. For example system no. 1 has been widely used for radio links, whereas system no.2 was intensely used for two-wire semiautomatic operation (Pearce, 1981).

In a telephone system, signalling provides the means of conveying information from user to system and system to system to complete a call for the user. It is designed to control and route information sent over a telephone network, and also to meter for charging purposes. The requirements of signalling systems vary with the capabilities of switching systems. Conceptually, higher capacities of switching require more sophisticated signalling systems. Therefore a simple signalling control is needed in the step-by-step switching systems and more sophisticated signalling control systems are required for a cross bar switch, and a digital SPC, respectively (Becker, 1984).

'...whether introduced as part of integrated digital transmission and switching networks, or as straight replacements for analogue switching units, such exchanges offer many advantages.' (p.45).

The advantages of a digital switch as discussed above were investigated by Garrone in 1995. In his study, Garrone examined the effects of digital switching equipment on the efficiency of telecommunications carriers. Panel data of 12 European countries between 1980 and 1989 were tested, using the translog cost function. Garrone found that under a static model cumulative savings could recover the early losses by 2.25 per cent after the ninth year of installing the digital switches into the networks. However, Garrone cited further that *'a static model misrepresents adjustments of the network to the new equipment'* (pp. 12-13). For this reason he further investigated by using a dynamic model. With the dynamic model, as a lower bound estimate, operators gain cost savings by 2.5 per cent after the third year of network installation. He concluded that operators can achieve some significant cost savings from the adoption of digital switches. Garrone stated further that telecommunications experts and regulators, however, should be aware that recent radical technical changes do not allow rapid and dramatic cost reductions.

In recent years a remote switching unit (RSU) is a technological alternative in switching equipment in telephone exchanges. It has been believed that such a technology provides a significant cost saving in the capital expenditure of small exchanges (RDI, 1993 and TT&T, 1994a). It has been stated further that RSU offers a better use of feeder pairs than digital loop carrier configuration (Lynch, 1987). For this reason the adoption of RSU has emerged in the telephone industry.

There are many sizes in the RSU switch. Its adoption varies according to the size of telephone exchanges, which is measured by the number of telephone lines. For example the size of RSU switches in Thailand ranges between 200 - 6,000 service lines (TOT, 1992b).

4.4.2 The Development of Switching Systems in the Thai Telephone System

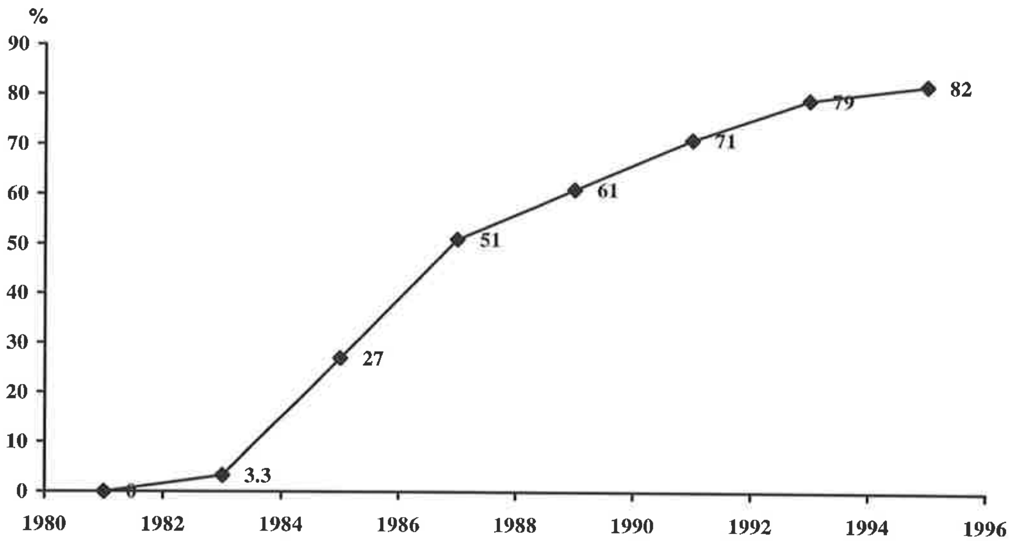
Prior to the introduction of digital switching equipment in Thai telephony the analogue network used the step-by-step or the Strowger switches that were first introduced in 1935 (TOT, 1994b). Because the step-by-step switches provide less flexibility of alternative routing, as mentioned previously, the switching equipment in the Thai telephony was superseded by the crossbar in 1959 (TOT, 1994b).

A major milestone for the telephone switching system in Thailand was established in 1983. That is, the volume of trunk lines handled by the common control or the crossbar switches was gradually surpassed by digital switches using a SPC feature.

In recent years, the adoption of the digital switch is an increasing trend. As illustrated in Figure 4-5 there was a high growth in the use of the digital switches between the late 80s and the early 90s. The adoption of this switch during the 90s has received encouragement from contracts signed to TA and TT&T (FTI, 1995).

FIGURE 4-5

The Adoption of Digital Switching in the Thai Telephone System



Source: TOT (1988), TOT (1992b) and TOT (1996)

4.5 THE RELATIONSHIP BETWEEN TELEPHONE TRAFFIC AND TELEPHONE EQUIPMENT

To quantify the amount of equipment required in a telephone system an understanding of telecommunications traffic and grade of service (GOS) is a must (Farr, 1988). Basically, telecommunications traffic is identified with two different concepts (Farr, 1988). First, a broad concept refers to the existence of all call attempts, no matter whether information is exchanged. For example, a user may lift the telephone handset to make a phone call. Then he changes his intention and hangs the handset up before dialling. Under this concept this will be counted in the total number of call attempts. The second concept refers to the existence of calls only when the information is delivered. In other words, the total number of calls in the latter case is the sum of successful calls. Theoretically, the former is used to measure the existence of telecommunications traffic. This is because when the handset is lifted the circuit between telephone and switching centre is immediately barred to other potential incoming calls, although the connection is not successful. The total traffic flow, therefore, is the sum of traffic in each circuit or each telephone. The number of circuits in terms of erlang is the classification of telecommunications traffic.[43]

GOS is the second condition required in designing the telephone system. By definition, GOS is a measure of service quality. It is the probability that a call will be lost during the busy hour (Farr, 1988). Conceptually, when the volume of telephone traffic increases, at the same level of GOS, a larger number of circuits is required.

[43] Erlang is the international unit which measures the number of telephone usages or traffic flow. It is the best indicator to predict and handle periods of heavy telephone use (Farr, 1988).

Therefore, if the traffic route is overloaded GOS will deteriorate more rapidly. In other words, there exists a poor service quality as the number of circuits is inadequate to carry the telecommunications traffic. To circumvent such a problem additional equipment is required to augment the number of routes (Farr, 1988).

To estimate the volume of telephone traffic, the number of calls and the length of call holding time are two important factors. In a telephone system the number of calls does not occur continuously. The number of calls applied to estimate the volume of telephone traffic will be represented by the average of telephone usage during busy hours. Similarly, the length of call holding time is the average value of a representative sample of measured holding time.[44] In a simple case, if it is assumed that each call has the same average call holding time, the number of traffic routes required in the telephone system is equal to the number of telephone calls. Therefore, at a given level of GOS and the same average call holding time, the equipment required in the telephone system totally depends on the number of telephone calls.

4.6 CONCLUSION

A telephone network comprises transmission paths and switching nodes disposed to enable users to make satisfactory calls. Because it is impracticable to interconnect all telephones in a network, or even to connect all land-lines in a telephone exchange, a hierarchical and mesh network have been applied to the structure of a telephone network.

[44] Call holding time is the duration of a call from the beginning of set-up to the end of clear down.

The evolution of telephone technologies from an analogue to a digital system has dramatically changed since the 1980s. Digital telecommunications networks can provide a variety of additional voice services. The networks also carry data, video and image. The range of services provided over telecommunications networks is likely to increase further with technological change and the convergence of the telecommunications, broadcasting, computing and entertainment industries.

A review of telecommunications technologies in this chapter provides interesting evidence. First, digital transmissions would lead to a better quality of service, while average cost per circuit is reduced. Second, other things being equal, the adoption of digital transmissions reduces the total capital costs of a communications network. Third, RSU is an alternative technology applied in telephone exchanges to gain a significant saving in the capital expenditure of telephone exchanges. Fourth, the amount of equipment required in the telephone system varies by the volume of telephone traffic measured in terms of the number of circuits and the levels of GOS. At a given level of GOS and constant call holding time, the number of phone calls is the measure of total amount of equipment required.

The discussion on innovations in telephone technology in this chapter leads to two interesting issues related to the cost of a telephone system. First, does digital RSU lead to any significant cost savings from scale economies in the Thai telephone system? Second, what is the relationship between telephone traffic in Thailand and the equipment in the telephone system? Does the problem of traffic overload exist? These two issues will be taken into account when the cost structure of the telephone system in Thailand is assessed in Chapter 6.

CHAPTER 5

A METHOD TO TEST THE MARKET STRUCTURE OF LOCAL TELEPHONE NETWORKS IN THAILAND

5.1 INTRODUCTION

In examining the cost structure of an industry, the concept of subadditivity has been applied widely in recent years. However, a review of prior research in Chapter 2 also showed inconsistent results from using this concept in testing hypotheses about the structure of a telecommunications market. This indicates some weaknesses in using such a theoretical framework. For this reason, it is doubtful whether subadditivity is the basis of an appropriate framework for this study.

In reality, a firm produces multiple products rather than a single output. The methodologies to test a market structure generally require a test for scope economies unless subadditivity applies. Data limitations are always a problem in using both concepts, in particular to test for the degree of scope economies, since information on the costs of each output and input are required. Allocating total costs into joint costs and common costs accurately is a difficult task. The consequence is biased results as have occurred, for example, in the study by Fuss and Waverman (1981) discussed in Chapter 2. To circumvent such a shortcoming a new method to measure output is proposed in this chapter.

In testing hypotheses about the cost structure of an industry production theory can be applied to develop a model of either a production function, a cost function or a cost function derived from duality theory. Each approach has both advantages and disadvantages. A cost function is used here to investigate the cost structure of the telephone market in Thailand. The reason why this approach is suitable for this study is discussed in this chapter.

Section 5.2 begins with a discussion of whether the concept of subadditivity is applicable in this study. A more appropriate method is then set out. This section also introduces an alternative method to measure production output in order to circumvent the problem of cost misallocation. Section 5.3 develops a simple cost function based on econometric and engineering concepts. Concluding remarks are presented in Section 5.4.

5.2 ANALYTICAL FRAMEWORK OF THIS STUDY

As discussed in Chapter 2 the estimation of scale effects can be classified into three parts: the test for scale economies alone, the test for both scale and scope economies and the test for subadditivity. Each approach contains strengths and weaknesses. To select an appropriate method to assess the cost structure of the telephone industry in Thailand each approach will be examined in this section.

5.2.1 The Shortcomings of Subadditivity

The original concept of subadditivity developed by Baumol et al (1982) has been argued to contain a number of shortcomings. Evans and Heckman (1983) identified three of these. First, the original concept of subadditivity developed by Baumol et al assumed that *'all firms use the same technology and therefore have the same costs for all levels of production'* (Evans and Heckman, 1983, p.130). Evans and Heckman stated that this assumption would lead to an unrealistic test since there are, in reality, a number of technological choices that firms can make. Each could provide a variation of degrees of scale effects. For example, the firms probably choose the technologies that provide a high degree of scale economies to deter entry (Dixit, 1982). Consider Figure 5-1, the extreme case of using different two types of technologies. Suppose that Firm-A is using technology 1 and Firm-B is using technology 2. The average cost of using technology 1 is AC_1 and of using technology 2 is AC_2. Assume that total output is q^*. In this case subadditivity is accepted because having only Firm-A to produce goods equal to or less than q^* in the market would lead to cost minimisation.

The assumption of the use of the same technology is impractical in an industry where there is a radical technological change, such as telecommunications. As discussed in the previous chapter the effects of innovations in, for example, digital equipment, fibre optics and digital switches, have led to a decrease in the average production cost. Thus, the existing firm was able to employ new technologies to deter entry by new firms.[45]

Baumol et al suggested that strict and global subadditivity is necessary and sufficient to decide whether an industry is a natural monopoly, in particular in the multiple products case. To estimate global subadditivity global information is required. As such information is seldom available Evans and Heckman (1984) proposed the use of what they called an 'admissible region', which was discussed in Chapter 2. However the concept of an admissible region also contains a weakness. That is, the test results are reliable if, and only if, subadditivity is rejected. When it is accepted it cannot be concluded that the whole industry is a natural monopoly (Albon et al, 1997). This is the second shortcoming of the subadditivity concept.

The third failure of the original concept of subadditivity is that it cannot distinguish the sources of cost savings clearly (Evans and Heckman, 1983). That is, although the test of a cost function may show the existence of subadditivity some proportion of cost savings probably arises from an improvement in the efficiency in management, rather than an efficiency in production. The Bell System is a typical case with Evans and Heckman stating that:

> '*... Even if the technology for providing telephone service has a subadditive cost function, it is conceivable that several firms with separate ownership over different portions of the telephone network might be able to provide telephone services at least as efficiently as a single firm. Multiple ownership might reduce managerial diseconomies and promote innovation...*' (p.131).

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[45] Currently the use of new technologies to deter the entry of new firms is no longer likely to be successful. The introduction of small sizes of switching equipment reduces the degree of scale effects which can cause a natural monopoly market. As a result, new technologies in the telephone industry can permit entrepreneurs to enter even small parts of the local telephone market (Wenders, 1990).

Apart from these three issues, subadditivity is an inappropriate tool to estimate the cost structure when the two following conditions exist.

The first is when entry into the market is not free. To discuss this issue further, recall the condition of strict subadditivity under a single product firm:

$$C\left(\sum_{i=1}^{m} q^i\right) \leq \sum_{i=1}^{m} C_i\left(q^i\right), \text{ for all quantities of } q^1,\ldots,q^m$$

where m is equal to the number of firms.

Baumol et al (1982) stated that when the above equation is accepted an industry requires a single firm to achieve cost minimisation. In turn, if the above condition is rejected, the total production cost for the whole industry would be cheaper when there are two or more firms in the market. To test whether subadditivity applies it is assumed that there is free entry into the market. This implies subadditivity is an inappropriate method to estimate the cost structure of the telecommunications industry under build-transfer (BT) regimes. As described in Chapter 3, the regulatory reform of the telephone industry in Thailand is subject to two particular regulations, The Telegraph and Telephone Act of 1934 and The Telephone Organisation of Thailand (TOT) Act of 1954. As a result the participation of private firms in this market must be approved by TOT and the State. This means there is no free entry into this market. Subadditivity, therefore, is not the basis of an appropriate approach for this study.

The second issue arises when the mechanisms of a competitive market, not only entry but also price determination, are not working. In the application of subadditivity there is no constraint on output or prices. Each firm can freely choose to produce any levels of output and sell at any prices. In other words, there is no quantity and price control. This assumption is contrary to the telecommunications law in Thailand, in particular the TOT Act of 1954. Under the TOT Act of 1954, as already detailed in Chapter 3, the prices and quantities of fixed-lines have been determined by the Thai Government, and private firms must follow all regulations identified in this Act. Thus, the use of the subadditivity concept to estimate the market structure of the Thai fixed-line industry may lead to biased results. For these reasons, subadditivity is not a suitable economic framework for this thesis.

5.2.2 Scope and Scale Economies

If subadditivity is considered to be an inappropriate approach to estimate the cost structure of the telephone industry in Thailand, then a test for scale associated with scope effects, theoretically, would be required to evaluate the market structure, in particular in the case of multiple product firms (Baumol 1977). However this economic framework, as discussed in Chapter 2, contains two problems. One is that of cost allocation in the scope economies test, and the other is that a test of scale economies alone is not sufficient to identify the market structure when the average cost is rising. To circumvent the first problem, considering a single firm producing a single output is suggested here.

It is true that once a telecommunications network is installed it can provide a variety of communications services as illustrated in Figure 5-2, for example toll fee services, mobile phones and paging services. Thus, an analysis of scale effects in the multiple products case has been considered to be a suitable approach. However the allocation of production costs into joint and common costs is a very complicated task. This problem has been debated in much research, for example Baumol et al (1962) and

Lewis (1946). In addition mistakes in cost allocation lead to unusual results as demonstrated, for example, in the study by Fuss and Waverman (1981). To overcome the difficult task of cost allocation an investigation of the cost structure under the assumption of a single product firm is proposed here. Such a configuration would not lead to biased results as argued by, for example, Berg and Tschirhart (1988) if the measurement of outputs is expressed in terms of equivalent units, for example the number of calls or the time of usage. Suppose the number of calls is used to measure the units of output. In a telephone industry there are two major types of services, local and long-distance calls. The total amount of output with no respect to distance (Cardozo, 1996 and Burkitt, 1997), therefore, is equal to the sum of the number of local calls and the number of long-distance calls.[46,47] When this assumption is accepted the test for scope economies is no longer necessary to estimate the cost structure of the multiple product firm.

Baumol (1977) stated that the outcome of a test of scale economies alone is necessary, but not sufficient, to evaluate the structure of an industry. This is because while average cost is rising, which means diseconomies of scale exist, the industry, in

[46] As discussed in the previous chapter, the effects of new technologies lead to a lower average production cost. Due to the use of digital transmissions the capital cost of trunk exchanges, which is the major cost of providing long-distance calls, has reduced rapidly (TDRI, 1993a and Saunders et al, 1994). Thus, distance is no longer a main factor in determining the capital cost of telecommunication investment (TDRI, 1993a).

[47] Because this study is focused only on the fixed-line market, in particular under the narrowband network (discussed in Chapter 4), other services, for example mobile phone and integrated services digital network (defined in appendix I), will not be included because such services are provided under different types of network structure. That is, to provide mobile phone services, different equipment and networks are required (RDI, 1993).

some cases, still requires a single firm to minimise cost (Berg and Tschirhart, 1988). In this case, the test for scale effects alone fails to indicate the optimum number of firms in the market. This argument is true if the aim is to test for the optimum number of incumbent firms. The aim of this study, however, is to evaluate Thailand's BTO regimes and to examine the nature of the Thai fixed-line industry. The application of econometrics, in the form of a cost function, is sufficient to respond to these two questions.

The biases in the estimation of the extent of scale economies were further discussed by Evans and Heckman (1983). They explained the failure of a test for scale economies by using the production costs of oranges and apples as an example. Evans and Heckman stated that while scale economies can exist in producing oranges and diseconomies in producing apples, the aggregate supply of these products can exhibit scale economies, as illustrated in Figure 5-3. Evans and Heckman concluded that a large scale elasticity at the aggregate level of outputs does not necessarily indicate the existence of scale economies of any or all products. This is an issue if the study aims to examine the nature of all the sectors in the industry. However, such an issue would not lead to biased results in this thesis since it aims to test for the market structure of the fixed-line industry alone. A test for scale economies at least can determine the nature of the fixed-line market.

All the above discussions are summarised in Figure 5-4. The next step is to develop a cost function model to measure the extent of scale economies in the Thai telephone market.

FIGURE 5-1

The Effects of Technological Options and the Presence of Natural Monopoly

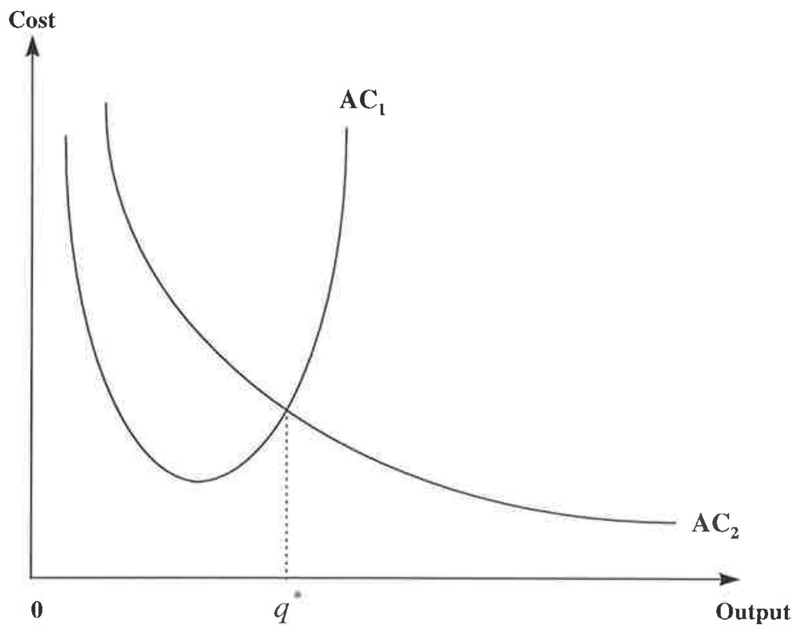
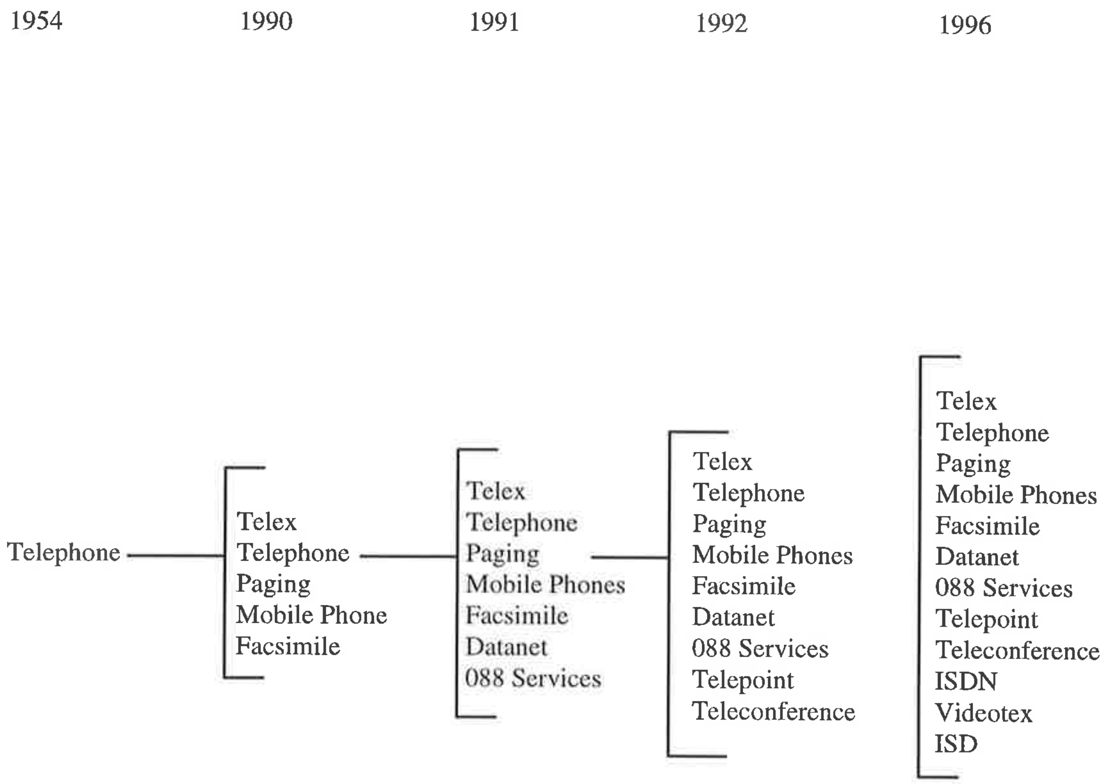


