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ECONOMIC GROWTH, BARRIERS AND TRADE LIBERALIZATION IN TELECOMMUNICATIONS IN THE APEC REGION

Eng Kooi LIM

Thesis submitted to the Faculty of Graduate and Postdoctoral Studies in partial fulfillment of the requirements for the degree of

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Acceptance

Dedications

This thesis is dedicated to
Mom, Phaik Har
Wife, Lai Fun
Son, Sean
Brothers and sisters

&

In memorial of my late father – Choi Cheoh

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Legend

ABT	Agreement on Basic Telecommunications
APEC	Asia-Pacific Economic Cooperation
FDI	Foreign direct investment
GATS	General Agreements on Trade in Services
GDP	Gross Domestic Product
GMM	Generalized Method of Moments
ICT	Information and Communication Technology
ITU	International Telecommunication Union
OECD	Organization for Economic Co-operation and Development
WTO	World Trade Organization

Abstract

This thesis consists of three research projects on the telecommunications industry in the Asia-Pacific Economic Cooperation (APEC) countries. These projects deal with, respectively, the relationship between economic growth and telecommunications infrastructure, the measurement of barriers to trade and investment, and the impact of trade and investment liberalization on economic growth.

In the first project, I examine the contributions of the telecommunications industry to economic growth in the APEC countries, taking into account country fixed effects and causality between telecommunication variables and income, with four structural equations estimated simultaneously. The findings from this project suggest that: models with fixed effects perform better than those without; models that include cellular mobile phones as a proxy for telecommunications infrastructure outperform those with only fixed lines; countries with lower penetration rates tend to demonstrate a higher impact of telecommunications on aggregate output; network externalities exist in those countries that achieve a penetration rate of up to 50 per cent. Together, these findings suggest that the developing countries may achieve faster economic growth by significantly improving their telecommunications infrastructure.

Projects two and three are conducted to test the hypothesis that liberalization of telecommunications market will stimulate investment in telecommunications infrastructure and enhance economic growth. In project two, I construct a set of indices to measure the openness of the telecommunications market in the APEC countries. It is evident that developed economies do not always have higher levels of market liberalization when different instruments such as market access, national treatment and/or regulatory principles are utilized. Some developing economies are more open than their developed counterparts in some aspects.

In project three, I use these indices to estimate the likely impact of liberalization on economic growth. I find some evidence that too great a degree of market liberalization may, surprisingly, lower the investment in telecommunications and hence harm the economic growth in developing countries. I estimate that the adverse impact of full trade liberalization on developing countries is about 5.3 per cent of Gross Domestic Product (GDP).

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CHAPTER 1:
INTRODUCTION

Section 1: Changes in the telecommunications industry

The telecommunications industry has gone through tremendous changes over the past two decades. It has moved beyond the traditional telephone services to include data communications. In particular, wireless networks have evolved from analogue to 3G technologies, which allow users to send and receive pictures, e-mail, short message services (SMS), and even television broadcasts. The introduction of Internet-based services through broadband technology has further enhanced business opportunities, making the goods and services market more competitive. As a result, the advancement of technology has led to the convergence of the broadcasting, information technology and telecommunications industries, defining a new sector called Information and Communication Technology (ICT). The ICT industry is now perceived by many countries as a main driving force to economic growth.

The market structure of the telecommunications industry in many countries has also been transformed from a natural monopoly to one with a few integrated firms offering wide ranges of related services within the converging industry. The cost of providing network access has also been reduced substantially over the years, partly due to changes in market structure and in the regulatory climate. In line with technological progress, many legislative and regulatory frameworks around the globe have also revamped accordingly to meet the needs of this dynamic environment[1].

[1] See ITU (2001). *Trend in Telecommunications Reform 2000-2001*, p. 1-17.

Table 1.1
Cumulative annual growth rate (CAGR) of GDP, GDP per capita and trade

Income Group	Gross Domestic Products (GDP) *(in constant 2000 US$ in billion)*			Population *(in billion people)*			GDP per capita *(in constant 2000 US$)*			Trade in goods and services *(in constant 2000 US$ in billion)*		
	1980	2002	CAGR(%)	1980	2002	CAGR(%)	1980	2002	CAGR(%)	1990	2002	CAGR(%)
Low (59)	360	920	4.16	1.39	2.26	2.12	258	407	2.01	164	410	4.05
Middle	2,811	5,404	2.88	2.20	2.95	1.30	1,254	1,829	1.65	1,802	3,443	2.86
Lower Middle (54)	1,234	3,159	4.17	1.76	2.39	1.34	702	1,324	2.79			
Upper Middle (40)	1,577	2,245	1.55	0.44	0.57	1.12	3,589	3,953	0.42			
High	14,498	26,285	2.62	0.84	0.99	0.71	17,280	26,583	1.89	6,438	12,658	2.98
NonOECD (31)	506	1,165	3.69	0.05	0.08	2.08	10,342	14,820	1.58			
OECD (24)	13,991	25,120	2.58	0.79	0.91	0.61	17,701	27,601	1.95			
World (208)	17,668	32,609	2.70	4.43	6.20	1.47	3,976	5,258	1.22	8,405	16,511	2.98
APEC (21)	9,516	19,624	3.20	1.96	2.56	1.16	4,850	7,663	2.01	3,214	7,256	3.60
% of world	53.86	60.18		44.29	41.30					38.24	43.95	