FIGURE 5-2

The Availability of Telecommunications Services in Thailand



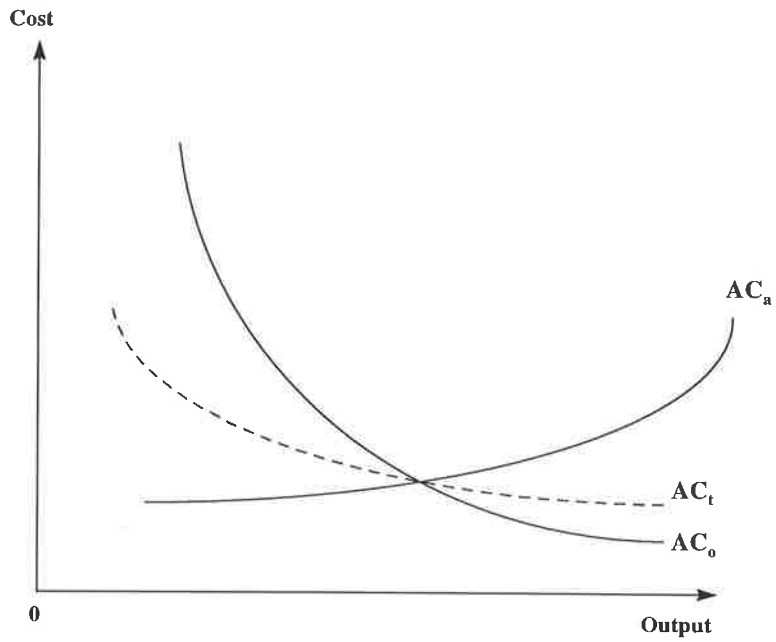
Notes: ISDN stands for Integrated Service Digital Network

ISD stands for International Subscriber Dialing Coin Phone

Source: TOT (1991-1996)

FIGURE 5-3

Economies of Scale in Apples and Oranges



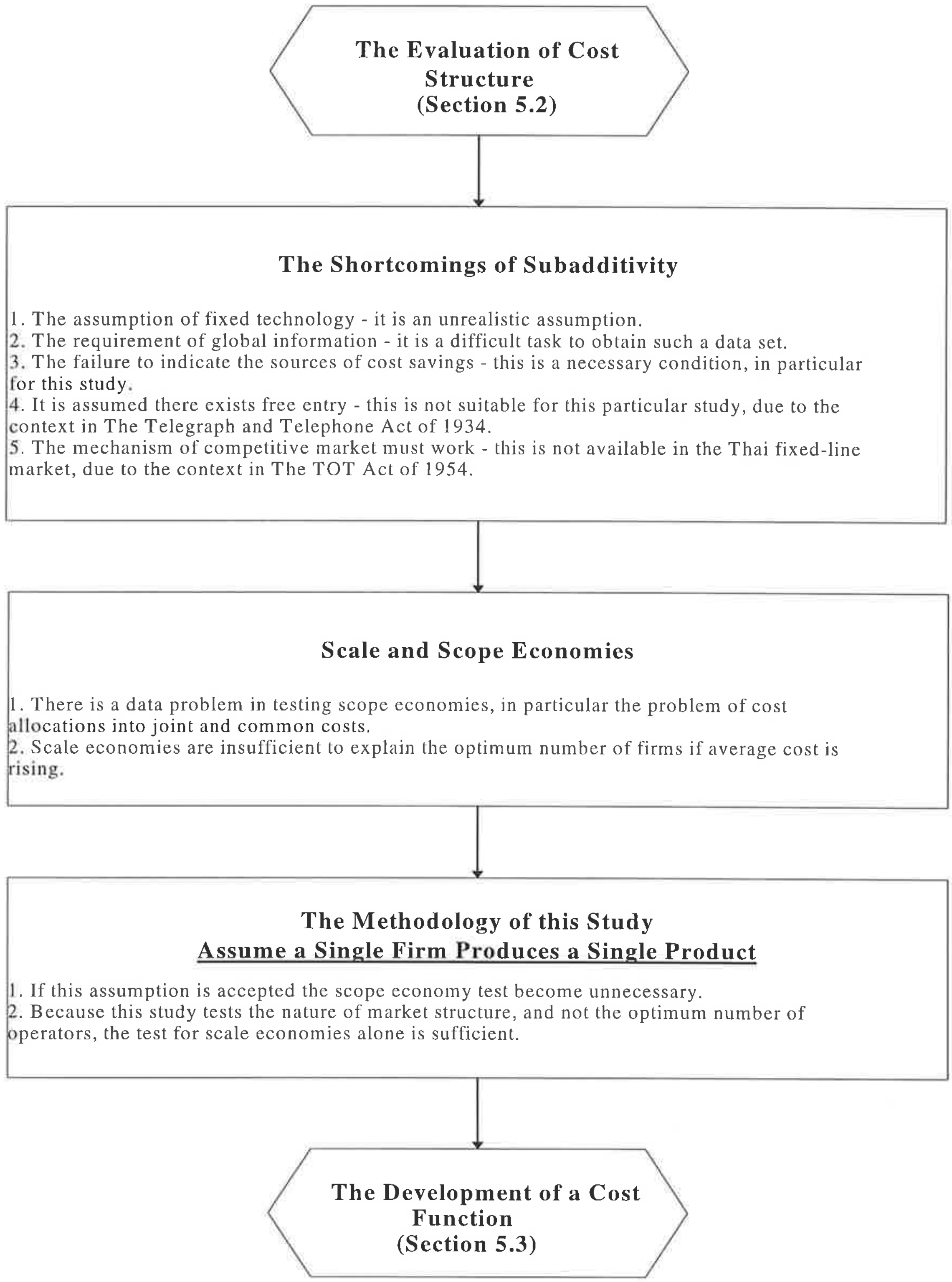
Note: AC_a = Average Cost of Apples

AC_o = Average Cost of Oranges

AC_t = Average Cost of Apples plus Oranges

FIGURE 5-4

Analytical Framework for this Study



5.3 THE DEVELOPMENT OF A COST FUNCTION FOR THIS STUDY

Theoretically, a cost function is one of the common techniques used in analysing a production process.[48] The parameters of a cost function, depending on its specification, can indicate the degree of scale economies, the magnitude of scope effects (although scope is not a focus in this thesis) and the presence of natural monopoly. For this reason the cost function is used in this thesis to estimate the market structure of the fixed-line telephone industry. In this section a cost function which is developed from econometric and engineering methods is discussed.

5.3.1 The Basic Concept of a Cost Function

A cost function is intimately related to the production function. In the simplest case a stand-alone cost is calculated by choosing the cheapest bundle of inputs capable of producing a desired output.[49] If there are n inputs purchased at given prices $p_1, p_2, \ldots p_n$, and if Q is the number of outputs, a basic production cost function can be illustrated as:

[48] Compared with a production function, a cost function provides at least two advantages. First, it generates less of a problem of simultaneous equation bias because factor prices are more likely to be exogenous, particularly when a single firm exists in the industry. Second, the application of Shephard's Lemma provides a direct and simple way of generating a system of factor demand functions from the cost function rather than from the production function (Fuss, 1983).

[49] Stand-alone costs are the costs incurred in producing a service assuming the firm produced no other services. Stand-alone costs are the maximum costs an efficient firm will incur in producing the service.

$$C(Q) = \min(p_1 x_1 + p_2 x_2 + \ldots + p_x x_n),$$

$$\text{subject to } f(x_1, x_2, \ldots, x_n) \geq Q$$

When an analysis of the production process is considered using the Cobb-Douglas form $\left(Q = b\prod_{i=1}^{n} X_i^{ai} \right)$ (Waverman, 1975, Littlechild, 1979 and DeSerpa, 1988), the cost function is:

$$C = \sum_i p_i X_i = \alpha Q^{(1/\sum a_i)} \prod p_i^{(a_i/\sum a_i)} \qquad \text{(equation 5.3.1)}$$

where C is total production cost, Q is output, X_i is the vector of inputs, p_i is the price of input i and a_i is the coefficient on the input variables.

In this study, the natural logarithm of the data is applied into a regression analysis.[50] The transcendental logarithmic (translog) cost function can be written as:

$$\ln C = \ln \alpha + \sum_i \frac{a_i}{\sum a_i} \ln p_i + \frac{1}{\sum a_i} \ln Q \qquad \text{(equation 5.3.2)}$$

Because the study does not aim to investigate the impact of management on scale economies (ie, the benefits from negotiating power in terms of input prices) or the effects of rapid growth in the electronic industry, which might affect input prices, the

---

[50] The log-linear model has had many important applications in economics. However, a test of whether a dependent variable should be expressed in a logarithmic form is required. In this study, the Box and Cox technique, which is a statistical test based on the comparison of the residual sums of squares for a linear function and that for a log-linear function, is applied (Doran, 1989). As a result, the log-linear model was selected.

price of each explanatory variable is held constant. Then, the final equation is the following:

$$\ln C = \ln \alpha_0 + \alpha_1 \ln Q \qquad \text{(equation 5.3.3)}$$

5.3.2 Cost Function Estimation Issues

Theoretically, a cost function *per se* is workable under the assumption of fixed technological possibilities. Failure to meet this led to biases in the estimates of the cost function in some previous studies. For example Waverman (1975), Littlechild (1979) and Fuss (1983) stated that the results from the simple cost function cannot indicate the effects of technological change and the effects of improved labour skills. They stated further that an increased output in such a functional form may arise from either 'learning by doing' or by technical improvements in the quality of capital equipment. However, in practice, the application of dummy variables into the cost function can circumvent this problem. This point will be illustrated in the next chapter.

5.4 CONCLUSION

The discussion in this chapter can be summarised as follows:

(1) Subadditivity is regarded as an inappropriate method to estimate the structure of the Thai fixed-line telephone market for two reasons. First, subadditivity can be applied to investigate the cost structure of an industry into which there is free entry. The breaking up of AT&T is a good example of this situation. On the other hand, there is no free entry yet in the fixed-line market in Thailand because of the conditions in The Telegraph and Telephone Act of 1934 and The TOT Act of 1954. Generally, the elimination of price and quantity control is the second important condition that renders subadditivity workable. In Thailand, with respect to The TOT Act of 1954, price and quantity determination still apply. Therefore the estimation of the cost structure of the Thai fixed-line telephone market through a subadditivity cost function would be expected to generate biased results.

(2) In this study, the concept of a single firm providing a single product is proposed to circumvent the problems that would occur if a test for scope economies were required. With this approach, a test for scope economies is not necessary. As a result the degree of scale economies alone is sufficient to determine the structure of fixed-line market.

This chapter has set out the analytical framework for this study. The next step is to apply this framework to the cost structure of the fixed-line market and this will be reported in the next chapter.

CHAPTER 6

THE MARKET STRUCTURE OF TELECOMMUNICATIONS IN THAILAND: AN EMPIRICAL TEST

6.1 INTRODUCTION

The study of Soonthonsiripong (1998) is an example of early research on the structure of the fixed-line market in provincial areas (PA) in Thailand.[51] In that study the evaluation of the cost structure of the fixed-line network focused on three issues: the market structure of local telephone exchanges in PA, the effects of build-transfer-operate (BTO) regimes, and the relationship between telephone traffic and the capital cost of each telephone exchange. The contribution of three explanatory variables (the number of telephone lines, the number of calls and an indicator of the impact of BTO regimes) to variations in capital expenditure on new telephone exchanges in PA was investigated. A cross section data set of 794 exchanges in 1994 was tested, using a translog cost function. It was found that (1) the fixed-line market in PA is no longer a natural monopoly, (2) an increase of 100 per cent in the volume of traffic would reduce the capital cost of each telephone exchange by 4.8 per cent and (3) the investment cost

[51] The assessment of the cost structure of the fixed-line network in the provincial market was presented at the seminar '*Measuring Impediments to Trade in Services Workshop*', held by the Australia-Japan Research Centre (AJRC) in May 1998.

under BTO agreements was less expensive than the investment cost before the BTO regimes by 4.5 per cent.

However the model of the cost function used in this research contained a number of weaknesses. First, the evaluation was focused only on the fixed-line market in PA. As we know from Chapter 3, telecommunications in Thailand consists of two main areas, PA and Bangkok Metropolitan Areas (BMA). Thus, the results of Soonthonsiripong (1998) cannot indicate the structure of the whole fixed-line market.

Second, because the data examined in Soonthonsiripong (1998) refer to the year 1994, which is only two years after the granting of concessions to TA and TT&T, the number of fixed-lines installed under BTO contracts, therefore, is a small proportion of the number of telephone lines installed before the reform. Thus, the findings in Soonthonsiripong (1998) may be biased.

Third, an indicator of the size of switching equipment in each telephone exchange was omitted. Small switch sizes have been argued to provide cost savings (TT&T, 1994a), and it is possible that the benefits attributed to the BTO project may have arisen from the use of such switch sizes.

Fourth, the difference in types of switching technologies (analogue and digital) was also omitted. This omission means the effects of technological changes from analogue to digital on capital costs are not identified. Cost savings may be attributed to BTO projects incorrectly due to this effect.

To overcome the first weakness, the estimation of the structure of costs of fixed-line provision in this chapter will include telephone exchanges in BMA. Also the assessment in the following section will investigate the relationship between the number of fixed-lines which were installed in 1994 and the average capital expenditure in the same year, rather than evaluating the relationship between the accumulated total capital expenditure on telephone exchanges and the total number of telephone lines, as investigated in Soonthonsiripong (1998). Then, to overcome the omission of some variables as discussed above, the evaluation of the cost structure of fixed-lines for the whole market will focus on seven issues:

(1) the structure of the market at the local telephone exchange level,

(2) the effect of BTO regimes on capital cost,

(3) the effect of the number of new telephone lines in 1994 on the capital costs of installing new lines in 1994,

(4) the effect of the volume of telephone traffic on costs of new lines,

(5) the difference in capital expenditures on the telephone system between BMA and PA,

(6) the effect of switch sizes (small and large) on the capital expenditure of new lines,

(7) the effect of switch types (analogue and digital) on the capital expenditure of new lines.

This chapter is divided into six parts. Section 6.2 discusses the scope of the assessment. Section 6.3 details the sources of data. Section 6.4 defines variables used in the assessment. Section 6.5 develops the specification model of a cost function to investigate the market structure of the fixed-line industry in Thailand. Interpretation of the results and concluding remarks are presented in Section 6.6 and Section 6.7, respectively.

6.2 SCOPE OF THE ASSESSMENT

With respect to the contracts between the Telephone Organisation of Thailand (TOT) and two private firms, TelecomAsia (TA) and the Thai Telephone and Telecommunication (TT&T), TA was delegated to install 2.6 million telephone lines in BMA. A telephone network built up in the BMA project includes the areas between secondary trunks and end users (RDI, 1993).[52] In other words, as shown in Figure 6-1, this area includes the equipment in the secondary trunks, primary trunks and telephone exchanges. This is different from the network under the contract between TOT and TT&T. Refer to Figure 6-1 again. TT&T has been responsible for building up a telephone network between primary trunks and end users (RDI, 1993). Thus, the two projects might employ different technologies, in particular in the level of trunks. That is, the equipment installed within a primary trunk, for example types of switches and cables, is different from one trunk to another. Most trunks in BMA have been equipped with fibre optics, while some trunks in PA have been equipped with fibre optics and some are microwave (RDI, 1993 and TT&T, 1994a).[53] Consequently, the results of an

[52] The interrelationships between each item can be summarised as follows. When there is a large number of telephone users, it is costly to provide everyone a line with a separate transmission path. For this reason a telephone network is designed to connect each subscriber to the nearest switching centre. Then, all local exchanges in each province are connected to a primary trunk. The facility of moving information from one point to another is called a transmission system, which requires an interconnection medium such as coaxial cables or fibre optics. A switching system is needed to connect circuits between desired points. For example, the switching equipment manages the interfaces between local exchanges and primary exchanges. For more details, see Chapter 4.

[53] The terminology of technical terms is described in Chapter 4 and Appendix I.

empirical test which includes investment at this level may be unclear.[54] To circumvent such a problem the test will focus on the cost structure of each telephone exchange, rather than testing the cost structure of the whole telephone system.[55] In other words, scale effects are tested only with respect to equipment installed between end users and each local exchange, as illustrated in Figure 6-2.

In addition, the investigation of scale effects between end users and local exchanges illustrated in Figure 6-2 is more practical than a study on scale effects for the whole network (from secondary trunk to end users in Figure 6-1). As discussed in Chapter 4, the link between the end users and switching in local exchanges is the first connection in the telephone system (Albon et al, 1997). Thus, the capital expenditure of local exchanges, or what Albon calls the 'consumer access network' (CAN), has direct effect on the determination of access charges for fixed-lines (Albon et al, 1997). This implies that the effects of scale economies between local exchanges and end users has a direct impact on welfare. That is, if it is found that there exist diseconomies of scale at the level of local exchanges the policy to open free entry, at least at this level in the telephone system, should be considered.[56] As a result, consumers will have more options in the consumption of telephone services, because they can select to consume

[54] In some provinces, for example Loei and Mae Hong Son, microwaves are installed between telephone and primary trunk exchanges while in others, for example Ayutthaya and Phetchaburi, fibre optics are installed (TOT, 1995b).

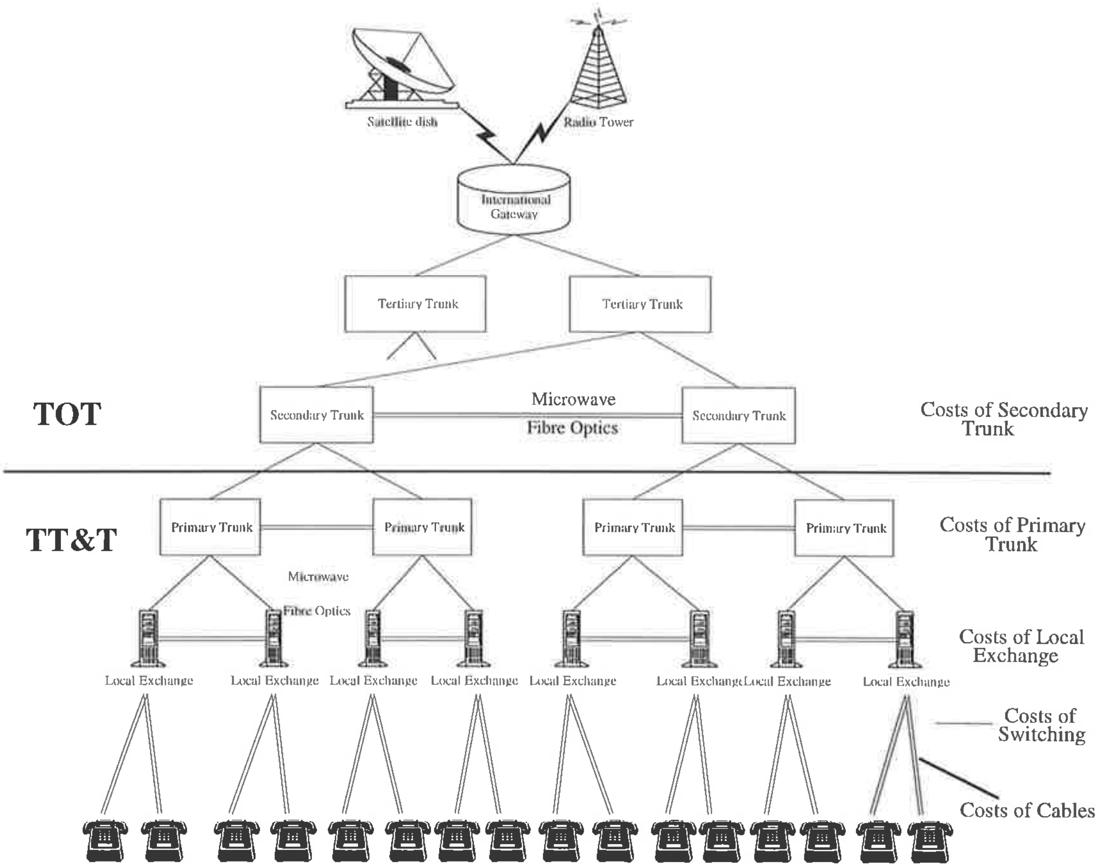
[55] From personal communication with TOT's engineers, TA and TT&T projects used similar technology so both sets of projects can be tested at the same time.

[56] One might expect that an opening up of free entry may lead to a number of problems, for example excess capacity and price cuts. However these problems would not appear when the mechanism of competitive market is working.

services from operators who provide better service quality and cheaper prices. It has been found that the presence of a competitive market even at the level of local exchanges would provide a welfare improvement (Shin and Ying, 1992, Shin and Ying, 1994 and Berg and Tschirhart, 1995).

FIGURE 6-1

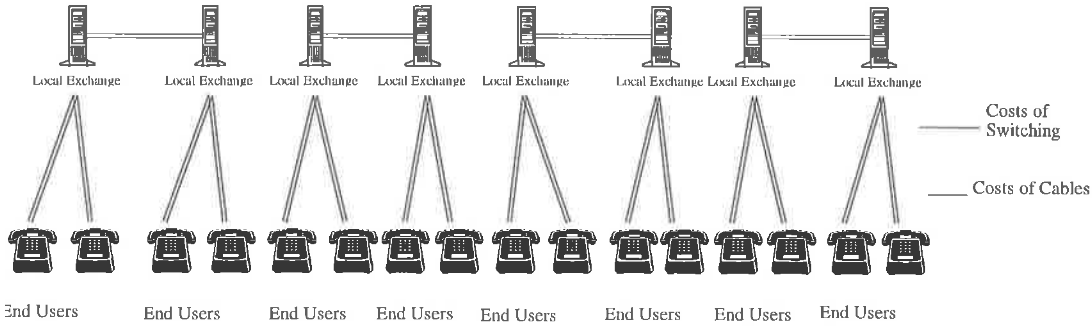
Telephone Network in Thailand



Source: TT&T (1994a)

FIGURE 6-2

Scope of the Assessment



6.3 SOURCES OF DATA

The data sources employed in this chapter were collected from the Telephone Statistic Report, published annually by the TOT, the annual report of TA and TT&T, and the Prospectus of Newly Issued Ordinary Shares published by TT&T. Because of omissions and changing reporting formats some data have been collected from the Telecommunications Indicator published by International Telecommunication Union (ITU).

In general, an investigation of cost relationships associated with advanced technologies has three major problems: the choice of data, the number of observations and the estimation techniques. In many studies time series data lead to unbiased results. In a study of the impact of technological change, Shin (1988, cited in Shin and Ying, 1992) noted that time series data produces biased estimates, in particular of scale elasticity. This is because there is a high correlation between technological development and the outcomes of economic interaction, that is, rapid technological change would lead to an appearance of scale economies (Shin, 1988 cited in Shin and Ying, 1992). For this reason this study will use cross section data to circumvent such a shortcoming.

The local telephone exchanges investigated in this chapter are located both in PA and BMA. The provincial areas were classified into 9 regions (TT&T, 1994a). In 1994, there were 1,108 telephone exchanges in 71 provinces (TOT, 1992b). The total number of fixed-lines in provincial areas was approximately 1.349 million, comprising 0.984 million lines constructed by the TOT and 0.365 million lines constructed by TT&T (TOT, 1996). The BMA had a total of 498 telephone exchanges in 1994. The total number of fixed-lines was 2.158 million lines, comprising 1.6 million lines constructed by TOT and 0.558 million constructed by TA (TOT, 1996). Therefore the total population in this assessment is 1,606 telephone exchanges.

In 1994 some exchanges contained two types of switches, analogue and digital. To avoid biased results from the effects of technological innovation telephone exchanges which contain both models of switching equipment in one exchange are excluded. Therefore, only the exchanges with a single type of switch (analogue or digital) are selected. As a result, 1,005 telephone exchanges are investigated in this test.

6.4 DEFINITION OF VARIABLES

The average capital cost per new line in each telephone exchange in 1994 is the dependent variable (c) examined in this assessment. The capital costs are calculated from the capital expenditures of telephone exchanges for each project, which include land and building, cables, and other equipment.[57] Holding technology constant, it is possible to assume that the useful life of communications equipment is infinite.[58] As a result, capital can be assumed to have constant productivity over its life. Therefore depreciation expense is equal to zero. Real capital costs are obtained by dividing capital costs by an industry deflator index (base year in 1987) available from World Bank Tables 1995 and Bank of Thailand (1995).[59] Because data on telephone exchanges installed before 1978 are not available, these exchanges are excluded.

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[57] Details of each terminology were presented in Chapter 4.

[58] Personal communication between the author and TOT's engineers.

[59] The industry deflator applies to the output of all manufacturing industries.

From Chapter 4, we know that the number of telephone lines, measured by *LINE*, is one of the two factors determining the amount of equipment installed in the telephone system.[60] The coefficient of *LINE* therefore can be used as an indicator to explain the market structure of local telephone exchanges through the existence of scale effects. If there exist scale economies, which are indicated by a negative value of the coefficient of *LINE*, local telephone exchanges are more likely to be a natural monopoly. In turn, if there exist diseconomies of scale, represented by a positive value of the coefficient of *LINE*, the local telephone market is less likely to be a natural monopoly. In addition, because *LINE* is the accumulated number of lines installed in each exchange, the test of the relationship between the average capital cost per new line and the number of lines can be used to identify the existence of scale effects in the long run.

The extent of telephone usage is another factor that may affect the capital costs of extending a telephone system. In this assessment the volume of traffic measured in terms of the number of calls is considered in order to see whether telephone usage had any effect on the average cost of each new line.[61] The number of calls, which is denoted by *CALL*, therefore is included in the cost function. The number of calls is the sum of the number of outgoing calls, which includes local, domestic long-distance and

[60] The number of calls is the second factor determining the amount of equipment in the telephone system. More details were described in Chapter 4.

[61] With respect to the assumption discussed in Chapter 5, when the measurement of outputs was expressed in terms of equivalent units (in this case the number of calls) an investigation of the cost structure under the assumption of a single product (service) firm is applicable. Such a configuration would not only lead to unbiased results, but it also tells us that the test for scope economies is no longer necessary to estimate the cost structure of the multiple product firm. For more details, see the discussion in 5.2.2.

international calls. Because there is a missing value for the number of calls in some telephone exchanges the number of observations is reduced to 764.

Littlechild (1979) referred to early research and stated that additional equipment is required if an increase in the number of calls causes the existence of a congestion problem. A positive coefficient of $CALL$ therefore indicates a positive linear relationship between the average capital cost per new line and the number of calls. That is, the average capital cost per new line increases as the number of calls increases.

The relationship between the number of new lines installed in 1994, denoted by $CHANGE$, and the average capital cost per new line enables us to estimate the slope of scale curve in the fixed-line market. Holding other things constant, a positive value of the coefficient of $CHANGE$ indicates that the average capital cost per new line rises as the number of new lines installed increases. In turn, a negative value of the coefficient of $CHANGE$ indicates that there are scale effects associated with the installation of a greater number of new lines.

As discussed in Chapter 1, build-transfer (BT) regimes are believed to circumvent the inefficiency of the existing operator. In Thailand the introduction of BTO regimes is expected to bring about greater efficiency, in particular in terms of cost savings. To examine whether this hypothesis is true a dummy variable, denoted by D, is included. This dummy variable takes the value of 1 for the exchanges installed under BTO projects, and 0 otherwise. A negative value of D is expected if there exists a cost saving in the installation of new lines in BTO projects (a negative value reduces the intercept of the estimated relationship). In turn, a positive value means higher capital expenditure is required in the installation of new BTO lines. The expected result is that D should have a negative coefficient if BTO regimes provide cost savings.

Generally, the cost of investment (for example, the price of land and building and labour costs) in capital cities (BMA) is comparatively more expensive than in provincial areas. The location of the telephone exchanges, denoted by *LOCATION*, is therefore included in this assessment to investigate the relationship between differences in the average capital cost per new line and differences in locations between PA and BMA. To estimate such a relationship a dummy variable is applied. It is defined as follows: 1 indicates the telephone exchanges that are located in BMA, and 0 otherwise. It is expected that the cost of a telephone line in BMA should be more expensive than in PA. If this hypothesis is true, a positive coefficient of *LOCATION* is expected.

As mentioned in Chapter 4, the installation of switching equipment is one of the major capital expenditures that influence the cost of each telephone exchange. More importantly, the use of smaller switching sizes, or so-called 'remote switching units' (RSU), has been claimed to bring about a significant percentage of cost savings, in particular for the cost incurred in small sized telephone exchanges (RDI, 1993 and TT&T, 1994a). As TT&T stated:

> '.. *the company uses many remote switching units, in which each can provide between 256 and 2,048 telephone lines.... With this method the company gains a significant saving in total costs...'* (translated from TT&T, 1994a, p. 66).

Accordingly, the size of switches, denoted by *SIZE*, is included in the cost function to investigate the relationship between the adoption of different sizes and the average capital cost of each new line.

To estimate the effects of different sizes of switch a dummy variable is used to quantify the sizes of switches. In this study switches are classified into five sizes.

Therefore four additional explanatory variables are included in the cost function. Here *SIZE*1 refers to the switch that can provide services for more than 2,048 telephone lines. In this case a dummy variable taking the value 1 for switching equipment holding more than 2,048 telephone lines, and 0 otherwise, is included in the cost function. *SIZE*2 represents the switch that provides services for more than 1,024 but less than or equal to 2,048 telephone lines (1 designates the switch that carries 1,025 - 2,048 lines, and 0 otherwise). *SIZE*3 is the switch providing services for more than 512 but less than or equal to 1,024 lines (1 for the switch that carries 513 - 1,024, and 0 otherwise). *SIZE*4 represents the switch providing services more than 256, but less than or equal to 512 lines (1 designates the switch size 257 - 512, and 0 otherwise).

As explained in Chapter 4, digital technology reduces the cost of a telephone exchange. To investigate whether this hypothesis is true, a dummy variable is applied. Let $TECHNO = 1$ for the exchanges equipped with digital switches and $TECHNO = 0$ otherwise. The dummy variable *TECHNO* enables us to differentiate between the capital costs of telephone lines when telephone exchanges are equipped with different types of switches. According to the review of the benefits of digital technology discussed in Chapter 4 it is expected that the coefficient of *TECHNO* should be negative. In other words, the cost of new lines equipped with digital technology is cheaper than that of analogue.

Summary statistics of variables used in this test are reported in Table 6-1.

To estimate the value of correlations between each pair of variables Pearson coefficients are used in this assessment.[62] As presented in Table 6-2, a large correlation

[62] This method measures the relationship between two variables in a sample and is used as an estimate of the correlation in the whole population (Borowski and Borwein, 1989).

coefficient (of either positive or negative value) can be interpreted to mean that those variables are strongly and linearly related. Table 6-2 reports that according to the 0.05 level of significance there are five pairs of variables which could be expected to produce severe multicollinearity in the model. These are:

(1) the number of lines ($LINE$) and the number of calls ($CALL$) (0.649),

(2) the number of lines ($LINE$) and the size of switches that can provide services for more than 2,048 lines ($SIZE1$) (0.614),

(3) the number of lines ($LINE$) and the location of telephone exchanges ($LOCATION$) (0.587),

(4) the dummy variable for BTO lines (D) and the location of telephone exchanges ($LOCATION$) (0.535), and

(5) The location of telephone exchanges ($LOCATION$) and the size of switches that can carry lines for more than 2,048 ($SIZE1$) (0.406).

However, potential problems that might be created by multicollinearity are avoided here by the use of the tolerance and stepwise technique.[63, 64] These methods are available in the SPSS program. Using the stepwise method, Norusis (1995) stated that all variables must pass the tolerance criterion to be entered into the equation. He noted

[63] Tolerance is the proportion of variability in an independent variable that is not explained by its linear relationships with the other independent variables in the model. The value of tolerance ranges from 0 to 1. A value close to 1 indicates that an independent variable has little of its variability explained by the other independent variables. A value close to 0 indicates that a variable is almost a linear combination of other independent variables, or there exists multicollinearity (Norusis, 1995).

[64] Under the stepwise method, at each step variables, which are in the equation, are evaluated according to the selection criteria for removal, then variables, which are not in the equation, are evaluated for entry. Such processes are repeated until no variable is eligible for entry or removal (Norusis, 1995).

that a variable is not entered if it would cause the tolerance of another variable already in the model to drop below the tolerance criterion (Norusis, 1995). The stepwise selection technique will choose and remove variables based on the significance of the probability of a likelihood ratio statistic.[65] The benefits of the stepwise technique are not only that it drops out variables which cause multicollinearity, but it also eliminates variables which cause other computational problems, for example heteroscedasticity (Norusis, 1995).

It might be possible that not only the current but also the lagged values of explanatory variables may be significant explanatory variables. That is, the number of lines installed in the year before 1994 has affected capital expenditure in 1994. If this hypothesis is true it means the regression model should also include some distributed lag variables. Because *LINE* is the accumulated lines installed in each telephone exchange including this variable in the cost function, therefore, would not only investigate the presence of scale effects of the fixed-line market as discussed previously, but also be an indicator of whether the cost function should include a distributed lag variable in the model or not. That is, if *LINE* is significant regression models including lagged values of this explanatory variable would need to be investigated further.

[65] The likelihood ratio is the probability of a given sample being randomly drawn, regarded as a function of the parameters of the population (Borowski and Borwein, 1989).

TABLE 6-1

Statistics Summary

Variables	Expected Sign	Mean	Units	Standard Deviation	Number of Observations
$\ln c_i$		-5.865	million baht	1.3944	1005
D_i	-	.2169	-	.4123	1005
$\ln LINE_i$	+	6.2348	lines	1.0882	1005
$\ln CALL_i$	+	15.3481	calls	.9091	764
$LOCATION_i$	+	.21	-	.41	1005
$SIZE1_i$	+	.0857	-	.2813	1005
$SIZE2_i$	-	.0845	-	.2784	1005
$SIZE3_i$	-	.2617	-	.4398	1005
$SIZE4_i$	-	.1891	-	.3917	1005
$TECHNO_i$	-	.96	-	.20	1005
$\ln CHANGE_i$	+	4.925	lines	.7010	1005

TABLE 6-2

Test for Correlations Coefficients

Variables	c_i	D_i	$LINE_i$	$CALL_i$	$TECHNO_i$	$SIZE1_i$	$SIZE2_i$	$SIZE3_i$	$SIZE4_i$	$LOCATION_i$	$CHANGE_i$
c_i	1.000	-.038	-.746	-.171	.127	-.428	-.227	.279	.033	-.388	-.004
D_i		1.000	.239	.197	.107	.113	.170	.154	-.112	**.535**	.291
$LINE_i$			1.000	**.649**	-.123	**.614**	.330	.317	-.053	**.587**	.215
$CALL_i$				1.000	.149	.310	.111	-.096	-.142	.331	.127
$TECHNO_i$					1.000	.045	-.084	-.203	.072	.105	-.015
$SIZE1_i$						1.000	-.094	-.183	-.149	**.406**	.131
$SIZE2_i$							1.000	-.181	-.147	.230	.142
$SIZE3_i$								1.000	-.287	.227	.056
$SIZE4_i$									1.000	-.218	-.013
$LOCATION_i$										1.000	.265
$CHANGE_i$											1.000
Sig											
c_i	.	.112	.000	.000	.000	.000	.000	.000	.150	.000	.453
D_i		.	.000	.000	.000	.000	.000	.000	.000	.000	.000
$LINE_i$			.	.000	.000	.000	.000	.000	.047	.000	.000
$CALL_i$				.	.000	.000	.000	.001	.000	.000	.000
$TECHNO_i$					.	.079	.004	.000	.011	.000	.318
$SIZE1_i$						.	.001	.000	.000	.000	.000
$SIZE2_i$							.	.000	.000	.000	.000
$SIZE3_i$								.	.000	.000	.037
$SIZE4_i$									.	.000	.343
$LOCATION_i$										.	.000
$CHANGE_i$											.

6.5 MODEL SPECIFICATION

To develop the specification of the cost function for this assessment, recall the translog cost function under the assumption of cost minimisation (equation 5.3.3), which was discussed in the previous chapter:

$$\ln C = \ln \alpha_0 + \alpha_1 \ln Q \qquad \text{(equation 6.5.1)}$$

where C is the capital cost, α_i is the coefficient on each variable, Q is the amount of output. Let i be the number of telephone exchanges (i = 1-1005). When we include all explanatory variables discussed previously in equation 6.5.1, then the estimated equation becomes:

$$\ln c_i = \begin{pmatrix} \alpha_1 + \alpha_2 D_i + \alpha_3 \ln CHANGE_i + \alpha_4 \ln LINE_i + \alpha_5 \ln CALL_i + \alpha_6 LOCATION_i \\ + \alpha_7 SIZE1_i + \alpha_8 SIZE2_i + \alpha_9 SIZE3_i + \alpha_{10} SIZE4_i + \alpha_{11} TECHNO_i \end{pmatrix}$$

(equation 6.5.2)

where c_i = the average capital cost per new line

The expected results from equation 6.5.2 are as follows. If there are economies in c_i, which is estimated by the coefficient of $LINE_i$, it is more likely that the local telephone market is a natural monopoly. If there is no economy of scale in c_i, the market is less likely to be a natural monopoly. The coefficient of $CHANGE_i$ indicates the effects of the extent of growth on the cost of new lines. The coefficient of the dummy variable D_i indicates the effects of a BTO presence on the average capital cost per new line. The coefficient of $CALL_i$ indicates whether the capital expenditure per new line varies with the number of calls. The coefficient of $LOCATION_i$ establishes whether any difference exists between capital expenditures for telephone exchanges located in PA and in BMA. The coefficient of $SIZE_i$ indicates the effects of the use of a particular switch size on the average capital cost per new line. The coefficient of $TECHNO_i$ represents the effects of the adoption of digital switches on the average capital cost per new line.

All variables in equation 6.5.2 are run at once to examine the relationship between the whole set of predictors and the dependent variables.[66] As illustrated in Table 6-3, it is found that on the basis of the partial F value, there exist some variables which are poor performers (p>0.05). The same equation then is run again using the tolerance technique and the stepwise method in the SPSS program. Variables which are not significant at the 0.05 level will be dropped out. The final equation, which is reported in Table 6-4, is:

$$\ln c_i = -3.170 - 0.113 D_i - 0.469 TECHNO_i \qquad \text{(equation 6.5.3)}$$

se = (0.104) (0.024) (0.105)

t = (-30.348) (-4.720) (-4.446)

$\overline{R}^2 = 0.595$

The t value of each explanatory variable is statistically significant at the 0.05 level. The computed $\overline{R}^2$ is quite high and the F test is also significant at the 0.05 level. This indicates that the sample regression provides a good fit.

[66] In this test, the cases (observations) that have missing values will be excluded from the analysis. As a result the number of observations used in estimating this model is 764.

To see how each independent variable contributes to the overall R^2, the partial R^2 between each pair of variables is computed.[67] It is found that the value of partial R^2 for the dummy variable of BTO lines (D_i) is 0.545 and for the dummy variable of digital technology $(TECHNO_i)$ is 0.538. A higher value of partial R^2 of D_i can be interpreted to mean that the proportion of the variation in the average capital cost per new line is primarily explained by the dummy variable of BTO lines (D_i).

To examine for violations of the regression assumptions (which are the assumptions of normality, homoscedasticity, linearity and unbiasedness), four techniques are used in this assessment: examining for normality, testing for heteroscedasticity, testing for multicollinearity and detecting model specification errors.

The chi-square test for goodness of fit is the method used to test whether the assumption of normality is accepted.[68] In this assessment, the chi-square value is insignificant (p=0.794) at the 0.05 level of significance. This means that the difference between the observed and expected values of the residuals is not serious enough to reject the normality assumption (Gujarati, 1995). In other words, it indicates that the data are not inconsistent with a sample from a normal distribution (Norusis, 1995).

To investigate whether heteroscedasticity is present in the data, the 'Park test' is the method used in this study.[69] It is found that at the 0.05 level of significance, the t

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[67] For more details, see Gujarati (1995, p. 214).

[68] The chi-square goodness of fit test is one of the methods to test for normality (Gujarati, 1988). It will test how well a model fits the observed data (Norusis, 1995).

[69] The Park test is a two-stage procedure. In the first stage, we run the regression, disregarding the heteroscedasticity question. Then, in the second stage, a regression is run again by using the residual value as the value of dependent variable and the predicted value is the independent variable. If the t value

value of the disturbance term is equal to -0.128 which is insignificant. This can be interpreted to mean that heteroscedasticity does not exist in the data (Gujarati, 1995).

To detect multicollinearity, the condition index (CI) is applied.[70] It is found that the value of CI for each independent variable is lower than 10 (dummy variable for BTO lines = 2.119 and dummy variable for switching technology = 3.167). This indicates that there is no collinearity between this pair of variables.

To detect the model specification errors (ie, omission of an important variable or incorrect functional form), the Durbin-Watson d statistic is used.[71] The lower and upper limits for n = 761 and k = 2 of the estimated value of Durbin-Watson (d) at a 0.05 level of significance are 1.748 and 1.789. It is found that the computed d value is 2.111 which means we can reject the hypothesis of model mis-specification (Gujarati,

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of disturbance term is statistically significant, it suggests that heteroscedasticity is present in the data. In turn, if it is not significant, we can accept the assumption of homoscedasticity (Gujarati, 1995).

[70] CI is one of the methods to detect multicollinearity: $CI = \sqrt{k}$, where k=(maximum eigenvalue/ minimum eigenvalue). For more details, see Gujarati (1995). Gujarati (1995) stated that, under the rule of thumb, if the value of CI is between 10 and 30 there is moderate to strong multicollinearity and if it exceeds 30 there is severe multicollinearity.

[71] The Durbin-Watson d test is one of the appropriate methods to detect model specification errors, in particular for the use of cross section data (Gujarati, 1995). The procedures to use the Durbin-Watson d test to detect model specification error(s) are follows. If we believe that the model is mis-specified because it excludes some relevant explanatory variables we have to run the regression again by including the residual value, which arises from the model, as one of the explanatory variables. Then, compute the d statistic by the usual d formula $\left[d = \frac{\sum_{t=2}^{n} (\hat{u}_t - \hat{u}_{t-1})^2}{\sum_{t=1}^{n} \hat{u}_t^2} \right]$. Based on the Durbin-Watson test, if the estimated d value is significant then one can accept the hypothesis of model mis-specification (Gujarati, 1995).

1995). This can be interpreted to mean that all relevant explanatory variables are included in equation 6.5.3.

As discussed in the previous section the number of lines is also used as an indicator of whether equation 6.5.3 is a distributed lag model. The insignificance of $LINE_i$ indicates that equation 6.5.3 does not require the lagged value of the explanatory variable(s). In addition, the computed d value as estimated above, which is greater than 2, can be used to support the insignificance of $LINE_i$. That is, equation 6.5.3 is the true specification.

Interpretation of the coefficients of equation 6.5.3 is provided in the following section.

6.6 INTERPRETATION OF EMPIRICAL RESULTS

Equation 6.5.3 can be interpreted as follows. Consider the relationship between the number of telephone lines available in each exchange $(LINE_i)$ and the average capital cost per new line. The existing number of telephone lines is not significant. This can be interpreted to mean that the average cost per new line does not increase with the size of the exchange. This indicates that there exist constant returns to scale at the level of each telephone exchange. The presence of constant returns to scale tells us that the local telephone market in Thailand is unlikely to be a natural monopoly.

Next, consider the relationship between the number of calls and the average capital cost of each new line. The result shows that the coefficient on $CALL_i$ is also not significant, so the average capital cost per line does not vary with the number of calls.

$CHANGE_i$ is insignificant. This means the average capital cost per line does not increase as there are more new lines installed.

The significance of D_i can be interpreted to mean that, other things equal, operators gain cost savings from the direct investment cost in the BTO projects (all BTO lines have been equipped by digital technology) by 10.69 per cent.

The negative coefficient of $TECHNO_i$ is significant. As discussed before, this means that the adoption of digital technology provides cost savings. This result tells us further that the expected average capital cost of each new line equipped with a digital switch is lower than the lines installed with an analogue technology by 37.44 per cent.

In this test it is found that none of the dummies representing sizes of switch $(SIZE1_i - SIZE4_i)$ are significant. This can be interpreted to mean that, other things being equal, the average capital cost per new line installed under different switch sizes is the same. This implies further that the cost savings occurring in the BTO projects do not arise from the use of small switch sizes, contrary to the claims of RDI (1993) and TT&T (1994a).

$LOCATION_i$ is not significant either. This indicates that the cost of a new line installed in BMA and in PA is the same. Higher expenditures in BMA, for example due to higher cost of labour and the prices of land and building, may be compensated by cost savings from transportation expenses and from expenditures on duct works. That is, Bangkok is the location of the main port in Thailand and imported communications equipment must be delivered to Bangkok for delivery to other provinces. Thus, a BTO project in BMA gains cost savings from lower delivery expenses. In addition, there would not exist extraordinary expenses on duct works (through mountains) to lay the cables in a BMA project, as is necessary in PA (TT&T, 1994a).

TABLE 6-3

Estimated Equation - Full Model

Variables	B	Standard Error	t-test	Sig.
Constant	-2.854	.272	-10.479	.000
D_i	-.161	.032	-5.108	.000
$\ln CHANGE_i$	.017	.010	1.648	.101
$\ln LINE_i$	-.022	.038	-.588	.557
$\ln CALL_i$	-.021	.013	-1.521	.130
$LOCATION_i$	.048	.048	1.003	.317
$SIZE1_i$	-.022	.123	-.180	.857
$SIZE2_i$	.065	.096	.675	.501
$SIZE3_i$	.061	.070	.867	.387
$SIZE4_i$	-.010	.048	-.212	.832
$TECHNO_i$	-.424	.108	-3.941	.000

$n = 764$

TABLE 6-4

Final Estimated Equation

Variables	B	Standard Error	t-test	Sig.	Collinearity Statistics (Tolerance)
Constant	-3.170	.104	-30.348	.000	
D_i	-.113	.024	-4.720	.000	.993
$TECHNO_i$	-.469	.105	-4.446	.000	.993

$R^2 = 0.597$

Adjusted $R^2 = 0.595$

df (residual) = 761

6.7 CONCLUSION

This chapter tested the cost structure of the telephone industry in Thailand after an introduction of BTO regimes. Seven issues are highlighted:

(1) the structure of the market at the local telephone exchange level,

(2) the effect of BTO regimes on the average capital cost per line,

(3) the effect of the number of new telephone lines in 1994 on the average capital cost per new line,

(4) the effect of the volumes of telephone traffic and the average capital cost of each new line,

(5) the difference in capital expenditures in the telephone system between BMA and PA,

(6) the effect of switch sizes (small and large) on the average capital cost of each new line, and

(7) the effect of switch types (analogue and digital) on the capital expenditure of each new line.

A translog cost function was applied to investigate the relationship between output characteristics and the average capital cost of new lines. Cross section data of 1,005 telephone exchanges in Thailand were examined. However, because there are some missing values appearing in the number of calls, the total number observations tested in the cost function is 764. A number of interesting findings from this test can be summarised as follows.

First, it is found that there are no economies of scale in terms of level of lines at the local exchange level in the fixed-line market. This suggests local telephone exchanges both in PA and BMA markets are unlikely to be natural monopolies.

While the question of whether the total telecommunications market is a natural monopoly cannot be finalised here, there do not appear to be economies in capital expenditure at the exchange level, which suggests that overall scale economies may not be important. Holding other things constant, when constant returns to scale are present the policy of opening free entry even at the level of local telephone exchanges should be considered.

Second, operators gain some cost savings not only from the adoption of digital technology but also from the introduction of BTO regimes.

Third, the relationship between the number of calls and the capital expenditure of telephone exchanges is insignificant. This means that the average capital cost per line does not vary with the number of calls.

Fourth, the average capital cost per line in the BMA is not significantly different from that occurring in the PA. This is probably because an operator in BMA gains some cost savings from transportation and duct work expenses to offset higher expenditures (the cost of land and buildings).

Fifth, the use of small switch sizes does not provide any cost savings, contrary to claims by operators.

The empirical results in this chapter contribute to our understanding of the nature of the fixed-line market and the effects of BTO regimes in terms of cost savings. An important question, however, still remains. In 1994 there were 71 provinces in Thailand, but BTO lines could not be installed in every province in the first installation year (RDI, 1993). This implies that some factors were used to determine the order of line installation. This issue will be investigated in the next chapter.

CHAPTER 7

THE PRIORITY OF INVESTMENT IN PROVINCIAL AREAS

7.1 INTRODUCTION

As mentioned in Chapter 3 the Thai Telephone and Telecommunication (TT&T) Company was granted a licence to install 1.5 million fixed-lines in provincial areas (PA) in 1992. At that time there were 69 provinces in Thailand so new fixed-lines could not be installed in every province simultaneously. As is illustrated in Figures 7-1, 7-2, 7-3 and 7-4, some provinces, for example Chiang Mai, Ranong and Rayong, had their first BTO lines in 1993, while in others, for example Chaiyaphum, Maha Sarakham and Phatthalung, lines were installed in later years. It is interesting to investigate the factors that influenced the priority of line installation in BTO projects. For that purpose, a logit model is estimated in this chapter.