Notes:

1 The figure in the bracket beside the income group indicate the number of the countries or member economies in that group. Income group is classified by the World Bank, check http://web.worldbank.org/

2 We calculated the World figure as the sum of the three income groups as in the case of GDP and Trade. This is because in the World data in WDI database, is bit different from the total of the three. See World Bank's website above or WDI.

3 Trade data is just the import plus export of goods and services. The data for middle income group is not availabe until 1990.

4 APEC's trade data for 1990 and 2002 do not include Brunei, Singapore, Taiwan and Papua New Guinea as these data are not available. Trade data for China is only available after 1997.

5 APEC comprises 10 developed countries or referred to as member economies and 11 developing countries (or member economies):

Developed economies (high income group):

Non OECD (4): Brunei, Hong Kong (China), Singapore and Chinese Taipei (Taiwan)

OECD (6): Australia, Canada, Japan, Korea, New Zealand and USA

Developing economies (low and middle income group):

Low (2): Papua New Guinea and Vietnam

Lower Middle (5): China, Indonesia, Peru, Phillippines and Thailand

Upper Middle (4): Chile, Malaysia, Mexico and Russia

6 The cumulative annual growth rate is calculated as:

$$\left(\frac{X_1}{X_0}\right)^{\frac{1}{n}} - 1$$

where X_0 and X_1 is the value for initial and end period, respectively. n is the number of periods.

Source: World Development Indicators Database (WDI)

Table 1.1 shows that, over the period of 1980 to 2002, the Gross Domestic Product (GDP) of the low and middle income groups of countries grew at the annual rates of 4.16 and 2.88 respectively, outperforming their high income counterpart, which grew at only 2.62 per cent annually. However, the per capita income disparity, for example, between the high income group and the middle income group, has also increased from approximately US$16,000 in year 1980 to about US$25,000 in year 2002. Obviously, the gap between the low income and the high income groups is even larger. This raises the question of what caused the increasing income gap during this period. Many researchers have suggested that the digital divide between developed and developing countries might be the problem[2]. If this is true, ICT will provide an opportunity for low and middle income groups to catch up with their high income counterpart.

From Table 1.2, we can see that the penetration of fixed lines, which is a measure the ICT infrastructure, grew rapidly from an average of 4.65 per 100 inhabitants in 1980 to 18.57 per 100 inhabitants in 2002 for those countries in the middle income group, for an annual growth rate of 6.21 per cent. Although the growth rate among high income countries (3.33 per cent) is just about half of the middle income group, in the high income countries, for every 100 people there are more than 50 people that have an access to a fixed line phone; this ratio is more than double the middle income group while the low income group is still very much behind with a penetration rate of only 2.76 as of 2002.

The rapid growth in mobile cellular technology only began in the late 1980s. Table 1.2, second column, shows that the number of mobile phone subscribers in the low income group grew at 51.38 per cent over the decade 1990-2002, outperforming their more developed middle income counterparts which grew at 33.83 per cent, while the high income group grew at only 20.10 per cent per annum. However, in terms of total penetration (column 3, Table 1.2), the middle income group, which

[2] The digital divide refers to unequal division of ICT between socio-economic groups within or between countries. See ITU (2002b). *World Telecommunication Development Report 2002*, p. 25-27.

grew at 9.92 per cent, seems to lead both the low and high income groups. In the high income group, on average, every one has at least one phone (to be exact, 1.25), whether it is a fixed line or mobile phone. When taking into account the mobile networks, the penetration rate among the middle income countries still very much lags behind (40.91 per cent), at approximately one third of the rate of the high income group, whereas in the low income group, only about five out of 100 individuals have access to a phone.