Two models (consumer demands, and the economic and social development plan) are examined in this chapter.

First, consider the contribution of consumer demands. It has been noted that good communications facilities would improve the efficiency of commerce (ie, reduce the need to travel) and other economic activities (ITU, 1984). For this reason, the demand for telephone lines, as discussed in Chapter 3, increased during the rapid economic growth during the 1980s. Therefore it is interesting to investigate whether consumer demand is a crucial factor which determines the order of line installation.

Next consider the impact of economic and social development. Thailand aims to change from a mainly agricultural to a more industrialised economy (NIRA, 1992), as well as to become the centre of investment in Southeast Asia (NITC, 1995). The contribution of the telephone system discussed previously has been regarded as not only an important tool to reach such goals (TDRI, 1997a), but it also improves the quality of life, in particular in rural and remote areas (ie, long-distance education and tele-medicine) (Saunders et al, 1994).[72] With respect to these benefits, an improved telecommunications system is one of the important targets which is included in the economic and social development plan in the National and Economic Development Plans (RDI, 1993). For this reason, indicators representing the economic and social development plans are also tested for their significance in explaining the sequence in which new lines were installed.

This chapter consists of five sections. The sources of data and definition of variables are reported in section 7.2 and section 7.3, respectively. The specification of the logit function is developed in section 7.4. Interpretation of the empirical assessment is provided in section 7.5. Concluding remarks are presented in section 7.6.

[72] Long-distance education and tele-medicine are the provision of training courses or education programs through communications facilities, for example telephone, television and Internet. The benefits from improved telecommunications have been observed to make the difference between life and death of a patient (Hudson, 1981 and Saunders et al, 1994). For example, Hudson (1981) found that about 3 to 5 per cent of telephone traffic was used for emergency communications.

7.2 SOURCES OF DATA

As mentioned earlier, TT&T was granted a concession to install 1.5 million lines in provincial areas in 1992. Before construction started in 1993 (TT&T, 1994a) an investment plan had been designed in 1992 (RDI, 1993). To investigate the factors that influence the investment plan a data set of explanatory variables from 1992 is used.[73] As a result, the explanatory variables are lagged by one year.

The data employed in this chapter were collected from:

- the Telephone Statistic Report, published by the TOT (TOT, 1992b),
- the Telecommunications Development Plan 1997-2006, proposed to the Ministry of Transport and Communications by the Thailand Development Research Institute (TDRI, 1997a),
- a list of industrial estates reported by the Board of Investment (BOI) (http://www.boi.go.th/business/g11.htm, http://www.ieat.go.th and Industrial Estate Authority of Thailand (IEAT, 1993)),
- sourcing guides by the Board of Investment (BOI, 1993),
- a guide to Thailand's provinces by the Tourism Authority of Thailand (http://www.tat.or.th/province/index.htr, TAT, 1993 and TDRI, 1993b) and
- Technology and Investment Opportunity in Telecommunications Services and Equipment, prepared by RDI (1993).

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[73] The 1992 data set is used, rather than one for earlier years, for two reasons. First, the actual plan which was designed in 1992 relied on the survey of demand for lines and the length of waiting lists in 1992 (TT&T, 1994a). Second, the rate of growth in the Thai economy and the rate of growth in population between 1991 and 1995 was constant (TDRI, 1997a and b). Thus, the use of the 1992 data set should not provide different results compared with using data from other years.

Cross section data on telephone exchanges are tested. Some adjustment to the data is required since Thailand consisted of 69 provinces in 1992 and this number increased to 71 provinces in 1994 (two provinces, Prachin Buri and Udon Thani, were separated into four provinces; Prachin Buri, Sakaeo, Udon Thani and Nong Bua Lam Phu). To be able to compare the impact of BTO regimes, the evaluation in this section will combine data on Sakaeo into that of Prachin Buri and all data on Nong Bua Lam Phu into that of Udon Thani. As a result there are 69 observations in this assessment.

7.3 EXPLANATORY VARIABLES

The 69 provinces in Thailand are divided into two groups because in a logistic regression, the dependent variable, Y_i, has to be dichotomous. These two groups comprise provinces with the first lines in BTO projects installed in 1993 and provinces with the first lines installed in later years. Thus, to evaluate the probability that a province will receive early installation, let $Y_i = 1$ designate a province that consists of telephone exchanges constructed under BTO regimes in 1993, and let $Y_i = 0$ otherwise.

In this assessment five proxies (the length of waiting lists, Gross Domestic Product (GDP) per capita, the growth rate of GDP, teledensity[74] and the location of business zones) are used to investigate two models (consumer demand, and the economic and social development plan).

[74] The ratio of telephone lines to population is called teledensity. It is measured in terms of the number of lines per 100 persons (Kellerman, 1993).

Consider the length of the waiting list. As mentioned earlier the demand for lines increases in the presence of economic growth. From Chapter 3 we know that TOT failed to provide sufficient fixed-lines, and as a result the number of people on waiting lists increased dramatically. Thus, to investigate the importance of consumer demands, the length of waiting lists, denoted by $WAITL$, is included in the logit model. It is expected that provinces with longer waiting lists will be ranked as higher priorities to receive new lines. As illustrated in Figure 7-1, Chon Buri and Chiang Mai are provinces having long waiting lists which therefore should be ranked among the high priorities.

GDP per capita is one of the key indicators to measure a country's wealth and is one of the indicators included in this context in the National Economic and Social Development (NESD) plans. It was planned that by the end of seventh NESD plan GDP per capita should be increased to 71,000 baht (NESDB, 1993). To achieve this aim provinces which are less developed, as indicated by low GDP per capita, are expected to have BTO lines installed earlier to improve wealth. To investigate this variable GDP per capita (denoted by GDP) is included in the logit model. If GDP per capita was used by the Government in determining the sequence of line installation provinces with low GDP per capita, for example Prae, Nakhon Phanom and Loei, as shown in Figure 7-2, are more likely to be ranked among the high priorities.

In turn, the level of GDP per capita might be used as a proxy in the consumer demand model in determining the order of line installation. That is, more lines may be required in the provinces which are wealthy (high GDP per capita). In other words, consumers in the provinces with high GDP per capita may need more telephone lines. If this hypothesis is true provinces with high GDP per capita, for example Rayong, Chon Buri and Samut Sakhon, as illustrated in Figure 7-2, are more likely to be ranked among high priorities.

The growth rate of GDP is another indicator discussed in the context in the NESD plans. That is, during the seventh NESD plan the growth rate of GDP should continue at the rate of 8.2 per cent per year over five years (NESDB, 1993). The contribution of telephones has been demonstrated as an accelerator to foster economic growth (Saunders et al, 1994), the first BTO lines therefore might be installed in the provinces with a low growth rate. For this reason the growth rate of GDP, denoted by $GROWTH$, is included in the logit model to see whether this variable has such effects on the determination of line installation in BTO projects. If the growth rate of GDP was used in the economic and social development plan in determining the sequence of line installation, provinces which had a low growth rate of GDP (for example, Satun and Pattani in Figure 7-3) should be ranked among high priorities.

In addition, the growth rate of GDP might be used as a proxy in the consumer demand model. That is, demand for lines might be increased in the provinces which had high growth rate of GDP. This is because more infrastructure, in this case an increase in the number of fixed-lines, would be required as the provinces grow. If this hypothesis is true, Saraburi, Chon Buri and Rayong, as illustrated in Figure 7-3, should be ranked among the high priorities.

Next consider teledensity, denoted by $TELD$. To improve the quality of life the Thai Government has planned to increase the number of lines according to the size of teledensity in each province (TOT, 1991). It was planned that by the end of the seventh NESD plan teledensity should be increased to 10 lines per 100 persons (NESDB, 1993). If it is true that teledensity is a key strategy used in the economic and social development plan in determining line installation, provinces with low teledensity are likely to be given higher priority than those of high teledensity. Thus Kalasin, Si Sa Ket and Phayao, as illustrated in Figure 7-4, will be ranked with a high priority.

Teledensity can be used as a proxy in the model of consumer demand as well. That is, when there was high economic growth, high demand for lines might appear in the provinces which had low teledensity. If this is true, Kalasin, Si Sa Ket and Phayao which are example provinces having low teledensity should be ranked among the high priorities.

The establishment of industrial estates is one of the strategies used to promote industrialisation, and the project 'Amazing Thailand' is one of the strategies to promote the tourism industry (http://www.boi.go.th/business/g11.htm and http://www.tat.or.th/province/index.htr). Facilities, for example telephone lines, will be provided earlier to firms located in industrial estates or in tourism provinces than to those located in other places (Boonyawinaikul, 1995). This is therefore another appropriate variable to be examined to see whether the economic and social development plan is a key factor in determining the order of line installations.

In this assessment, a province which is a focal location of industrial estates or which is a focus for tourism promotion is denoted by BUS. To investigate the relationship between the significance of the location of industrial or tourism zones and the installation plan of fixed-lines a dummy variable is applied. Let $BUS = 1$ for a province in which industrial estates were established in 1993 or which was announced as a tourism province in 1993, and let $BUS = 0$ otherwise.[75] If the location of industrial

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[75] One might question that the first BTO lines might be provided to firms located in the industrial estates not only established in 1993, but also established before 1993. For this reason, in the early test, BUS was defined for a province which is the location of industrial estates. This included all existing locations of industrial estates established **before** 1993 and **in** 1993. It was found that BUS was significant. However, this result was invalid when it was further investigated for the relationship between the actual sequence and the predicted sequence. That is, it appeared that the estimated predicted sequence cannot explain the

or tourism zones are a key factor used in the economic and social development plan to determine the installation priority of fixed-lines, the first BTO lines should be installed in industrial or tourism provinces in the earlier years. Chon Buri and Rayong, are examples of provinces in which some industrial estates were established in 1993 (BOI, 1993 and IEAT, 1993) and which should be given a high priority. Likewise, Chiang Mai and Phuket are examples of tourism provinces which were promoted specially in 1993 (TAT, 1993), which should be also ranked with a high priority.

A summary of the data set discussed above is given in Table 7-1.

To estimate the value of correlations between each pair of variables Pearson coefficients are used in this assessment.[76] As presented in Table 7-2, a large correlation coefficient (of either positive or negative value) can be interpreted to mean that those variables are strongly and linearly related. Table 7-2 reports that according to the 0.05 level of significance, there are five pairs of variables which are expected to exhibit severe multicollinearity:[77]

- the length of waiting lists $(WAITL)$ and teledensity $(TELD)$ (0.665),
- the length of waiting lists $(WAITL)$ and GDP per capita (GDP) (0.687),

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actual sequence well. For example, Ayutthaya, which is the location of industrial estates established before 1993 but had no BTO lines installed in 1993, exhibited high probability. Phuket, which is not the location of industrial estates but whose first BTO lines were installed in 1993, showed a low probability. As a result, BUS was redefined again as the location of industrial or tourism zones promoted in 1993.

[76] The definition of Pearson coefficient was described in Chapter 6.

[77] Table 7-2 tells us that most pairs of variables (except between $GROWTH$ and BUS) exhibit a positive linear relationship. However, only five pairs which show strong linear relationship are presented here since high correlations are more likely to be expected in the presence of multicollinearity.

• the length of waiting lists ($WAITL$) and the growth rate of GDP ($GROWTH$) (0.454),

• teledensity ($TELD$) and GDP per capita (GDP) (0.786), and

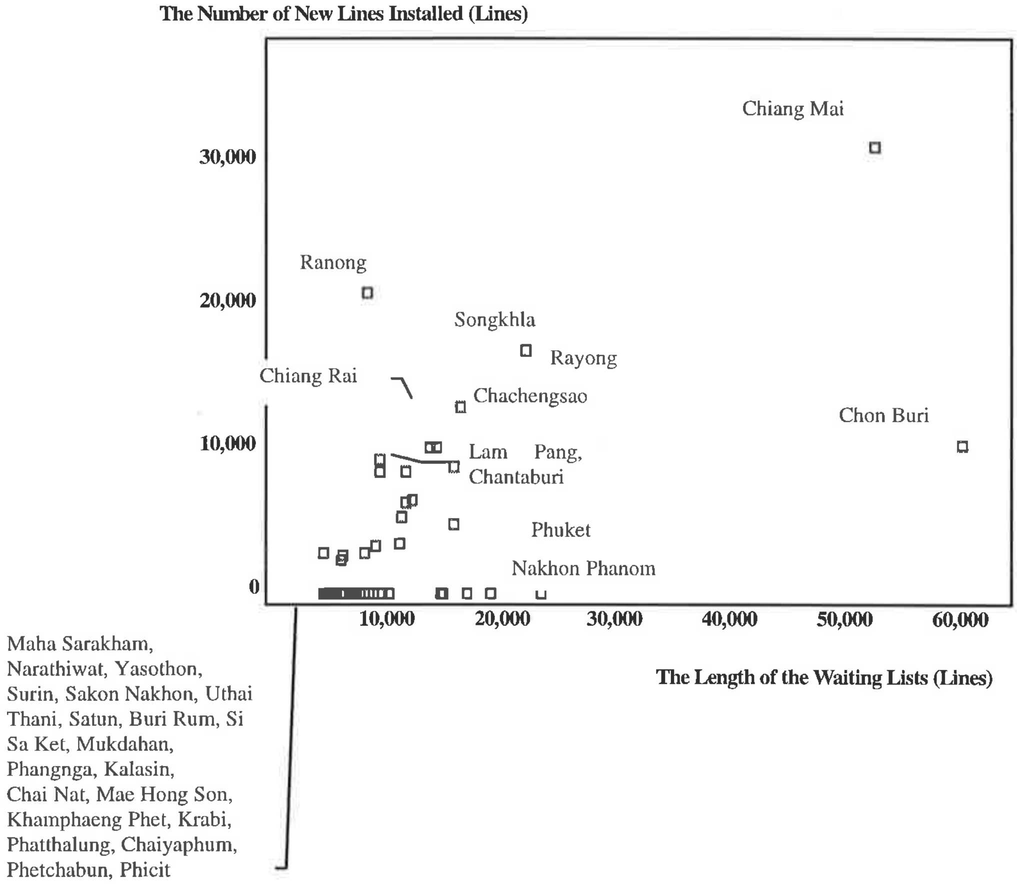
• GDP per capita (GDP) and the growth rate of GDP ($GROWTH$) (0.491).

As in the previous chapter, potential problems that might be created by multicollinearity can be avoided here by the use of the forward selection technique. This technique, which is available in the SPSS program, will choose and remove variables based on the probability of a likelihood ratio statistic.[78]

[78] The definition of likelihood ratio test was explained in Chapter 6.

FIGURE 7-1

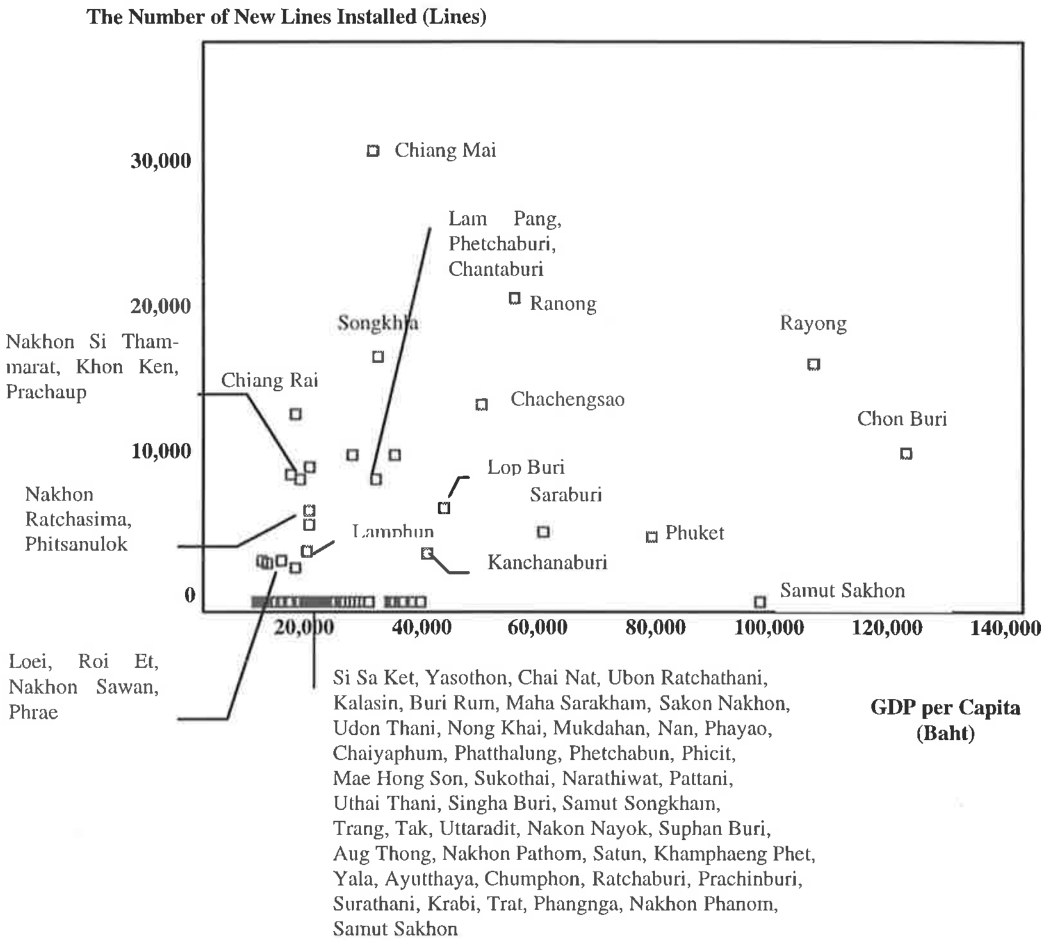
The Relationship between the Number of New Lines Installed in 1993 and the Length of Waiting Lists in 1992



Source: TOT (1992b) and RDI (1993)

FIGURE 7-2

The Relationship between the Number of New Lines Installed in 1993 and GDP per Capita by Province in 1992

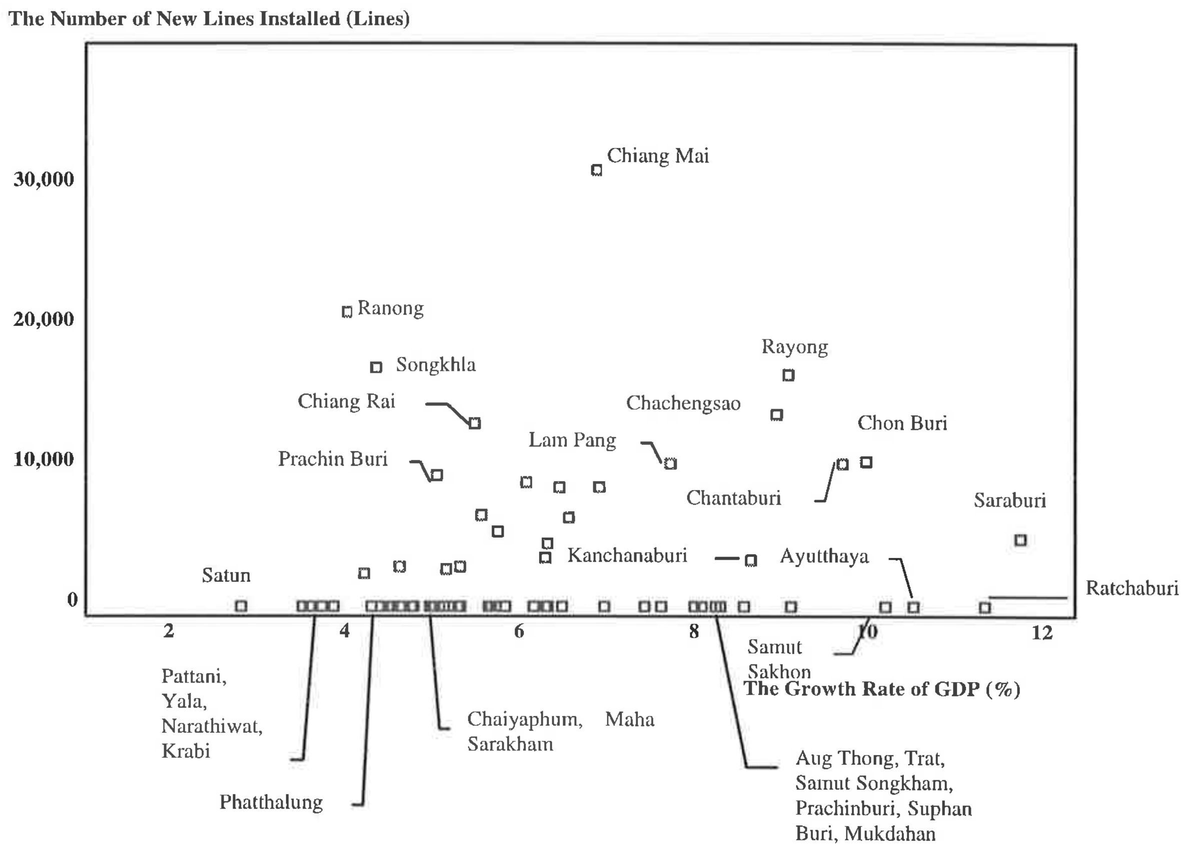


Source: TOT (1992b) and RDI (1993)

FIGURE 7-3

The Relationship between the Number of New Lines Installed in 1993

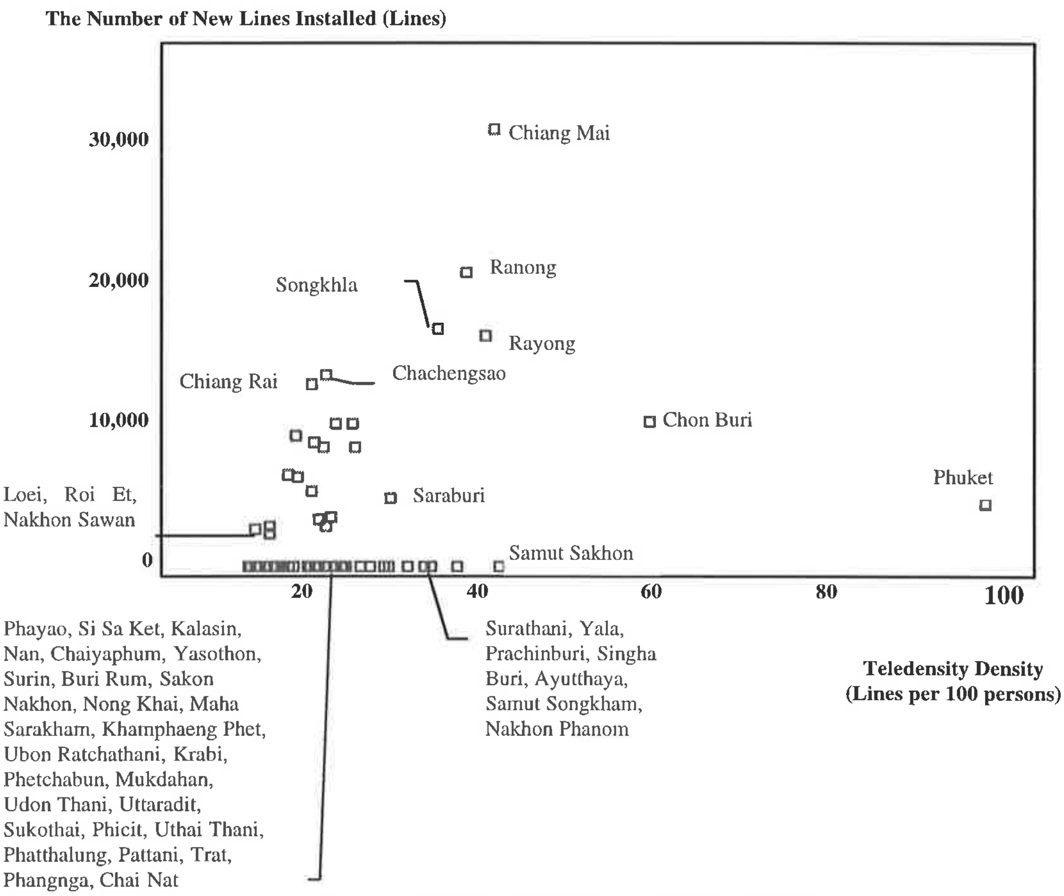
and the Growth Rate of GDP by Province in 1992



Source: TDRI (1997a) and RDI (1993)

FIGURE 7-4

The Relationship between the Number of New Lines Installed in 1993 and Teledensity by Province in 1992



Source: TOT (1992b) and RDI (1993)

TABLE 7-1

Statistics Summary

Variables	Sign	Mean	Units	Standard Deviation	Number of Observations
Y_i		0.4058	-	0.4946	69
$WAITL_i$	+	6,472.51	lines	9,640.55	69
$TELD_i$	+	20.9283	lines per 100 persons	18.2221	69
GDP_i	+	26,798.58	baht	21,373.74	69
$GROWTH_i$	+	5.9299	per cent	1.9879	69
BUS_i	+	0.4203	-	0.4972	69

TABLE 7-2

Test for Correlations Coefficients

Variables	Y_i	$WAITL_i$	BUS_i	$TELD_i$	GDP_i	$GROWTH_i$
Pearson Correlation						
Y_i	1.000	0.471	0.768	0.318	0.359	0.198
$WAITL_i$		1.000	0.395	**0.665**	**0.687**	**0.454**
BUS_i			1.000	0.306	0.292	0.094
$TELD_i$				1.000	**0.786**	0.350
GDP_i					1.000	**0.491**
$GROWTH_i$						1.000
Sig						
Y_i	.	0.000	0.000	0.002	0.002	0.103
$WAITL_i$		.	0.001	0.000	0.000	0.000
BUS_i			.	0.007	0.015	0.443
$TELD_i$				.	0.000	0.003
GDP_i					.	0.000
$GROWTH_i$						.

7.4 MODEL SPECIFICATION AND MAIN RESULTS

When all the above explanatory variables are included, the functional form is:

$$Y_i = \beta_1 + \beta_2 WAITL_i + \beta_3 TELD_i + \beta_4 GDP_i + \beta_5 GROWTH_i + \beta_6 BUS_i$$

(equation 7.4.1)

Where i = the number of provinces (1-69)

Y_i = 1 for provinces with exchanges which constructed the first BTO lines in1993, and 0 otherwise;

$WAITL_i$ = The length of waiting lists in 1992;

$TELD_i$ = Teledensity in 1992;

GDP_i = GDP per capita in each province in 1992;

$GROWTH_i$ = The growth rate of GDP in each province in 1992;

BUS_i = 1 for provinces which are industrial zones or tourism provinces, and 0 otherwise

$E(Y_i)$ can be interpreted as the conditional probability that the event Y will occur, conditional on the given values of the explanatory variables (Gujarati, 1988). The value of $E(Y_i)$ is written in the logit model in the form of $P_i/(1-P_i)$, where P_i in this study is the probability of selecting a province for installation of BTO lines in 1993, and $(1-P_i)$ is the probability of not selecting it. The ratio of $P_i/(1-P_i)$ is known as the odds ratio, which means the odds in favour of selecting the province (Gujarati, 1988). Therefore, equation 7.4.1 can be expressed in the form of the logit model as:

$$\ln\left(\frac{P_i}{1-P_i}\right) = \beta_1 + \beta_2 WAITL_i + \beta_3 TELD_i + \beta_4 GDP_i + \beta_5 GROWTH_i + \beta_6 BUS_i$$

(equation 7.4.2)

All variables in equation 7.4.2 are run at once to examine the relationship between the whole set of predictors and the dependent variables. As illustrated in Table 7-3 (model 1), it is found that on the basis of the partial F value there exist some variables which are poor performers (p>0.05). The same equation then is run again using the forward selection method in the SPSS program. Variables which are not significant at the 0.05 level will be dropped out. The final equation, which is reported in Table 7-3 (model 2), is:

$$\ln\left(\frac{P_i}{1-P_i}\right) = -5.3618 + .0002 WAITL_i + 4.884 BUS_i \qquad \text{(equation 7.4.3)}$$

se = (1.6837) (.0001) (1.3719)

Goodness of fit = 0.75

As illustrated in Table 7-3 (model 2), the *p* value of each explanatory variable is statistically significant on the basis of a two-tailed test at the 0.05 level. In the logit model, the computed goodness of fit is a measure of the degree to which the model fits the data.[79] The goodness of fit is significant at the 0.05 level of significance. This indicates that the sample regression provides a good fit.

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[79] The dependent variable in the logit model is either 0 or 1. Therefore all the values of dependent variable will lie along the line corresponding to 0 and 1. As a result, if the conventionally computed R^2 is used to check the fit in the logit model, it is more likely to be very much lower than 1. Gujarati (1988) observed that in most practical applications, the R^2 will range between 0.2 and 0.6. For this reason,

To test for violations of the regression assumptions (normality, homoscedasticity, collinearity and unbiasedness), the four techniques used in Chapter 6 are again used in this assessment: testing for normality, testing for heteroscedasticity, detecting multicollinearity and detecting model specification errors.

The chi-square test for goodness of fit is the method used to test whether the assumption of normality is accepted.[80] In this assessment, the chi-square value is insignificant (p=0.059) at the 0.05 level of significance. This means that the difference between the observed and expected values of the residuals is not serious enough to reject the normality assumption (Gujarati, 1995). In other words, it indicates that the data are not inconsistent with a sample from a normal distribution (Norusis, 1995).

To investigate whether heteroscedasticity is present in the data, the 'Park test' is used.[81] It is found that at the 0.05 level of significance, the t value of the disturbance term is equal to -0.158 which is insignificant. This can be interpreted to mean that heteroscedasticity does not exist in the data (Gujarati, 1995).

In this assessment, tolerance is used to detect multicollinearity in the model.[82] It has been noted that if any of the tolerances are smaller than 0.1, those variables are

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several alternatives, for example goodness of fit, are used in the estimation of a logit model. The concept of goodness of fit test is the same as that of the computed R^2. That is, the better the fit, the more confidently we can use the model for inference and prediction (Doran, 1989). The computed goodness of fit can be estimated from the squared differences between the observed and predicted probabilities (for more details, see Agresti, 1996).

[80] Definition of the chi-square goodness of fit was described in Chapter 6. For more details, see Gujarati (1988) and Norusis (1995).

[81] An explanation of the Park test was provided in Chapter 6.

[82] If the value of tolerance is close to 1, it means an individual variable is not correlated with the other regressors. The value of tolerance that is close to 0 means that multicollinearity exists (Gujarati, 1995)

highly related to the other regressors (Norusis, 1995). It is found that the value of tolerance of $WAITL_i$ is 0.440 and BUS_i is 0.841 which are sufficiently large. As a rule of thumb this indicates there is no collinearity between this pair of variables (Gujarati, 1995).

To detect the model specification errors (for example, omission of an important variable, omitting a relevant variable (ie, distributed lag of variables) or incorrect functional form), the Durbin-Watson d statistic is used.[83] The lower and upper limits for $n = 69$ and $k = 2$ for the estimated value of the Durbin-Watson (d) statistic at a 0.05 level of significance are 1.554 and 1.672. It is found that the computed d value is 1.919 which means we can reject the hypothesis of model mis-specification (Gujarati, 1995, pp. 463). This can be interpreted to mean that all relevant explanatory variables are included in equation 7.4.3.

Interpretations of the coefficients of equation 7.4.3 are provided in the following section.

[83] An explanation of the Durbin-Watson d test was provided in Chapter 6.

7.5 INTERPRETATION OF THE EMPIRICAL RESULTS

The interpretation of the logit model in equation 7.4.3 is as follows. Holding all other things constant (that is at the mean of the length of waiting lists), the predicted probability of BTO line installation is equal to 0.0168 in those provinces which are neither industrial or tourism zones, and 0.6935 in the provinces which are either industrial or tourism zones.[84] This can be interpreted to mean that the industrial or tourism provinces have a higher probability of having BTO lines installed compared with non industrial or tourism provinces.

Alternatively, equation 7.4.3 can be interpreted to mean that both the demand for telephone lines and the economic and social development plan are used as factors in determining the order of network installation. *TELD*, *GDP* and *GROWTH* appear to be statistically insignificant.[85] This means that the location of industrial or tourism zones alone appears to have been used by the Government in determining the order of new line installations.

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[84] The predicted probability of BTO line installation is equal to $\left(\frac{\exp(-5.3618+(0.0002*6{,}472.51))}{1+\exp(-5.3618+(0.0002*6{,}472.51))}\right)$ for the non industrial or tourism zones, and equal to $\left(\frac{\exp(-5.3618+(0.0002*6{,}472.51)+4.884)}{1+\exp(-5.3618+(0.0002*6{,}472.51)+4.884)}\right)$ for the industrial or tourism provinces.

[85] One might question that the insignificance of teledensity, GDP per capita and the growth of GDP may arise from the use of the length of waiting lists as a proxy for all these variables by the Government. For this reason, equation 7.4.2 was tested again by leaving out the length of waiting lists. It was found that *TELD*, *GDP* and *GROWTH* were still not significant. This suggests that these three variables were not included in the consideration of the ordering of new line installations.

Equation 7.4.3 tells us the factors that influenced the priority of line installation in BTO projects. The next interesting question is whether each province might be given a different priority. Thus it is worthwhile to calculate the probabilities for each province to see which provinces were ranked as top priorities according to the estimated equation. By putting the values of the explanatory variables for each province into equation 7.4.3, we can obtain the estimated value of P_i.[86]

The predicted values of P_i, as illustrated in Table 7-4, can be explained as follows. The value for Chon Buri Province is 0.999, which means the probability that BTO lines will be installed in Chon Buri in 1993 is 99 per cent. Consider Maha Sarakham Province. The estimated probability in Table 7-4 is 0.005 which means the probability of this province having new BTO lines in 1993 is only 0.5 per cent.

To illustrate how well the model in equation 7.4.3 can explain the actual sequence of installation, the relationship between the actual sequence and the predicted sequence is shown in Figure 7-5. In that Figure, provinces which constructed the first lines of a BTO project in 1993 are located on the horizontal axis at one. The provinces which had the first BTO lines in later years are located on the horizontal axis at zero. It is found that at the actual value of 1, the predicted values lie almost entirely between 0.5 and one. A high probability means that provinces in which the BTO lines were installed in the first year in the actual plan were given a high priority. In turn, at the actual value of zero, the predicted values lie between 0 and 0.6. The presence of a low probability means provinces in which the BTO lines were installed in later years in the actual plan were given a low priority. Such a result can be interpreted to mean that the explanatory

[86] For more details, see Gujarati (1995).

variables in equation 7.4.3 can be used to shed light on the priority of line installation in the BTO projects quite satisfactorily.

Consider Figure 7-5 again. One scatter point which is located on the horizontal axis at the value one has a probability value close to zero. This point represents Roi-Et province which is one of the provinces in the North East region (TT&T, 1994a). It is interesting that this province is neither the location of industrial estates nor a focus for tourism promotion in 1993 (http://www.boi.go.th/business/g11.htm and Ministry of Interior, 1993). It also has a comparatively short waiting list (TOT, 1992b). Even so, the first BTO lines were also installed in this province in 1993 (RDI, 1993). This is probably because there was a local re-election in 1993 (Ministry of Interior, 1993) and a number of BTO lines therefore were presumably installed in 1993 for this purpose. However, because this is relevant to political issues which are beyond the scope of this study, this issue is suggested for further study.

In addition, four scatter points which are located on the horizontal axis at the value of zero have high probabilities $(0.7 < p < 0.4)$. These provinces are Sukothai, Singha Buri, Ubon Ratchathani and Chumphon. The appearance of high probabilities in these provinces probably arises from their plans to promote themselves as industrial provinces or tourism provinces in later years (http://www.boi.go.th/business/g13.htm and TAT, 1995). As a result, although the first BTO lines were not installed in 1993 in these provinces they were ranked by the estimated equation among the high priorities compared with other provinces. Because this is beyond the study period defined here, this is another issue suggested for further study.

7.6 CONCLUSION

In 1994 there were 71 provincial areas in Thailand. Every province could not install BTO lines in the same year, in particular in the first year. This implies that there should be some factors that systematically determined the order of line installation. The aim of this chapter was to investigate some of those factors.

Two models (consumer demand and economic and social development) were examined to see which factors are significant in determining the priority of line installation. A logit function was applied in the assessment.

To investigate the significance of the consumer demand and economic and social development plan factors, five proxies (the length of waiting lists, GDP per capita, the growth rate of GDP, teledensity and the location of industrial or tourism zones) were included in the logit model.

The assessment in this chapter provides a number of interesting findings and some policy implications.

First, the length of waiting lists and the location of industrial or tourism zones are significant determinants of the probability of new line installation. This indicates that influences from both consumer demand for fixed-lines, indicated by the length of waiting lists, and criteria from the economic and social development plan, indicated by the location of industrial or tourism provinces, were important determinants of the order of line installation in the BTO projects.

Second, the provinces which are neither industrial nor tourism zones have lower probabilities to have BTO lines installed compared with industrial or tourism provinces. This means that the benefits of BTO projects are not distributed over the population.

Consequently, this might lead to a problem of income distribution among provinces. However, this issue is beyond the scope of this study.

Third, the growth rate of GDP was apparently not considered by the Government when determining the sequence of line installation in the BTO projects. As discussed earlier, provinces which have a low growth rate presumably require more fixed-lines so lack of consideration by the Government of this variable may lead to a problem of insufficient infrastructure in those provinces. Therefore, although the growth rate of GDP is statistically insignificant in the estimated equation, it should still be considered in ordering the sequence of line installations when the next telecommunications investment projects are introduced.

Fourth, the lack of significance in GDP per capita and teledensity indicates that the provinces which are less developed (low GDP per capita and teledensity) were not given the same significance (by the Government) as the provinces of the industrial or tourism zones. Omission of these variables in the ranking of line installation implies that the aim to improve wealth in terms of increasing GDP per capita and the ratio of teledensity in less developed provinces is unlikely to be achieved. This suggests that although GDP per capita and teledensity are statistically insignificant, in order to reach the goals stated in the NESD plan these variables should also be included in ranking the priority of line installations when there are new telecommunications investment programs.

So far we have discussed the impact of BTO regimes in terms of cost savings (discussed in Chapter 6) and the factors influencing the priority of line installation in provincial areas. However, the impact on welfare effects of the introduction of BTO regimes, which is one of the objectives of this thesis, has not yet been discussed. This will be evaluated in the next chapter.

TABLE 7-3

Factors Determine the Priority of Investment in PA

Model 1: Estimated Equation - Full Model

Variables	B	Standard Error	Significance
Constant	-5.1762	2.4135	.0320
$WAITL_i$	.0003	.0002	.0644
BUS_i	5.0895	1.4869	.0006
POP_i	-.0748	.0600	.2127
GDP_i	.00003	.00004	.4595
$GROWTH_i$	-.0630	.3384	.8522

Model 2: Final Estimated Equation

Variables	B	Standard Error	Significance
Constant	-5.3618	1.6837	0.0014
$WAITL_i$	0.0002	0.0001	0.0335
BUS_i	4.8840	1.3719	0.0004

TABLE 7-4

The Probability of Selected Provinces

Province	P_i	Province	P_i
Aug Thong	0.009	Lamphun	0.759
Ayutthaya	0.092	Loei	0.476
Buri Rum	0.005	Lop Buri	0.803
Chachengsao	0.959	Mae Hang Son	0.006
Chai Nat	0.006	Maha Sarakham	0.005
Chaiyaphum	0.006	Mukdahan	0.005
Chantaburi	0.874	Nakhon Nayok	0.007
Chiang Mai	0.999	Nakhon Pathom	0.319
Chiang Rai	0.921	Nakhon Phanom	0.005
Chon Buri	0.999	Nakhon Ratchasima	0.908
Chumphon	0.544	Nakhon Sawan	0.013
Kalasin	0.005	Nakhon Si-Thammarat	0.780
Kanchanaburi	0.655	Nan	0.007
Khamphaeng Phet	0.006	Narathiwat	0.005
Khon Ken	0.671	Nong Khai	0.557
Krabi	0.006	Pattani	0.009
Lam Pang	0.859	Phangnga	0.005

TABLE 7-4

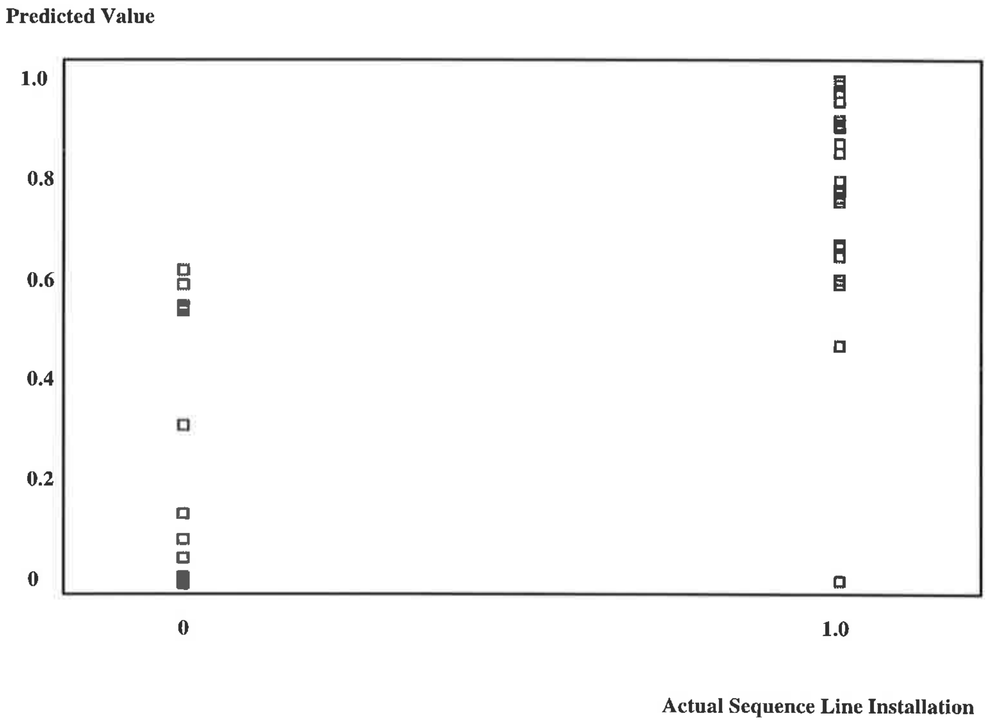
The Probability of Selected Provinces (cont)

Province	P_i	Province	P_i
Phatthalung	0.006	Satun	0.005
Phayao	0.009	Si Sa Ket	0.005
Phetchabun	0.007	Singha Buri	0.598
Phetchaburi	0.782	Songkhla	0.979
Phichit	0.007	Sukothai	0.624
Phitsanulok	0.768	Suphan Buri	0.019
Phrae	0.599	Surathani	0.054
Phuket	0.991	Surin	0.005
Prachin Buri	0.675	Tak	0.009
Prachuap	0.056	Trang	0.599
Ranong	0.607	Trat	0.009
Ratchaburi	0.091	Ubon Ratchathani	0.555
Rayong	0.993	Udon Thani	0.016
Roi Et	0.007	Uthai Thani	0.005
Sakon Nakhon	0.005	Uttaradit	0.007
Samut Sakhon	0.143	Yala	0.552
Samut Songkharm	0.008	Yasothon	0.005
Saraburi	0.910		

FIGURE 7-5

The Relationship between

the Actual Plan of Line Installation and the Predicted Value



Note: 1 for provinces with exchanges constructed under BTO regimes in 1993, and 0 otherwise

CHAPTER 8

THE IMPACT OF REGULATORY REFORM ON SOCIAL WELFARE

8.1 INTRODUCTION

So far the question of whether build-transfer-operate (BTO) regimes are justified has been evaluated in terms of production cost alone (as presented in Chapter 6). The effects of the introduction of BTO arrangements in terms of welfare effects have not yet been studied. This is the focus of this chapter.

As discussed in Chapter 3, the Telephone Organisation of Thailand (TOT) could not supply enough telephone lines to meet market demand at the going price. As a result, BTO regimes have been introduced in the fixed-line industry to overcome a supply shortage. It is interesting to investigate the welfare effects of BTO regimes.

Conceptually, the presence of demand for lines in the market reveals only the marginal private benefits or the benefits that subscribers receive from joining the network (Wenders, 1987).[87,88] In a telephone system, installation of new lines will not

[87] Marginal private benefits refer to the benefits received by subscribers themselves (Varian, 1987).

[88] In this chapter, this demand curve is called an apparent demand.

provide benefits only to new subscribers but also increase the benefits accruing to existing subscribers (Saunders, 1983 and Capello, 1996).[89] The benefits to third parties are called externalities.[90] In telecommunications, such benefits are called network externalities.

Network externalities can be separated into two sources: subscriber and call externalities (Hayashi,1992). Subscriber externalities arise when new subscribers connect to the system. The connection of new subscribers provides a benefit to other existing telephone users because the number of telephones that can be reached is increased (Griffin, 1982 and Hayashi, 1992).

Call externalities arise from two sources. First, they arise when there exist completed phone calls because the successful telephone calls require the participation of a second party, and the utility of this party is accordingly affected. However, whether the second party can gain benefit from receiving phone calls is another issue (Taylor, 1980). Second, call externalities arise from the fact that the benefits of telephones are not only generated from completed calls, but also from calls that may not be made (Taylor, 1980). That is, when a consumer decides to be a subscriber to the telephone

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[89] One might question that there might exist negative externalities if there are too many subscribers in the telephone system. However, the presence of people on the waiting lists implies that the number of subscribers is not too large. More importantly, it was found in Chapter 6 that the number of calls existing in recent years does not have any effect on the average cost of each new line. With respect to Moe's principle (1923 cited in Littlechild, 1979), this indicates that the volume of traffic is not serious enough to cause the problem of traffic congestion, which is one source of negative externalities. Therefore, it is possible to assume that the presence of externalities in the Thai telephone system is, on balance, positive.

[90] Externalities refer to costs or benefits of market transactions which are not reflected in market prices (Hyman, 1986). The externalities arise when an external person to a transaction is directly affected either positively or negatively (Capello, 1996).

system he, in effect, purchases options to make and receive calls even when the phone calls have not yet been made.

For the above reasons, the total welfare effects must be obtained from the use of a demand curve which reveals not only the marginal private benefits but which also reveals the value of externalities.[91] Consequently, the estimation of welfare effects from the apparent demand curve will underestimate the true value. The second task of this chapter, therefore, will be to estimate the total welfare effects which include the presence of network externalities.

This chapter consists of five sections. The discussion of the sources of data is presented in section 8.2. Section 8.3 defines the set of variables used. Sections 8.4 and 8.5 evaluate the welfare effects of the introduction of BTO regimes. Concluding remarks are presented in Section 8.6.

8.2 SOURCES OF DATA

Because the installation of 4.1 million new BTO lines was finished in 1996 (TA, 1996 and TT&T, 1996), the impact of BTO regimes on welfare in this year is highlighted.

The data employed in this chapter were collected from the following sources. The number of fixed-lines available is gathered from the Telephone Statistic Report, published by the TOT and the annual report of TelecomAsia (TA) and of Thai Telephone and Telecommunication (TT&T). The price of access is reported in the

[91] The sum of the marginal private benefit and the value of network externalities is called marginal social benefit. In this chapter, the demand curve which reveals the marginal social benefits will be called the real demand.

Prospectus of Newly Issued Ordinary Shares published by TT&T. The demand function for fixed-lines was estimated by the Thailand Development Research Institute (TDRI, 1997a).

8.3 DEFINITION OF VARIABLES

8.3.1 The Value of Externalities

In what follows, I will analyse the welfare effects of policy changes in the market for telecommunications. This market will be defined in terms of the supply of, and demand for, lines. This specification raises the question of the treatment of externalities. As explained earlier, holding other things constant, network externalities will arise from an increase in the number of lines[92] and an increase in the number of completed calls.[93] Under these circumstances the total welfare effects are the sum of the externalities arising from those two sources. However, the treatment of externalities discussed in this chapter will focus only on the existence of externalities that arises from increasing BTO lines, so those associated with completed calls are excluded. This is because the introduction of BTO regimes as discussed in Chapter 3 has a direct impact

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[92] With respect to Taylor (1980), when there is an increase in the number of new lines, the value of network externalities (both subscriber and call externalities) is present. Subscriber externalities arise from an increase in the number of new lines in the telephone system, and call externalities arise from an increase in the opportunity to be connected.