Table 1.2
Mainlines and mobile phones penetration rate

Income group	Mainlines *(per 100 inhabitants)*			Mobile phones subscribers *(per 100 inhabitants)*			Total penetration *(per 100 inhabitants)*		
	1980	2002	CAGR	1990	2002	CAGR	1980	2002	CAGR
Low (65)	1.23	2.76	3.58	0.00	2.57	51.38	1.23	5.33	6.58
Middle	4.65	18.57	6.21	0.03	22.33	33.83	4.65	40.91	9.92
Lower Middle (52)	2.90	11.65	6.23	0.01	12.89	39.37	2.90	24.54	9.73
Upper Middle (37)	6.91	27.08	6.12	0.06	33.95	31.71	6.91	61.03	9.93
High	24.64	52.38	3.33	1.08	73.10	20.10	24.64	125.48	7.33
NonOECD (29)	18.00	44.90	4.05	0.59	68.83	23.03	18.00	113.73	8.35
OECD (24)	31.27	57.98	2.72	1.58	75.95	18.33	31.27	133.93	6.53
APEC (21)	14.00	36.25	4.22	0.66	42.69	19.87	14.00	78.95	7.81

Note:

1.The figure besides the income group indicate the number of countries/member economies, ITU's classification is a bit different from WDI.
2. Total penetration is the sum of mainlines and mobile phones subscribers.
3. Data on mobile phone subsribers was not significant and thus not reported by many countries until late 1980s.

Source: World Telecommunication Indicators Database (ITU)

If the hypothesis that ICT infrastructure stimulates economic growth is true, then it might be worthwhile for developing countries to invest heavily in ICT infrastructure in order to catch up with their more developed counterparts. However, there is a huge debate in the literature regarding whether ICT infrastructure causes economic growth, or vice versa. Research has been conducted to investigate the relationship between economic growth and ICT infrastructure, but most of the researchers focus mainly on Organization for Economic Co-operation and Development (OECD) countries, with only a few on developing countries. There appears to be no

study of the telecommunications industry that focuses on the Asia-Pacific Economic Cooperation (APEC) region.

Section 2: WTO and telecommunications

Given the importance of the telecommunications sector and the existence of significant barriers to trade and interest in this sector, there have been substantial pressures on many countries to open up their markets, especially with the establishment of General Agreements on Trade in Services (GATS)[3] under the umbrella of the World Trade Organization (WTO) in 1995. The Agreement on Basic Telecommunications (ABT), which sets new rules relating to trade in telecommunication services, came into effect on February 5, 1998. By November 1998, specific commitments regarding market access, national treatment, and the application of pro-competitive regulatory principles were undertaken (partially or fully) by all 89 participants to the ABT.

These commitments were made on market access or on national treatment disciplines with respect to four modes of supply: cross-border supply, consumption abroad, commercial presence and presence of natural persons. Member countries were allowed to specify which segments of the telecommunication services sector they wish to open to foreign competition (for instance, local, long-distance services, international calls and/or mobile telephony). If a member country does not comply with any one of the four modes of delivery of GATS, it is considered to be impeding trade in telecommunication services. Since the ABT is based on a reciprocal rather than a Most-Favoured-Nation (MFN) basis, member countries that have not opened up their markets are not entitled to benefit from market liberalization as a result of the agreement.

[3] See *www.wto.org* for detailed principles and developments including GATS and ABT.

Member countries which signed the ABT included additional commitments concerning regulatory principles in their schedules. These regulatory principles of ABT are presented in the WTO Reference Paper[4]. The Reference Paper requires member countries to address the issues of dominance of the incumbents and to provide competitive environments for the trading members. It articulates five main principles regarding telecommunications regulation: competitive safeguards, interconnection, universal service, licensing criteria and independent regulator.

It has been pointed out that the above measures are not sufficient to ensure actual competition given the typical strength of the incumbents and their control over local telecommunications network. Also, barriers to market access do not end at the border. Non-tariff barriers such as regulatory practices and firms' anticompetitive behaviour in the telecommunications sector also limit the ability to penetrate a foreign country. Therefore, liberalization of trade and investment in telecommunication services have to deal with both tariff and non-tariff barriers.

Section 3: Trade in telecommunication services

Table 1.3
Telecommunications equipment trade

Income group	Exports (Million US$)			Imports (Million US$)			Total Trade (Million US$)			
	1997	2002	CAGR % 1997-02	1997	2002	CAGR % 1997-02	1997	2002	As % of world 1997	As % of world 2002
Low	248	202	-5.3	2,179	2,957	4.4	2,427	3,159	1.5	1.3
Lower Middle	4,193	13,263	25.8	12,575	15,940	4.4	16,768	29,203	10.4	11.9
Upper Middle	4,157	14,929	28.7	7,362	10,102	5.0	11,519	25,031	7.1	10.2
High	70,602	94,579	6.4	59,867	93,867	9.6	130,469	188,446	80.9	76.7
World	79,200	122,973	9.5	81,983	122,866	8.3	161,183	245,839	100.0	100.0

Source: ITU World Telecommunication Development Report, various issues.