[93] An increase in the number of completed calls has impact on the presence of call externalities (for more details, see Taylor, 1980).

only on the number of fixed-lines, while an increase in the number of completed calls depends on several factors.[94] Therefore, incorporating externalities arising from completed calls into the analysis in this chapter is likely to obtain biased results. For this reason, the analysis of the impact of BTO regimes in this chapter will consider only the externalities arising from an increase in the number of new lines.

Capello (1996) noted that in a market where the number of subscribers is small, the marginal utility which existing subscribers get from new subscribers is large. The marginal utility is an increasing function, but at a decreasing marginal rate, of the number of subscribers. In other words, when the number of total subscribers is large, the size of network externalities grows more slowly.

The shape of the demand curve in the presence of externalities as discussed above is illustrated in Figure 8-1. D_1D_2 is the apparent demand which reveals only the value of marginal private benefit, while D_3D_2 is the real demand which represents the value of marginal social benefit. The presence of externalities as discussed above has affected the shape of the real demand curve. That is, when there is a small number of

[94] Waverman (1974, cited in Taylor, 1980), Griffin (1982) and Imai (1994) found that the demand for calls varies according not only with the number of lines but also income, price and the number of calls in the previous period. More importantly, they found that changes in income and in the prices of calls have direct effects on an increase in the number of calls, while an increase in the number of lines has indirect effects on the number of calls. Thus, the number of calls in 1996 in Thai telecommunications is more likely to be determined not only by the increase in the number of BTO lines but also from other effects. During rapid economic growth in the Thai economy Gross Domestic Product (GDP) per capita increased dramatically and usage charges in real terms have been falling every year (Soonthonsiripong, 1997). This implies that the growth in the number of calls did not arise from the increase in the number of BTO lines alone. For this reason, the estimation of welfare effects which includes the value of externalities from calls is likely to provide an overestimated result.

subscribers or lines the value of marginal social benefit is large. In this case, the distance between the real and apparent demand is large. The distance between the real and apparent demand curve becomes smaller as the number of subscribers increases. The relative distance between these two demand curves represents the existence of externalities measured by e in this study. In other words, the value e is used as an indicator of the size of the externalities. This relative value is the ratio of marginal social benefit to marginal private benefit (Wenders, 1987).

Rohlfs (1979) noted that the value e in a telephone system lies between 1 and 2. The value 1 involves the situation in which there is an absence of externalities (the value of marginal social benefit equals marginal private benefit). In this case, the real demand curve is the same as the apparent demand curve. However, such a situation has been argued to be underestimated in the analysis of welfare effects of the use of telephones. This is because many studies, for example Saunders et al (1983), found that subscribers can gain benefits from the use of services by more than the amount that they pay for it. That is, subscribers not only incur benefits for themselves, but also increase the benefits of being connected to the system for other subscribers. Nevertheless, the value e=1 is still used in the analysis of welfare effects as a lower bound case in many studies, for example Rohlfs (1979) and Griffin (1982).

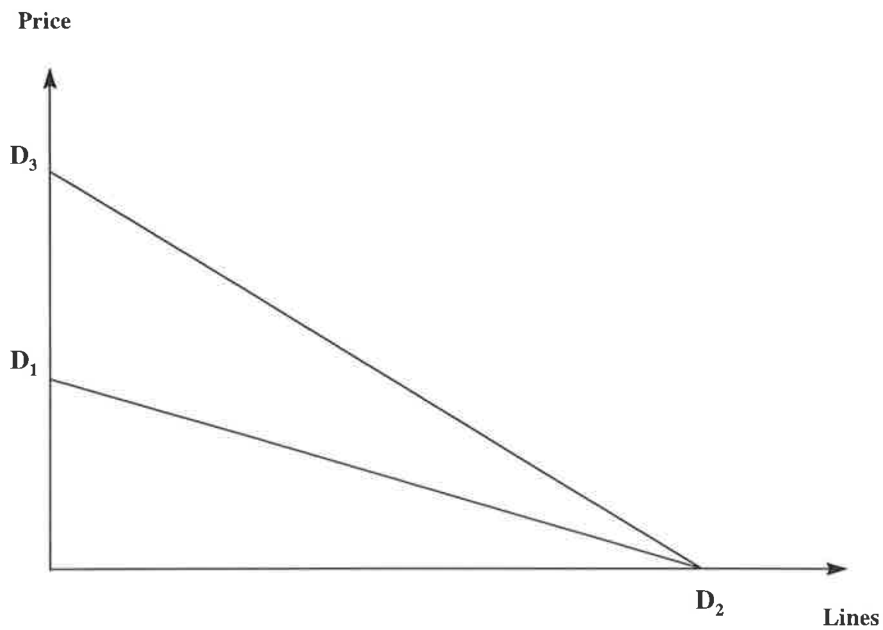
Griffin (1982) stated that at e =2, while new subscribers obtain the benefits from communications (making and receiving calls) with others (ie, friends, relatives or customers), at the same time other subscribers also gain the same benefits. That is, they have a greater opportunity to communicate and be communicated with by others. When the benefits of the communications are the same to both, it can be assumed that the value of marginal social benefit is twice the value of marginal private benefit (Griffin, 1982).

In some cases, there might exist unpleasant calls (ie, nuisance calls), which will lead to a decrease in the value of marginal social benefits. In this case, the value of e lies between 1 and 2. In many studies, for example in the study of Rohlfs (1979) and in the study of Griffin (1982), this situation is assumed to be represented by the value of e=1.5. Accordingly, the value of e=1, 1.5 and 2 has been frequently used in the welfare analysis of communications. For this reason, a range of e values 1, 1.5 and 2 is used to estimate the sensitivity of welfare effects in this study as well.

To apply the value of e in the empirical analysis, consider Figure 8-1 again. In the presence of externalities, the value of marginal social benefit is greater than the value of marginal private benefit. The real demand curve lies above the apparent demand curve. The slope of the real demand curve is equal to the slope of the apparent demand curve multiplied by the value of e. This is because, as mentioned earlier, e = the ratio of marginal social benefit to marginal private benefit. Suppose the slope of the apparent demand curve is equal to 1, then at e=2 the slope of the real demand curve will be equal to 2. In other words, at e=2 we know that the value of marginal social benefit is twice the value of marginal private benefit.

FIGURE 8-1

The Real Demand Curve



8.3.2 Marginal Cost

The marginal cost of fixed-lines can be derived from equation 6.5.3 in Chapter 6. For further discussion, recall equation 6.5.3:

$$\ln c_i = -3.170 - 0.113 D_i - 0.469 TECHNO_i$$

where c_i = the average capital cost per new line (million baht per line, base year 1987), D_i is a dummy variable for BTO lines and $TECHNO_i$ is a dummy variable for digital lines.

The above cost function can be interpreted as follows. The average cost per new line is subject to the type of technology (analogue or digital) and how the lines are installed (BTO or not BTO projects). The above equation indicates further that the average cost per new line does not vary with the number of lines installed. In other words, the marginal cost is constant. The marginal cost of analogue lines is equal to exp(-3.170)*1,000,000 = 42,004 baht per line.[95] The marginal cost of digital lines is equal to exp(-3.170-0.469)*1,000,000 = 26,279 baht per line. Because all BTO lines have been equipped with digital technologies, the marginal cost of BTO lines is equal to exp(-3.170-0.113-0.469)*1,000,000 = 23,471 baht per line.

However, the marginal cost of BTO lines estimated in this way cannot be used to analyse the impact of BTO regimes. This is because such a value includes the marginal cost of providing lines (the cost of connecting lines from the local telephone exchange to end users) and the marginal cost of providing services (calls). While the

[95] Because new lines installed in recent years have been equipped with digital technology, the discussion in this chapter will focus on digital lines only.

analysis of welfare effects in this chapter is focused on the presence of externalities arising from providing lines alone, as discussed in the previous section, biased results can be expected if the value of marginal cost of BTO lines discussed above is used in the analysis. As a result, we must subtract the marginal cost of providing services from the marginal cost of BTO lines to obtain the marginal cost of providing lines only.

The marginal cost of providing lines is called 'the cost of access network' or CAN in Albon et al (1997). CAN includes the costs of network cables laid between local telephone exchanges and end users, depreciation[96] and maintenance expenses (Albon, et al, 1997).[97,98] In the Thai telephone system, the marginal cost of providing services is approximately 70 per cent of the marginal cost (RDI, 1993). So this indicates that CAN is approximately 30 per cent of total cost of the whole network. As a result, the marginal cost of CAN is equal to 30 per cent of the marginal cost. Therefore, the marginal cost of CAN for digital lines (non BTO projects) is equal to 7,883.70 baht per line,[99] and of BTO lines is equal to 7,041.30 baht per line.[100]

The marginal cost of CAN is the lump sum amount of capital expenditure incurred at the initial period of investment. In the local telephone system, the

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[96] In personal communications between the author and TOT's engineers, the useful life of cables is infinite. Therefore, depreciation expense is equal to zero.

[97] Albon suggests that the CAN does not depend on the cost of switching equipment in the local telephone exchanges since those costs are related to the cost of providing phone calls (personal communications).

[98] Because maintenance expenditure is different from one year to another (in some years that had a big flood maintenance expenditure was higher than others) (TOT, 1995b), the average value of maintenance expenditure between 1991 and 1995 therefore is used here in the estimation of the value of CAN.

[99] 7, 883.70 is equal to 26,279 multiplied by 0.30.

[100] 7,041.30 is equal to 23,471 multiplied by 0.30.

subscription fee is charged on a monthly basis. For this reason, to analyse the impact of welfare effects and to compare between the costs and revenues of providing lines, the marginal cost of CAN is converted to an annual basis by applying a constant discount rate at 12 per cent.[101] Because the useful life of cables is infinite, the discounted value of CAN is computed from multiplying the present value of CAN by the discount rate. Thus, the discounted value of CAN for digital lines is 946.04 baht per line per year,[102] and for BTO lines is 844.96 baht per line per year.[103]

The value of CAN discussed above represents the marginal cost of accessing the network annually. Therefore, the discounted value of CAN must be divided by 12 to obtain a monthly rate. It is found that the value of the marginal cost of accessing the network is approximately 78.84 baht per line per month for digital lines or MC_1 in Figure 8-2,[104] and 70.41 baht per line per month for BTO lines or MC_2.[105]

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[101] This is the interest rate at which the streams of cash inflows and outflows associated with an investment project are to be discounted. A rate of 12 per cent, which is the private sector interest borrowing rate, is commonly used as a base discount rate in appraising investment projects both in the public and private sector in Thailand, for example by the M Group and Bank for Agriculture and Agricultural Cooperatives (for more details, see M Group, 1996).

[102] 946.04 is equal to 7,883.7 multiplied by 0.12.

[103] 844.96 is equal to 7,041.30 multiplied by 0.12.

[104] 78.84 is equal to 946.04 divided by 12.

[105] 70.41 is equal to 844.96 divided by 12.

8.3.3 Price Elasticity of Demand for Fixed-Lines

Although the demand for access is one of the important issues in the study of telecommunications economics, this topic has not received much empirical attention, in particular in developing countries. In Thailand, so far I have found only three studies - TDRI (1997a), M Group (1996) and TOT (1993a) - that contain estimates of the equations for the demand for access. The findings of TDRI (1997a) are used here for the following reasons.

The first reason is that there is a large number of degrees of freedom in the study of TDRI compared with other studies (M Group and TOT). In the study of TDRI a time series data set of 24 observations was tested, using a translog demand function, while only 9 observations were investigated in the study of M Group, and there is no discussion about the number of observations in the TOT's study. Higher degrees of freedom enable us to use the estimated results of TDRI with more confidence.

Secondly, the TDRI model appears to be reasonably well specified since there is no evidence of positive first-order serial correlation in the findings of TDRI, while there is inconclusive evidence regarding the presence or the absence of positive first-order serial correlation in the study of M Group, and there are no statistical tests to detect autocorrelation in the study of TOT. In the study of TDRI, the Durbin-Watson d statistic is used to detect the presence of autocorrelation. TDRI found that the lower and upper limits for $n = 21$ and $k = 3$ of the estimated value of Durbin-Watson (d) at a 0.05 level of significance are 1.026 and 1.669. It is found in the study of TDRI that the computed d value is 1.673, which means that hypothesis of the presence of positive first-order serial correlation can be rejected. M Group found that the lower and upper limits for $n = 8$ and $k = 1$ of the estimated value of Durbin-Watson (d) at a 0.05 level of significance are

0.763 and 1.332. The computed *d* value was 1.112 which means it is not clear whether autocorrelation exists in the findings of M Group.

The third reason is that the estimated results reported by TDRI (1997a) are more plausible. TDRI (1997a) reported that price elasticity for fixed-lines is around 1 while it is 1.98 in M Group study. When compared with the findings of other studies, for example Korea Telecom who estimated the price elasticity of the telephone industry in Indonesia and found that the price elasticity in Indonesia is 0.65 (M Group, 1996), the finding of M Group is likely overestimated. For this reason, the findings of TDRI (1997a) seem the more plausible to be used in this study.

Because the elasticity of demand estimated by TDRI is around 1, the elasticity of demand used in this chapter will be assumed to be equal to 1 over the range between quantity supplied (Q_{bto}) and the optimal demand (Q_{MC2} in Figure 8-3).

8.3.4 Willingness to Pay

At the going price (the access charge in real terms, base year 1987 = 85.63 baht per line per month), the quantity demanded of fixed-lines is equal to 7.53 million lines or Q_d in Figure 8-2.[106,107] In 1996, TOT could supply 2.61 million lines represented by S_1 or Q_{tot} in Figure 8-2 (TOT, 1996). TA and TT&T were granted concessions to build up to 4.1 million lines for the whole nation (TA, 1996 and TT&T, 1996). The aggregate supply after the introduction of BTO regimes therefore is equal to the sum of the production of TOT and of the private firms which is equal to 6.71 or S_2 in Figure 8-2.

[106] This price is determined by the State (for more details, see Chapter 3).

[107] Qd is equal to the sum of the number of lines available (6.71 million lines) and the number of people in waiting lists (0.82 million lines).

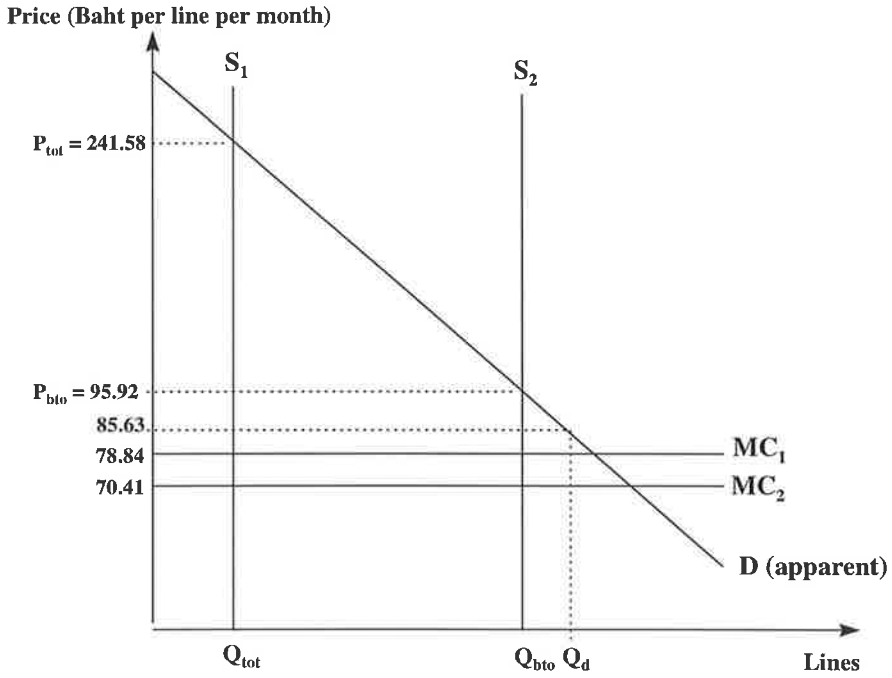
As we see in Figure 8-2, without price determination by the State, the value of marginal willingness to pay would vary according to the number of lines supplied in the market. That is, at the total production of 2.61 million lines or Q_{tot}, the value of marginal willingness to pay is P_{tot}. The value of marginal willingness to pay decreases when there are more lines in the market. Therefore at Q_{bto} the marginal willingness to pay is equal to P_{bto}.

Because there might be large changes in the demand for lines when there is a change in price, the use of point elasticity of demand to calculate the value of P_{tot} is likely to provide biased results (Mansfield, 1994). This is because the results may vary considerably depending on which value of P and Q is used in the calculation. Suppose that we want to estimate the value of P_1 as $Q_1 = 20$. Suppose further that at $P_2 = 5$, Q_2 is 3, and the demand elasticity is 3.40. Using the point elasticity of demand, we will get two values of P_1. That is, $P_1 = 3.33$ when $3.40 = -\frac{20-3}{3} \div \frac{P_1 - 5}{5}$. And $P_1 = 1.875$ when $3.40 = -\frac{3-20}{20} \div \frac{5-P_1}{P_1}$. To avoid this inconsistency, the arc elasticity formula is used in the computation for the marginal willingness to pay (for more details, see Mansfield, 1994).

The estimation process of the value of willingness to pay is as follows. At the going price (85.63 baht per line per month), Q_d in Figure 8-2 is equal to 7.53 million lines. By using the value of demand elasticity estimated by TDRI (1997a), and by putting Q_d, Q_{tot} and the going price into the arc elasticity formula, we can estimate for the value of willingness to pay (P_{tot}). That is, from the arc elasticity formula, $1 = -\frac{(7.53-2.61)}{(7.53+2.61)/2} \div \frac{(85.63 - P_{tot})}{(85.63 + P_{tot})/2}$, then we can obtain the value of P_{tot}, which is approximately 241.58 baht per line per month. The same method is also used to compute the value of willingness to pay (P_{bto}). That is, from the arc elasticity formula, $1 = -\frac{(7.53-6.71)}{(7.53+6.71)/2} \div \frac{(85.63-P_{bto})}{(85.63+P_{bto})/2}$, then we can obtain the value of P_{bto}, which is approximately 95.92 baht per line per month.

FIGURE 8-2

The Value of Marginal Cost and the Value of Willingness to Pay



8.4 THE PRESENCE OF WELFARE GAINS

As illustrated in Figure 8-3, MC_2 represents the marginal cost of BTO lines. Without price and quantity control by the State the optimal demand for lines in the unregulated market is point w. As mentioned in the early chapter, the aggregate supply in 1996 was approximately 6.71 million lines or Q_{bto} in Figure 8-3. TOT alone could supply only 2.61 million lines or Q_{tot}, this indicates that although BTO arrangements cannot supply at the optimal demand, they at least reduce the size of the supply shortage.[108] This implies further that BTO regimes provide welfare gains to society. The magnitude of welfare gains under the absence of externalities is equal to the area *mnuv* in Figure 8-3.

Before proceeding to the discussion of the empirical results of the magnitude of social gains, the sources of gains (the area *mnuv*) will be discussed here. The econometric results in Chapter 6 tell us that BTO operators do not gain cost savings only from the adoption of digital technology but they also achieve a significant saving in investment in BTO projects. It is found in the previous section that the MC of BTO lines (MC_2) is lower than the MC of non BTO lines (MC_1).[109] This indicates that society, in particular the operators, can gain additional benefits from BTO arrangements. The magnitude of gains from BTO projects is equal to the difference between MC_1 and MC_2 times the number of BTO lines, which is equal to the area *opuv* in Figure 8-3. Consequently, the maximum magnitude of welfare gains from the introduction of BTO regimes under the absence of externalities (the area *mnuv*) consists

[108] Because the access charge has been priced above MC, this implies that more lines would be required when there is a reduction in the access charge towards MC.

[109] In recent years all lines have been equipped with digital technologies. The analysis of welfare gains in this section will focus only on the cost and benefit of digital lines between BTO and non BTO lines.

of the gains to producers (the area *opuv*) and the gains to consumers (the area *mnop*) in Figure 8-3.

Holding other things constant, the magnitude of social gains from the introduction of BTO regimes in real terms (base year 1987) is approximately 403.19 million baht per month.[110] This value consists of the gains from the area *mnop* which is equal to 368.63 million baht per month[111] and the gains from cost savings in BTO projects (the area *opuv*) which is equal to 34.56 million baht per month.[112] As a result, the gain distributed to each subscriber is equal to 60.09 baht per line per month.[113] This indicates clearly that an increase in the number of lines provides benefits to existing subscribers.

Next consider the sensitivity of social gains to externalities. As discussed earlier, the estimation of welfare effects from the apparent demand reflects only the value of marginal private benefit. To obtain the total welfare effects, which include the presence of externalities, we must estimate their value from the real demand curve. Consequently, the magnitude of welfare gains is not only the areas *mnuv* as discussed above, but it also includes the value of externalities which is equal to the area *rsmn* in Figure 8-3. As a result, the total welfare gains are equal to the area *rsuv*.

Table 8-1 reports the sensitivity of welfare gains from the introduction of BTO regimes to externalities (over the range of e=1, 1.5 and 2). The presence of externalities increases as the ratio of marginal social benefit to marginal private benefit or e

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110 403.19 million is equal to ((241.58-95.92)*0.5*4,100,000)+((95.92-70.41)*4,100,000).

111 368.63 million is equal to ((241.58-95.92)*0.5*4,100,000)+((95.92-78.84)*4,100,000).

112 34.56 million is equal to (78.84-70.41)*4,100,000.

113 60.09 is equal to 403.19 divided by 6.71.

increases. That is, at e=1.5, the social gains are equal to 749.13 million baht per month,[114] and the social gains increase to 1,095.07 million bath per month when e=2.[115] This can be interpreted to mean that the size of social gains is larger as the number of lines increases.

To see the significance of the contribution of BTO regimes, the magnitude of welfare gains, as presented in Table 8-1, is further compared with the investment cost of 4.1 million BTO lines. The cost of investment for 4.1 million lines is equal to the marginal cost multiplied by the number of lines.[116] It is found that in the absence of externalities or e=1 the ratio of welfare gains to the cost of investment is approximately 39.67 per cent.[117] The ratio of welfare gains to the cost of investment increases significantly when the contribution of telephone services increases the benefits to

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[114] The total welfare gains are equal to the area *rsuv*, which consists of the gains in the areas *rsmn* and *mnuv*. To compute the area *rsmn*, we must estimate the value of points r and s. At e=1.5, point r is equal to 241.58 times 1.5, which is equal to 362.37, and point s is equal to 95.92 times 1.5, which is equal to 143.88. With respect to the trapezium formula (Marlin, 1998), the area *rsmn* is $\left(\left((362.37-241.58)+(143.88-95.92)\right)*4{,}100{,}00*0.5\right)$, which is equal to 345.94. As a result, the value of *rsuv* = 403.19 (the area *mnuv*) + 345.94 (the area *rsmn*), which is equal to 749.13 million baht per month.

[115] The same method as discussed previously is used here to estimate the value of social gains (the area *rsuv*). Therefore, point r is equal to 241.58 times 2, or 483.16, and point s is equal to 95.92 times 2, which is equal to 191.84. The value of area *rsmn* is equal to $\left(\left((483.16-241.58)+(191.84-95.92)\right)*4{,}100{,}000*0.5\right)$, which is equal to 691.88. As a result, the total gains (the area *rsuv*) at e=2 are equal to 403.19 (the area *mnuv*) + 691.88 (the area *rsmn*), which is equal to 1,095.07 million baht per month.

[116] The total investment cost is equal to 70.41 multiplied by 4.1 million = 288.681 million Baht per month

[117] 39.67 per cent is equal to $\left((403.19-288.681)\div 288.681\right)*100$.

society. That is, at e=1.5, the ratio of welfare gains to the cost of investment increases from 39.67 per cent to 159.50 per cent.[118] This ratio is approximately 7 times (from 39.67 to 279.34 per cent)[119] when the contribution of telephone service provides benefits at the same amount to both the caller and receiver or at e=2. This indicates that having more lines in the telephone system contributes a great significant social gain.

The above results can be applied to shed light on the presence of welfare gains in provincial areas. It was found in Chapter 7 that the probability of having BTO lines installed in industrial or tourism provinces (0.6935) is higher than other provinces (0.0168). This means that more BTO lines are installed in industrial or tourism provinces, which in turn means that the benefits of BTO projects are not distributed evenly over the population. This implies that the industrial or tourism provinces are likely to achieve a larger share of the welfare gains than other provinces.

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[118] 159.50 per cent is equal to $\left((749.13-288.681)\div 288.681\right)*100$.

[119] 279.34 per cent is equal to $\left((1{,}095.07-288.681)\div 288.681\right)*100$.

FIGURE 8-3

The Impact of BTO Regimes

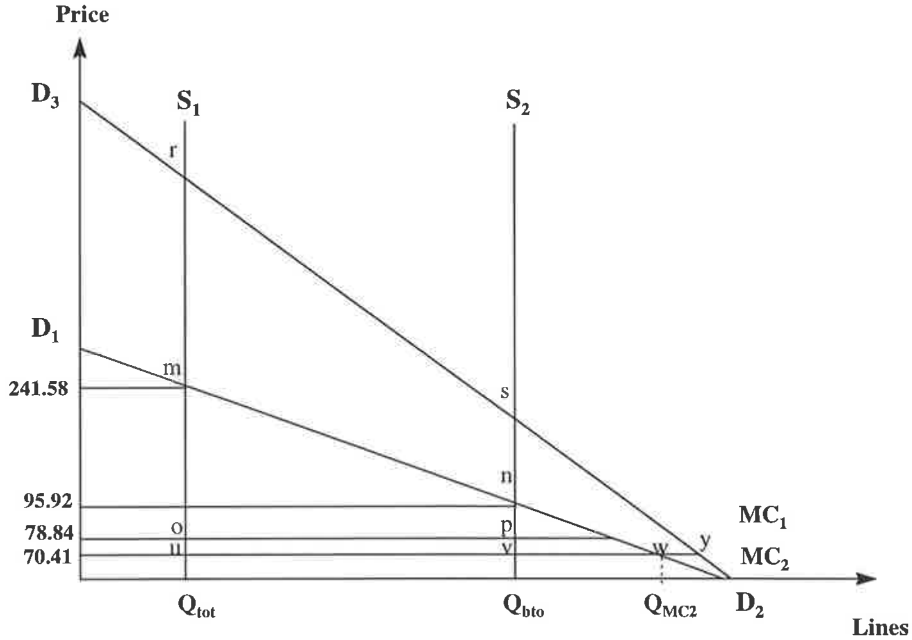

TABLE 8-1

Welfare Gains from BTO Regimes

The Value of Externalities	Gains from BTO Lines (million baht per month) (base year 1987)	Gains from Cost Savings (million baht per month) (base year 1987)	Total Gains (million baht per month) (base year 1987)
$e=1$	368.63	34.56	403.19
$e=1.5$	714.57	34.56	749.13
$e=2$	1,060.51	34.56	1,095.07

8.5 THE AMOUNT OF THE REMAINING WELFARE LOSS

Recall Figure 8-3 again. Without any constraints (ie, price and quantity determination), after the introduction of BTO regimes there still exists excess demand (at an access price equal to marginal cost) equal to the difference between Q_{bto} and Q_{MC2}. This tells us that if there is no further expansion in the number of lines there will occur a deadweight loss in society. In this case, the magnitude of the deadweight loss is equal to *nwv* in Figure 8-3.

To estimate the value of deadweight loss for the area *nwv* we must identify the optimum number of fixed-lines (point w). The value of w, which reflects the quantity demanded at marginal cost (MC_2) theoretically, can be estimated from the elasticity of the demand curve estimated by TDRI (1997a). It is found that the value of Q_{MC2} is equal to 8.49 million lines.[120] Holding other things constant, it is found that the magnitude of deadweight loss in real terms (base year 1987) is equal to 22.70 million baht per month.[121]

To estimate the size of deadweight loss in the presence of externalities the values of e=1, 1.5 and 2 are used again. The magnitude of welfare loss in the presence

[120] The quantity demanded at the optimal level can be estimated by using the value of elasticity of demand. As discussed previously, the elasticity of demand in this study is assumed equal to 1 over the range between Q_{bto} and Q_{MC2}. Under the absence of externalities, the quantity demanded (8.49 million) is the solution of the change in quantities (Q_{MC2} - 6.71 million) divided by change in prices (95.92-70.41), and multiplied by the ratio of price over quantity (95.92 divided by 6.71 million), equal to one.

[121] 22.70 million is equal to ((0.5*(95.92-70.41)*(8.49-6.71 million)).

of externalities is equal to the area *svy* in Figure 8-3.[122] This area reflects the value of deadweight loss discussed above (*nwv*) and the value of externalities (*snwy*). Table 8-2 reports the sensitivity of deadweight loss from a supply shortage to externalities after the introduction of BTO regimes. It is found that the size of welfare loss is larger as the ratio of marginal social benefit to marginal private benefit is larger or the value of *e* increases. That is, at *e*=1.5, the magnitude of deadweight loss is equal to 126 million bath per month,[123] and increases to 258.04 million baht per month when *e*=2.[124]

In the absence of externalities, the ratio of the remaining deadweight loss to social gains already obtained from BTO projects is relatively small. That is, the ratio of deadweight loss to social gains is only 5.63 per cent.[125] However, as discussed in the

[122] Because the slope of the real demand curve is equal to the slope of the apparent demand curve multiplied by the value of *e*, therefore the quantity demanded at y in Figure 8-3 can be computed by using the value of the adjusted marginal cost. That is, when we put the value of marginal cost, which is divided by the value of *e*, into the formula of elasticity of demand we can obtain the quantity demanded (y) in Figure 8-3. At *e*=2, the quantity demanded (y), which is equal to the solution of the change in quantity divided by the change in prices (70.41 divided by 2, and minus 95.92), and then multiplied by the ratio of price over quantity, is equal to 10.96 million lines, equal to one. Using the same method, we can estimate the quantity demanded at *e*=1.5. That is, the value of y at *e*=1.5 is equal to the solution of the change in quantity divided by change in price (70.41 divided by 1.5, and minus 95.92), and then multiplied the ratio of price over quantity, equal to one. It is found that the value of y at *e*=1.5 is equal to 10.14 million lines.

[123] As discussed previously, when *e*=1.5 the value of point s in Figure 8-3 is equal to 95.92 times 1.5, or 143.88. Therefore, the magnitude of deadweight loss (the area svy) is equal to 0.5*(10.14-6.71)*(143.88-70.41), or 126.

[124] At *e*=2, the value of point s in Figure 8-3 is equal to 95.92 times 2, or 191.84. Thus, the magnitude of deadweight loss (the area *svy*) is equal to 0.5*(10.96-6.71)*(191.84-70.41), or 258.04.

[125] 5.63 per cent is equal to 22.70 divided by 403.19 (from Table 8-1) and multiplied by 100.

previous section, the situation when e=1 (in the absence of externalities) is a lower bound case for the estimation of the effects of BTO regimes. When e=2, the ratio of the remaining deadweight loss to the gains from the BTO reform is greater. That is, the ratio increases to 23.56 per cent.[126] This shows that the remaining welfare loss to society is quite significant under more plausible values of e.

Alternatively, the size of deadweight loss as discussed above can be interpreted as the additional social gain if there is a line expansion project to meet the market demand. It is worthwhile to estimate the relationship between cost and benefit if such a project is introduced. In this case, the investment cost is equal to an increase in lines from Q_{bto} to Q_{MC2} in Figure 8-3 multiplied by the marginal cost obtained in the previous section. It is found that the cost of having additional lines is equal to 125.33 million baht per month,[127] while the incremental social gain at e=1 (the area *nwv* in Figure 8-3) is equal to 22.70 million baht per month. The ratio of additional social gain to total cost of the new lines is therefore 18.11 per cent.[128] As discussed earlier, the effects of having more lines (or more subscribers) in the telephone system should be considered in the situation where externalities are taken into account. For this reason, the comparison between costs and benefits considered at e=1 is likely to be underestimated. Thus, it is considered again at the value of e=2. In this case, while the incremental cost is still equal to 125.33 million baht per month, the incremental social gain from having more lines as presented in Table 8-2 is 258.04 million baht per month (the area *svy* in Figure

[126] 23.56 per cent is equal to 258.04 divided by 1,095.07 (from Table 8-1) and multiplied by 100.

[127] 125.33 is equal to 8.49 minus 6.71 and multiplied by 70.41.

[128] 18.11 per cent is equal to 22.70 divided by 125.33 and multiplied by 100.

8-3) or 205.89 per cent of total cost.[129] This indicates that increasing lines to the optimal level will bring about a great significant increase in social gain to society. This suggests that the projects to expand lines to meet the market demand at marginal cost should be considered.

Another feature of these results is that social gains from the reform will not be distributed evenly in Thailand. As discussed in the previous section, the probability of early installation of BTO lines in industrial or tourism provinces is higher than in non industrial or tourism provinces. This implies that areas where lines remain to be installed are likely to be concentrated in non industrial or tourism provinces. As a result, this suggests that these parts of Thailand (non industrial or tourism zones) have a strong interest in future reform in order to have more lines installed.

[129] 205.89 per cent is equal to 258.04 divided by 125.33 and multiplied by 100.

TABLE 8-2

Remaining Welfare Loss after the BTO Projects

The Value of Externalities	Social Loss (million baht per month) (base year 1987)
e=1	22.70
e=1.5	126.00
e=2	258.04

8.6 CONCLUSION

In this chapter, the introduction of BTO regimes was examined for its impact on welfare effects. Reference was made to two issues:

(1) the impact on welfare of the introduction of BTO regimes, and

(2) the sensitivity of the analysis of welfare effects in the presence of externalities.

This chapter provides a number of interesting results which can be summarised as follows:

First, the introduction of BTO regimes provides social gains. In addition, BTO regimes provide not only cost savings adding to producer surplus but also add to consumer surplus.

Second, welfare gains increase as the value of externalities increases. In other words, the size of total welfare gains increases as the number of lines increases.

Third, the findings in this chapter can be applied to shed light on the magnitude of welfare gains arising in provincial areas. The econometric results in Chapter 7 tell us that BTO lines will be first installed in industrial or tourism provinces. This possibility implies that the magnitude of welfare gains in the industrial or tourism provinces is likely to be greater than those in other provinces. In turn, the larger size of deadweight loss is likely to be present in the non industrial or tourism provinces.

Fourth, BTO regimes are not capable of removing all the deadweight loss. This suggests that other policies to expand the number of fixed-lines, for example opening free entry, should be considered. However, before well-defined telecommunications policies can be developed, other key issues must be tackled. For example, whether there are other barriers to entry, and what is the impact of other forms of deregulation (ie, liberalisation and privatisation)? Discussions of these issues will be addressed in some detail in the final chapter.

CHAPTER 9

CONCLUSIONS AND SUGGESTIONS FOR FURTHER STUDY

9.1 CONCLUSIONS

9.1.1 BT Regimes and the Thai Constitution

A build-transfer (BT) regime is a structural reform to allow private firms to participate in a monopoly market. The aim of this strategy is to circumvent a supply shortage in providing public services. BT regimes have been modified into several forms, for example build-transfer-operate (BTO) or build-operate-transfer (BOT), to be appropriate for each country. However, all forms of BT regimes have the same theme. That is, the ownership of all assets constructed under BT arrangements must be transferred to the public sector.

Thailand has experienced rapid growth in its economy during the last two decades, and the demand for infrastructure, in particular telephone lines, has increased dramatically. Because of the weaknesses (lack of skilled labours inefficient management and tight budget constraint) of the Telephone Organisation of Thailand (TOT), TOT, a sole network and service provider for fixed-lines, could not supply sufficient lines to meet the quantities demanded. The participation of private firms was recognised as one of the methods to circumvent a supply shortage. Due to the Thai legislation, in particular The Telephone and Telegraph Act of 1934 and The TOT Act of 1954, liberalisation has not been possible in Thai telecommunications, because the right to install and to operate telephone networks has been reserved to state owned enterprises. To overcome this problem BTO arrangements were introduced in order to allow the entry of private firms.

Although private firms have been permitted to invest in telecommunications the market mechanism is still not working. There is still a single supplier in the telecommunications market, and prices and quantities are controlled by the State. For this reason, BTO arrangements are likely to represent illusory competition.

In the fixed-line market, TelecomAsia (TA) and the Thai Telephone and Telecommunications (TT&T) were granted a 25 year concession to expand networks. TA was permitted to provide and operate 2.6 million telephone lines in the Metropolitan Telecommunications Areas (MTA) in 1991, and TT&T was permitted to provide 1.5 million lines in provincial areas (PA) in the following year.

9.1.2 The Market Structure of Local Telephone Networks in Thailand

In this thesis a test for scale economies was applied to evaluate the structure of the fixed-line industry in Thailand, as well as to estimate the cost savings from BTO regimes. Applying this approach in a model of a single firm which produces a single product was proposed as a way of overcoming data problems. This approach is possible if outputs are measured in terms of equivalent units, for example the number of calls. Such a method renders a scope economies test unnecessary. A test for scale economies alone is sufficient to determine the structure of the fixed-line market.

In this thesis, the evaluation of the cost structure of the fixed-line market focused on seven issues:

(1) the structure of the market at the local telephone exchange level,

(2) the effect of BTO regimes on average capital cost per line,

(3) the effect of the number of new telephone lines in 1994 on the average capital cost per line,

(4) the effect of the volume of telephone traffic on the average capital cost of each new line,

(5) the difference between the average capital cost of each new line in the telephone system between big cities and rural and remote areas,

(6) the effect of changes in switch sizes on the average capital cost of each new line,

(7) the effect of switch types (analogue and digital) on the average capital cost of each new line.

To investigate all these issues, a translog cost function was derived from a combination of econometric and engineering concepts. Engineering concepts can help to explain the relationship between scale effects from telephone technologies and output characteristics. Dummy variables were applied to investigate the efficiency of BTO regimes, the effect of different locations of telephone exchanges, the effect of the use of different switch sizes, and the effect of different switching technologies on costs of new capacity.

Cross section data on 1,005 telephone exchanges were examined. The use of time series data was not suggested here as the results would likely be biased by the effects of technological development, in particular when technological change is rapid and large. Using cross section rather than time series data is more likely to provide more reliable and unbiased results.

A number of interesting findings were obtained.

First, other things being equal, operators gain cost savings not only from the adoption of digital switches but also from the introduction of BTO regimes.

Second, the relationship between the number of calls and the capital expenditure on telephone exchanges is insignificant. This can be interpreted to mean that the average capital cost of new lines does not vary with the number of calls.

Third, the average capital cost per line in the Bangkok Metropolitan Areas (BMA) is not different from that in the provincial areas (PA). This is probably because an operator in BMA gains some cost savings from transportation expenses (in the delivery of equipment) and the expenditure on duct work (to lay cables), to offset higher expenditure in other investment costs (ie, prices of land and buildings).

Fourth, the use of small switch sizes does not provide any cost savings as claimed by operators.

Finally, and most importantly, there exist constant returns to scale in terms of the number of lines in the fixed-line market, with respect to capital costs. This suggests that the fixed-line market at the level of local telephone exchanges is not likely to be a natural monopoly. The significance of this result is that although the question of whether the total telecommunications market is a natural monopoly cannot be finalised here, there do not appear to be economies in capital expenditure at the exchange level, which suggests that overall scale economies may not be important. Holding other things equal, when constant returns to scale are present the policy of opening free entry even at the level of local telephone exchanges should be considered.

9.1.3 The Factors Influencing the Priority of Line Installation in Provincial Areas

TT&T was granted a licence to install 1.5 million fixed-lines in provincial areas in 1992. There were 69 provinces in 1992, so new fixed-lines could not be installed in every province simultaneously. For this reason, this thesis also investigates the factors that influenced the priority of line installation in BTO projects.

Consumer demand and the economic and social development plan were tested for their influence on the sequence of line installation in provincial areas. To investigate these two factors, five proxies (the length of waiting lists, Gross Domestic Product (GDP) per capita, the growth rate of GDP, teledensity and industrial or tourism provinces) were included in the logit model. Cross section data of 69 provinces were investigated. There were two major findings.

First, the length of waiting lists and the existence of industrial or tourism zones were significant. This indicates that both consumer demand, measured in terms of the length of waiting lists, and the economic and social development plan, measured in terms of the location of industrial or tourism zones, are important factors influencing the order of line installation in the BTO projects.

Second, provinces which are neither industrial nor tourism zones have lower probabilities of having BTO lines installed, compared with industrial or tourism provinces.

9.1.4 The Impact of BTO Regimes on Social Welfare

An analysis of the impact of BTO regimes on welfare effects was also undertaken. The analysis of social welfare focused on two issues: the magnitude of the welfare effects of BTO regimes and a sensitivity analysis of the welfare effects in the presence of externalities. Several important results were found.

First, the introduction of BTO regimes provides gains to society. Holding other things constant, the magnitude of social gains from the introduction of BTO regimes in real terms (base year 1987) in the absence of externalities is approximately 403.19 million baht per month. When the value of externalities was taken into account, the contribution of telephone lines increases to 1,095.07 million baht per month.

Second, BTO regimes provide not only cost savings adding to producer surplus, but also add to consumer surplus. That is, the additional consumer surplus from an increase in 4.1 million lines is equal to 368.63 million baht per month, and the producer gains from cost savings in BTO projects is equal to 34.56 million baht per month.

Third, the remaining deadweight loss after the BTO reform can be interpreted as the additional social gain if there is a further line expansion project to meet the market demand at prices equal to marginal and average cost. It is found that in the absence of externalities there exist additional social gains of 22.70 million baht per month if such a project is introduced. The amount of social gains increases to 258.04 million baht per month when the value of externalities is also taken into account. This indicates that increasing lines to the optimal level will bring about a significant increase in social gain to society. This suggests that further reform to expand lines to meet the market demand at marginal cost should be considered.

9.1.5 Implications of the Study

The findings of this study suggest a number of interesting policy implications which can be summarised as follows.

First, the structure of the fixed-line market at the level of the local telephone exchanges is unlikely to be a natural monopoly. This suggests that if free entry into the whole telecommunications market is not introduced, a policy to encourage free entry, at least at the level of local telephone exchanges, should be considered. In addition, The Telegraph and Telephone Act of 1934 and The TOT Act of 1954 are important barriers to entry for new firms. The redefinition of this legislation to allow for free entry is recommended.

Second, the adoption of digital technology provides not only an efficiency gain in terms of cost savings, but also improves the quality of service and reduces the maintenance cost. For this reason, a policy to replace the existing analogue lines with digital technology should be considered.

Third, the growth rate of GDP was apparently not considered by the government in determining the order of line installation in provincial areas. Provinces which have a low growth rate require more fixed-lines to foster economic growth, so lack of consideration by the Government of this variable may lead to a problem of insufficient infrastructure in those provinces. It is suggested that this factor should be considered in ordering the sequence of line installations when the next telecommunications investment projects are introduced.

Fourth, GDP per capita and teledensity, which are two indicators identified in the National Economic and Social Development Plan, appear not to have been taken into account in determining the sequence of line installation in the BTO projects. While these variables are indicators of the level of economic and social development, lack of consideration of them implies that the aim to improve wealth in terms of increasing GDP per capita and the ratio of teledensity in less developed provinces is unlikely to be achieved. For this reason these variables should also be considered when ranking the priority of line installations when there are new telecommunications investment programs.

Fifth, although BTO regimes increase efficiency in terms of cost savings and other welfare gains, the presence of deadweight losses even after the introduction of BTO regimes implies that there may be alternatives which are preferable to BTO arrangements. Other types of deregulation, for example, opening entry to other domestic firms, should be considered. However, although the scale of potential welfare gains indicates further reform is worthwhile a number of issues should be considered. These will be discussed in some detail in the following section.

9.2 SUGGESTIONS FOR FURTHER STUDY

9.2.1 Is Thai Telecommunications a Contestable Market?

The investigation in this thesis mainly focused on the question of whether BTO regimes are justified. To clarify whether the Thai telecommunications market is contestable, in theory the issue of whether sunk costs is a barrier to entry must be tackled (Sharkey, 1982). That is, telecommunications investment basically requires an initial large amount of investment and some of this represents sunk costs. Thus, although the elasticity of total costs does not indicate economies of scale, a single firm may still dominate the market if there are barriers to entry in terms of sunk costs (Sharkey, 1982). For this reason, to ensure that the Thai telecommunications market is contestable, the question of whether there are sunk costs, which are a significant barrier to entry, should be further investigated.

9.2.2 The Impact of Liberalisation

From Chapter 3 we know that external pressures from the Belo Horizonte agreement with the World Trade Organisation are planned to lead to a full liberalisation in the telecommunications market by 2006. Two interesting questions can be raised here: should the telecommunications market be liberalised before 2006, and what is the impact of liberalisation on social welfare?

Consider the first question. Because the telecommunications market in recent years is unlikely to have been a natural monopoly, the market structure therefore should no longer be a monopoly. For this reason society might gain more benefits if liberalisation is introduced before 2006. Not only does this contribute to competition but also foreign investors might employ more advanced technology than that of domestic investors. As discussed in this thesis, operators can gain a significant saving in costs of investment from using advanced technology. This implies that the average cost and the marginal cost could be lower than in recent years. As a result, when the mechanism of a competitive market is working and open to foreign entry the access charge, which is normally priced at the marginal cost, could be lower than the current marginal cost. Foreign suppliers may be more efficient, for example, than local firms. Therefore, consumers will gain benefits not only from consuming products at cheaper prices but also obtaining a better quality of service. It would be worthwhile to investigate further the magnitude of social welfare when liberalisation is introduced. However these issues are beyond the scope of this study and they therefore are suggested for further study.

9.2.3 Should TOT be Privatised?

We know from Chapter 3 that TOT has encountered three problems: its performance is inefficient, there is inadequate skilled labour, and TOT faces a tight budget constraint. These observations lead to three interesting questions: should TOT be privatised to overcome those weaknesses, when should TOT be privatised, and what is the impact of privatisation on social welfare? These issues are suggested for further study as well.

APPENDIX I

KEY TERMS[130]

Access Charges They can be interpreted in different ways in each country. In the United Kingdom access charges are levied by a network operator with obligations to provide specific loss-making services on other interconnected networks in order to offset these losses (Beesley and Laidlaw, 1989). Meanwhile, customers in the United States will pay access charges when they have to make long-distance calls. In this study access charges means a fee where a user or customer registers as subscriber to a communications service.

Analogue Signal It is an electrical signal transmitting information from one place to another. The flow of transmitted information under this signal is continuous. Initially, the analogue signal is generic to the public switched telephone network (PSTN), as well as to certain other audio-frequency and radio-frequency facilities.

Asynchronous Transfer Mode (ATM) ATM is a fast packet switching which is used on networks to fit with cables. ATM with fibre optics can carry more data and transmit information at greater speed than with other types of cables.

Backbone Network It is a central, high speed, communications corridor that connects disparate networks. Backbone network enables all points to connect to each other.

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[130] Source: Beesley and Laidlaw (1989), Farr (1988), Graham (1991) and Livesey (1993).

Bandwidth It is the range of signal frequencies or the amount of data that a carrier can handle.

Broadband Integrated Services Digital Network (B-ISDN) It is a very high speed telecommunications service. This type of network can transmit multimedia services, for example video and audio, over the telephone line.

Cables They are the set of insulated wires for carrying electricity or electronic signals. There are many types of cables, for example cables made with fibre glass and copper cables.

Call Holding Time The time that a circuit or item of telecommunications equipment is engaged for the purpose of transferring, or attempting to transfer, information between users.

Channel It is one-way communications path where information, for example voice and data, are transmitted.

Circuit It provides for the transmission of electronic signals in both directions. If the circuit uses a separate transmission path for each direction, then each of these uni-directional paths is called a channel.

Coaxial Cable This cable is made up of one or more concentric pairs of conductors. It is widely used in telephone and television systems. In contrast to twisted-pair wires, coaxial cable has a much higher bandwidth to carry more data and offers greater protection from noise and interference. However, this type of cable is unable to carry as much bandwidth as digital transmissions.

Congestion The term is used to describe the situation when telecommunications traffic cannot be transferred to its destination because of a shortage of circuits.

Connection Charge It is a single payment charge made by a new subscriber for being connected to a communications service. In this study the connection charge has the same meaning as access charge and installation payment.

Copper Wire It is the materials used in both twisted-pair and coaxial cables.

Digital Network This type of network incorporates both digital switch (ie, digital SPC switch) and digital cables (ie, fibre optics and microwave).

Digital Signal Contrasting with an analogue signal, a digital signal is a discontinuous wave form. It is made up of discrete pulses with specific values. Binary notation, which uses 0 and 1, is a typical pulse of digital signal.

Erlang The international unit measures the number of telephone usages or traffic flow. It is the best indicator to predict and handle periods of heavy telephone use.

Fibre Optics They are a type of digital cable made of thin filaments of glass or plastic. Light beam is the technique used in transmitting information. Compared with analogue cables, optical fibres offer more capacity at higher speed. In recent years, fibre optics are a direct replacement for conventional coaxial cables and wire pairs.

Frequency Division Multiplexing System (FDM) A transmission system which can carry a large number of circuits to be provided over two coaxial cable pairs, one for each direction of transmission. This system uses several frequencies on the same channel to transmit different messages.

Grade of Service (GOS) GOS is a measure of service quality. It is a probability that a call will be lost during the busy hour.

Hierarchical Network A telecommunications network in which the switching centres are organised in hierarchical tiers.

Integrated Digital Network (IDN) It is a telephone network in which all switching centres and interconnecting transmission links use digital transmission techniques, analogue transmission being retained only on local circuits.

Integrated Services Digital Network (ISDN) It is a high speed transmission of any digital signal. ISDN offers greater bandwidth or more capacity than a conventional telephone, using an analogue signal.

International Telecommunication Union (ITU) ITU is a telecommunications agency of the United Nations. Its functions are to provide standardised communications procedures and practices including frequency allocation and radio regulations on a worldwide basis.

Mesh Network A telecommunications network in which locations that require to communicate with each other are directly linked.

Microwave System It is a point to point radio transmission system. It can be modulated in the same way as an electromagnetic wave. This system can transmit messages over two different signals, analogue and digital.

Outside Plants A telephone network which is designed to connect each subscriber to the nearest switching centre

Paging Service The transmission of a message to a beeper carried by the person who is to be paged. The beeper is a tiny receiver that usually displays the telephone number of the caller. Thus, the person who is paged can call back. Some beepers can also display as characters.

Public Switched Telecommunications Network (PSTN) A publicly owned and operated network which provides the facility for customers to communicate with each other and with the customers of other public telecommunications networks on a fee-paying basis.

Pulse Code Modulation (PCM) It is a translation process from an analogue voice signal to a digital form. PCM makes the transmission of voice convenient because it can travel on a line with other kinds of digital information.

Signalling System It is the exchange of electrical information specifically concerned with the establishment and control of connections and management. It is applied in the communications network to transmit or to receive coded information. Because there are different communications networks (ie, radio wave, transit traffic, international connection) the signalling systems are designed to different standards to use for a specific purpose. For example system no. 1 was widely used for radio links, whereas system no. 2 was intensely used for two-wire semiautomatic operations.

Star Network A telecommunications network in which each user is connected to a central hub. Each message is passed to the central hub before sending to other users.

Stored Program Control (SPC) SPC refers to a computer program designed to give centralised control over the operational, administrative and maintenance functions of switching system.

Switch It is a device for establishing and maintaining a switched connection between two circuits (input and output ports).

Telecommunications It can be defined in different ways. It sometimes means a communication between two people using equipment which need not necessarily be electronic, and not necessarily two way communications. It, however, is also identified as a transmission process of information from a sender to one or more receivers by means of any electromagnetic system.

Teleconferencing It refers to a communications service that enables more than two people, who are in different places, to participate in a conversation.

Time Division Multiplexing (TDM) It is the coded electrical or optical pulses which represent information to be transmitted digitally.

Traffic The amount of data transmitted over a network.

Transmission Path Any path over which telecommunications signals can be transmitted, for example a cable pair.

Transmission System It is a transmission package which is designed to carry a fixed maximum number of one or more traffic route over two cable pairs.

Twisted-Pair Copper Wires One type of analogue cable, which is made from bundles of pairs of twisted insulated copper wires. Twisted-pair copper wires provide less capacity than other types of cables, for example, coaxial cables and fibre optics.

Video on Demand It is a service that allows the users to order a program for viewing in the home. Subscribers can choose the channel that they want and then obtain services or order products through telephone lines.

Videotex It is a system that transmits data from a central computer to a home television set, either via coaxial cable or telephone link.

BIBLIOGRAPHY

Abu, B.M. (1993) 'Privatisation in Malaysia: A Case Study of the Telecommunications Department' in Quah, E. et al (eds.) *Law and Economic Development: Cases and Materials from Southeast Asia* Jurong: Longman

Agresti, A. (1996) *An Introduction to Categorical Data Analysis* New York: John Wiley and Sons

Albon, R, A. Hardin and P. Dee (1997) 'Telecommunications Economics and Policy Issues' *Staff Information Paper* Canberra: Industry Commission

APT (Asia-Pacific Telecommunity) (1996) *The APT Yearbook* Bangkok: APT

AT&T (American Telephone and Telegraph) (1980) 'Defendants' Third Statement of Contentions and Proof' *Documents and Testimony in US. v. AT&T* volume 3

Bank of Thailand (BOT) (1995) *Economic Indicators* Bangkok: BOT

Baumol, W.J. (1977) 'On the Proper Cost Test for Natural Monopoly in a Multiproduct Industry' *American Economic Review* 67(5), pp. 809-22

Baumol, W.J., B. N. Behling, J.C. Bonbright, Y. Brozen, J. Dean, F.K. Edwards, C.B. Hoover, D.F. Pegrum, M.J. Roberst and E.W. Williams (1962) 'The Role of Cost in the Minimum Pricing of Railroad Service' *Journal of Business* 35, pp. 361-2

Baumol, W.J., J.C. Panzar and R.D. Willig (1982) *Contestable Markets and the Theory of Industry Structure* New York: Harcourt Brace Jovanovich

Becker, F.K. (1984) 'Telephone System' in Lewin, L. (ed) *Telecommunications: An Interdisciplinary Text* Dedham, MA: Artech House

Beesley, M.E. and B. Laidlaw (1989) *The Future of Telecommunications: An Assessment of the Role of Competition in UK Policy* London: Institute of Economic Affairs

Bellamy, J. (1991) *Digital Telephony* Canada: John Wiley & Sons

Berg, S.V. and J. Tschirhart (1988) *Natural Monopoly Regulation: Principles and Practice* New York: Cambridge University Press

______ (1995) 'A Market Test for Natural Monopoly in Local Exchange' *Journal of Regulatory Economics* 8, pp. 103-24

BOI (Board of Investment) (1993) *Sourcing Guide* Bangkok: The Build Unit

______ (1996) *Investment Opportunity Study: Telecommunications in Thailand* Bangkok: BOI

Boonyawinaikul, W. (1995) 'Collaboration between the Public and Private Enterprises: A Case Study of the Landline Telephone Network' *Master Thesis* Bangkok: Thammasat University

Borowski, E.J. and J.M. Borwein (1989) Dictionary of Mathematics Glasgow: Harper Collins Publishers

Breslaw, J. and J.B. Smith (1980) *Efficiency, Equity and Regulation: an Econometric Model of Bell Canada* A Paper Reported to the Department of Communications: Canada

Bureau of the Budget (1998) *Thailand's Budget in Brief: Fiscal Year 1999* Bangkok: Secretary of the Department of the Prime Minister

Burkitt, M. (1997) 'Call of the Wired' *International Communications* 24(9), pp. 67-70

Capello, R. (1996) *Spatial Economic Analysis of Telecommunications Network Externalities* Aldershot: Avebury

Cardozo, N.B. (1996) 'The Vary Latest' *Worldbusiness* 2(6), pp. 42-3

CAT (Communications Authority of Thailand) (1997) *Price of International Calls* (mimeo)

Chanrojanakij, B., V. Sookjaroen, and S. Chatsakulwilai (1994) *TOT under Anand Panyarachun Premiership (March 1994 - April 1995 and June - September 1995)* Bangkok: Somsri Press

Chanya (1989) 'TOT and Time Zone Metering for BMA in 1989' *Commercial News Newspaper* 23 (11), pp. 8-9

Charnes, A., W.W. Cooper and T. Sueyoshi (1988) 'A Goal Programming/ Constrained Regression Review of the Bell System Breakup' *Management Science* 34(1), pp. 1-26

Dalton, M.M. and P.C. Mann (1988) 'Telephone Cost Allocation: Testing the Variability of Costs' *Land Economics* 64(3), pp. 296-305

Denny, M. and M. Fuss (1980) 'The Effects of Factor Prices and Technological Change on the Occupational Demand for Labour: Evidence from Canadian Telecommunications' *Working Paper no. 8014* Institute for Policy Analysis: Canada

DeSerpa, A.C. (1988) *Microeconomic Theory: Issues and Applications* Boston: Allyn and Bacon

Dixit, A. (1982) 'Recent Developments in Oligopoly Theory' *American Economic Review* May, pp. 12-17

Doran, H.E. (1989) *Applied Regression Analysis in Economics* New York: Marcel Dekker

Ellis, L.W. (1975) 'The Law of the Economies of Scale Applied to Telecommunications System Design' *Electrical Communication* 50(1), pp. 4-19

Evans, D.S. and J.J. Heckman (1983) 'Natural Monopoly', in Evans, D.S. (ed.) *Breaking Up Bell: Essays on Industrial Organisation and Regulation* New York: Elsevier Science

______ (1984) 'A Test for Subadditivity of the Cost Function with an Application to the Bell System' *American Economic Review* 74(4-5), pp. 615-23

Farr, R.E. (1988) 'Telecommunications Traffic, Tariffs and Costs: An Introduction for Managers', in Flood, J.E. et al (ed.) *IEE Telecommunications Series 19* London: Peter Peregrinus

Flood, J.E. (1991) 'Transmission Principles' in Flood J.E. et al (eds.) *Transmission Systems: IEE Telecommunications Series 27* London: Peter Peregrinus

Foster, T. and A. Knight (1997) 'Legal Issues in BOT Projects in Vietnam' *Journal of Project Finance* 3(2) pp. 16-29

FTI (Federation of Thai Industries) (1995) *Feasibility Study for Digital Telephone Switching Equipment Manufacturing in Thailand* Bangkok: ATEEI (The Association of Thai Electrical and Electronic Industries) and PC&M (Project Consultants and Management)

Fuss, M. and L. Waverman (1977) 'Multi-Product, Multi-Input Cost Functions for a Regulated Utility: The Case of Telecommunications in Canada' *Working Paper no. 7810* Institute for Policy Analysis: Canada

______ (1981) 'Regulation and the Multiproduct Firm: The Case of Telecommunications in Canada' in Fromm, G. (ed.) *Studies in Public Regulation* Washington DC: The MIT Press

Fuss, M.A. (1983) 'A Survey of Recent Results in the Analysis of Production Conditions in Telecommunications' in Courville L. et al (eds.) *Economic*

Analysis of Telecommunications: Theory and Applications New York: Elsevier Science Publishers

Gabel, D. and D.M. Kennet (1994) 'Economies of Scope in the Local Telephone Exchange Market' *Journal of Regulatory Economics* 6(4), pp. 381-98

Garrone, P. (1995) 'The Adoption of Technological Innovation: Dynamic and Cumulative Effects in Telecommunications Networks' *Economics Innovation New Technology* 4(1), pp. 1-15

Gasmi, F., J.J. Laffont and W.W. Sharkey (1997) 'Incentive Regulation and the Cost Structure of the Local Telephone Exchange Network' *Journal of Regulatory Economics* 12, pp. 5-25

Graham, J. (1991) *Dictionary of Telecommunications* revised and updated by Lowe, S.J. London: The Penguin Books

Griffin, J.M. (1982) 'The Welfare Implications of Externalities and Price Elasticities for Telecommunications Pricing' *Review of Economics and Statistics* 64(1), pp. 59-66

Gujarati, D. N. (1988) *Basic Econometrics* New York: McGraw-Hill

______ (1995) *Basic Econometrics* New York: McGraw-Hill

Guldmann, J.M. (1990) 'Economies of Scale and Density in Local Telephone Network' *Regional Science and Urban Economics* 20, pp. 521-35

Hall, A.D. (1975) 'An Overview of Economies of Scale in Existing Communications Systems' *IEEE Transactions on Systems, Man, and Cybernetics* SMC-5(1), pp. 2-14

Hayashi, K. (1992) 'From Network Externalities to Interconnection: The Changing Nature of Networks and Economy' in Antonelli C. (ed.) *The Economics of Information Networks* Amsterdam: North-Holland

Herrera, A. (1992) 'The Privatisation of the Argentine Telephone System' *CEPAL Review* 47, pp. 149-61

Hudson, H.E. (1981) *Three Case Studies on the Benefits of Telecommunications in Social-Economic Development: The Cook Islands Interisland Radio System, The University of the South Pacific Satellite Network, Satellite - Delivered Telecommunication Services in Alaska* Geneva: ITU

Hyman, D.N. (1986) *Modern Microeconomics: Analysis and Applications* St. Louis: Times Mirror/ Mosby College

IEAT (Industrial Estate Authority of Thailand) (1993) *Industrial Estate Authority of Thailand* Bangkok: IEAT

Imai, H. (1994) 'Assessing the Gains from Deregulation in Japan's International Telecommunications Industry' *Working Paper No. 37* School of Oriental and African Studies: University of London

ITU (International Telecommunication Union) (1984) 'Report of the Independent Commission for World Wide Telecommunications Development' *The Missing Link* Geneva: ITU

______ (1994) *Telecommunication Indicator* Geneva: ITU

______ (1997) *World Telecommunication Development Report: Trade in Telecommunications* Geneva: ITU

Kahn, A.E. (1971) *The Economics of Regulation: Principles and Institutions vol. II* New York: Wiley

Kellerman, A. (1993) *Telecommunications and Geography* London: Belhaven Press

Lewis, W.A. (1946) 'Fixed Costs' *Economica* 13, pp. 231-58

Littlechild, S.C. (1979) 'Elements of Telecommunications Economics' in Flood, J.E. et al (eds.) *IEEE Telecommunications Series 7* England: Peter Peregrinus

Livesey, F. (1993) *Dictionary of Economics* London: Pitman Publishing

Lynch, G.P. (1987) 'Take Your Pick: A Digital Loop Carrier System or a Remote Switch Unit' *Telephony* 212(18), pp. 42-8

M Group (1996) *Six Million Lines Project* Bangkok: True Communications

Mansfield, E. (1994) *Applied Microeconomics* New York: W.W. Norton

Marlin, W.S. (1998) *Important Facts & Formulas* New South Wales: W.S. Marlin

Ministry of Interior (1993) *Summary of Lecture Changwat Roi-Et* Roi-Et: Office of Changwat Roi-Et

Morse, D. (1996) *Cyber Dictionary: Your Guide to the Wired World* Massachusetts: Wordworks

Nadiri, M.I. and M. Shankerman (1981) 'The Structure of Production, Technological Change and the Rate of Growth of Total Factor Productivity in the Bell System' in Gowing, T. et al (eds.) *Productivity Measurement in Regulated Industries* New York: Academic Press

NESDB (National Economic and Social Development Board) (1993) *The Seventh National Economic and Social Development Plan (1992 - 1996)* Bangkok: NESDB

NIRA (National Institute for Research Advancement) (1992) *Development of the Machinery and the Equipment for Information Industries in Thailand* A Paper Presented to NIRA Japan: Simul International, Inc.

NITC (National IT Committee) (1995) *IT2000: National IT Policy* Bangkok

Norusis, M.J. (1995) *SPSS 6.1 Guide to Data Analysis* New Jersey: Prentice Hall

Panzar, J.C. and R.D. Willig (1977) 'Economies of Scale in Multi-Output Production' *Quarterly Journal of Economics* 91, pp. 481-94

______ (1979) 'Economies of Scope, Product-Specific Economies of Scale, and the Multiproduct Competitive Firm' *Discussion Paper no. 152* Bell Laboratories Economics

Pearce, J.G. (1981) *Telecommunications Switching* New York: Plenum Press

Pollard, J.R. (1975) 'Introduction' in Flood, J. (ed.) *Telecommunications Networks* Herts: Unwin Brothers

RDI (Research Development and Innovation) (1993) *Technology and Investment Opportunity in Telecommunications Services and Equipment* (mimeo)

Redmill, F.J. and A.R. Valdar (1994) 'SPC Digital Telephone Exchanges' in Flood J.E. et al (eds.) *IEEE Telecommunications Series 21* London: The Eastern Press

Rohlfs, J. (1979) 'Economically Efficient Bell-System Pricing' *Discussion Paper no. 138* Bell Laboratory

Roller, L.H. (1990) 'Proper Quadratic Cost Functions with an Application to the Bell System' *Review of Economics and Statistics* 72(1-2), pp. 202-10

Saunders, R., J. Wardord and B. Wellenius (1983) *Telecommunications and Economic Development* Baltimore: The Johns Hopkins University Press

______ (1994) *Telecommunications and Economic Development* Baltimore: The Johns Hopkins University Press

Scale, I. (1994) Beyond the Great Wall *International Communications* 21(7), pp. 5-8

Sharkey, W.W. (1982) *The Theory of Natural Monopoly* Cambridge: Cambridge University Press

Shin, R.T. (1988) 'Econometric Estimation of Telephone Costs for Local Exchange Companies: Implications for Economies of Scale and Scope and Regulatory Policy' *PhD Dissertation* Berkeley: University of California

Shin R.T. and J.S. Ying (1992) 'Unnatural Monopolies in Local Telephone' *RAND Journal of Economics* 23 (2), pp. 171-83

______ (1994) 'Viable Competition in Local Telephone: Superadditive Costs in the Post-divestiture Period' *Working Paper no. 94-8* College of Business and Economics: University of Delaware

Smith P.L. and G. Staple (1994) 'Telecommunications Sector Reform in Asia: Toward a New Pragmatism' *World Bank Discussion Papers no. 232* Washington, DC: The World Bank

Soonthonsiripong, N. (1996) 'South East Asia Region: Thailand Country Report' in *Advances in Information Technology - Issues for Development in Asia/Pacific* A Paper Proposed to the Australian Agency for International Development (AusAID), Adelaide: Centre for Telecommunications Information Networking (CTIN)

______ (1997) *Telecommunications in Thailand: A Case Study of Fixed-Line Telephones* A Paper Prepared during the Internship Program at the Economic and Social Commission for Asia and the Pacific (ESCAP), Bangkok

______ (1998) *Regulatory Reform and Telecommunications Structure: A Case Study of Telecommunications in Thailand* A Paper Presented at the Seminar Measuring Impediments to Trade in Services Workshop Australia-Japan Research Centre (AJRC), Canberra

Stair, R. (1996) *Principles of Information Systems: A Managerial Approach* Danvers: Boyd and Fraser

TA (TelecomAsia) (1994) *Annual Report 1994* Bangkok: TA

______ (1995) *Annual Report 1995* Bangkok: TA

______ (1996) *Annual Report 1996* Bangkok: TA

TAT (Tourism Authority of Thailand) (1993) *The Master Plan for Tourism Development* Bangkok: TAT

______ (1995) *Tourism Survey* Bangkok: TAT

Taylor, L.D. (1980) *Telecommunications Demand: A Survey and Critique* Massachusetts: Ballinger Publishing

TDRI (Thailand Development Research Institute) (1993a) *The Role of Information Technology in the Information Society in the Year 2010* Bangkok: Science and Technology Development Program

______ (1993b) *The Review of the Master Plan for Tourism Development* Bangkok: Sectoral Economics Program

______ (1997a) *The Telecommunications Development Plan 1997-2006* A Paper Proposed to the Ministry of Transport and Communications, Bangkok: TDRI

______ (1997b) *Economic and Social Indicator* Bangkok: TDRI (mimeo)

Tikaput, P. (1996) *Telecommunication* Bangkok: Se-Education

TOT (Telephone Organisation of Thailand) (1982) *Annual Report 1982* Bangkok: Division of Statistics and Report

______ (1984) *Annual Report 1984* Bangkok: Division of Statistics and Report

______ (1986) *Annual Report 1986* Bangkok: Division of Statistics and Report

______ (1987) *Telephone Statistic Report 1987* Bangkok: Division of Statistics and Report

______ (1988) *Telephone Statistic Report 1988* Bangkok: Division of Statistics and Report

______ (1989) *Annual Report 1989* Bangkok: Division of Statistics and Report

______ (1990) *Annual Report 1990* Bangkok: Division of Statistics and Report

______ (1991) *Annual Report 1991* Bangkok: Division of Statistics and Report

______ (1992a) *Annual Report 1992* Bangkok: Division of Statistics and Report

______ (1992b) *Telephone Statistic Report 1992* Bangkok: Division of Statistics and Report

______ (1993a) *Demand Forecasted for Telephones 1993-2008* Bangkok: Department of Engineering

______ (1993b) *Annual Report 1993* Bangkok: Division of Statistics and Report

______ (1994a) *Telephone Statistic Report 1994* Bangkok: Division of Statistics and Report

______ (1994b) *From Past to Present: The Leader in Telecommunications* Bangkok: Department of Public Relations

______ (1995a) *Telephone Statistic Report 1995* Bangkok: Division of Statistics and Report

______ (1995b) *The Project to Develop Telephone Service* Bangkok: Office of Corporate Policy and Planning

______ (1996) *Telephone Statistic Report 1996* Bangkok: Division of Statistics and Report

______ (1997a) *Price of Local and Domestic Long-Distance Calls* Bangkok: Financial Planning Division (mimeo)

______ (1997b) *Length of Waiting Lists* Bangkok: TOT (mimeo)

TT&T (Thai Telephone and Telecommunication) (1994a) *The Prospectus of Newly Issued Ordinary Share* Bangkok: TT&T

______ (1994b) *Annual Report 1994* Bangkok: TT&T

______ (1995) *Annual Report 1995* Bangkok: TT&T

______ (1996) *Annual Report 1996* Bangkok: TT&T

Varian, H.R. (1987) *Intermediate Microeconomics: A Modern Approach* New York: W.W. Norton & Company

Viscusi, W., J. Vernon and J. Harrington (1994) *Economics of Regulation and Antitrust* Massachusetts: D.C. Heath and Company

Waverman, L. (1974) *Demand for Telephone Services in Great Britain, Canada and Sweden* A Paper Presented at the Birmingham International Conference in Telecommunications Economics, Birmingham: England

______ (1975) 'The Regulation of Intercity Telecommunications' in Phillips, A. (ed.) *Promoting Competition in Regulated Markets* Washington DC: The Brookings Institution

Wenders, J.T. (1987) *The Economics of Telecommunications* Massachusetts: Ballinger Publishing Company

______ (1990) 'Two Views of Applied Welfare Analysis: The Case of Local Telephone Service Pricing' *Southern Economic Journal* 57(2), pp. 340-48

William, P. and N. Jequier (1983) *Telecommunications for Development* Geneva: General Secretariat, ITU

World Bank (1995) *World Tables* Baltimore: Johns Hopkins

Yaged, B. (1975) 'Economies of Scale, Networks, and Network Cost Elasticity' *IEEE Transactions on Systems, Man, and Cybernetics* SMC-5(1), pp. 30-40

Yoonaidharma, S. (1993) 'Appendix A: Role of Laws over the Communications Authority of Thailand Operation' *Future Directions of the Communications Authority of Thailand* Bangkok: STD, TDRI

INTERNET ACCESS

http://www.boi.go.th /business/g13.htm, 12 October 1998

http://www.boi.go.th/business/g11.htm, 25 September 1998

http://www.ieat.go.th, 25 September 1998

http://www.sice.oas.org/ftaa/belo/forum/workshop/syno9%5Fe.st, 25 August 1998

http://www.tat.or.th/province/index.htr, 30 September 1998