The International Telecommunication Union (ITU) defines international trade in telecommunications as the sale of equipment or services that cross national borders[5]. Over the 1997-2002 period, the world export of telecommunications equipment increased at an annual rate of 9.5 per cent (see Table 1.3 for the

[4] *www.itu.int/newsarchive/press/WTPF98/WTORefpaper.html*
[5] ITU (1996). *World Telecommunication Development Report 1996/1997*, p.2.

performance of countries by income group). The middle-income group of countries experienced a growth in exports of more than 25 per cent per annum over that period, while the high-income group enjoyed a growth of 6.4 per cent per annum. The low-income group, however, recorded a negative growth of 5.3 per cent per annum. At 9.6 per cent, the high-income group has the highest annual growth in the import of telecommunications equipment. The import growth of the low and middle-income groups was between 4 and 5 per cent less than the world growth of 8.3 per cent. In terms of total trade (the sum of import and export), the high-income group accounted for 77 per cent of the world trade in 2002, a decrease of 4 percentage points since 1997. The share of the low-income group in world trade also slipped slightly, by 0.2 percentage points. The middle-income group was the only group whose share strengthened, by more than 4 percentage points to 22.1 per cent of the total world trade in 2002.

Table 1.4
International telephone traffic

Income group	Outgoing traffic (Million minutes) 1998	Outgoing traffic (Million minutes) 2004	CAGR % 1998-2004	As % of bothways 2004
Low	1,791.6	2,058.5	2.3	18.3
Lower Middle	7,255.8	9,687.2	4.9	23.2
Upper Middle	8,436.4	10,248.0	3.3	31.5
High	66,240.7	122,611.4	10.8	61.5
World	83,724.6	144,605.1	9.5	49.6

Source: World Telecommunication Development Report, various issues.

The most common cross-boarder trade in telecommunication services is in the area of international telephone calls. The international telephone traffic of countries by income group is provided in Table 1.4. In terms of outgoing traffic, with the annual rate of 10.8 per cent during the 1998-2004 period, the high-income group recorded the highest growth, surpassing the world rate of 9.5 per cent. In fact, as of 2004, the high income group was the only group that experienced a net outflow of traffic, the outgoing traffic being more than half (62 per cent) of the total traffic (incoming and outgoing) generated.

Investment in telecommunications has increased substantially (see Table 1.5). Thus, the importance of investment is evident in the share of gross fixed capital formation (GFCF). Except in the upper middle-income group, all other income groups showed an increased significance of the investment. As a whole, the contribution of that investment in the GFCF has increased from 2.4 per cent in 1998 to 3.0 per cent in 2004.

Table 1.5
Telecommunications investment

Income group	Total (M US$) 1998	As a % of GFCF	Total (M US$) 2004	As a % of GFCF
Low	4,591.4	2.7	5,614.2	3.3
Lower Middle	25,296.1	3.3	42,913.7	4.5
Upper Middle	21,184.5	3.6	11,999.7	2.5
High	124,583.1	2.2	124,475.3	2.8
World	175,655.0	2.4	185,002.9	3.0

Note: GFCF is the gross fixed capital formation.

Source: World Telecommunication Development Report, various issues.

Table 1.6
Telecommunications revenue

Income group	Total (M US$) 1998	As a % of GDP	Total (M US$) 2004	% Mobile 2004	As a % of GDP
Low	11,597.5	1.2	26,223.2	42.9	2.4
Lower Middle	49,761.4	1.8	127,073.1	47.0	3.8
Upper Middle	62,132.7	2.2	85,632.4	47.3	3.7
High	599,056.6	2.5	969,271.1	34.6	3.3
World	722,548.2	2.4	1,208,199.8	37.2	3.3

Source: World Telecommunication Development Report, various issues.

Consistent with the increase in the investment in telecommunications, the industry revenue has also improved substantially. In 2004, world telecommunications revenue accounted for 3.3 per cent of the GDP, compared to 2.4 per cent in 1998 (Table 1.6). With a contribution of approximately 3.7 per cent of GDP, the middle-

income group produced the highest share of telecommunications revenue. Given the rapid development of mobile technology, it is not surprising to observe that more than 35 per cent of the 2004 telecommunications revenue was derived from mobile services in most income groups. The mobile revenue in the middle-income group recorded nearly half (47 per cent) of the total industry revenue.

Section 4: The APEC

The Asia-Pacific Economic Cooperation (APEC) is a unique economic cooperation organization which was founded in 1989 to facilitate economic growth, cooperation, trade and investment and to work on the environment of non-binding commitments, open dialogue and equal respect for the views of all participants.[6] The 21-member APEC comprises 10 developed economies (7 of which are in OECD) and 11 developing economies (6 of which are Asian); see Table 1.7. APEC is responsible for approximately 60 per cent of world GDP and accounts for more than 40 per cent of the world's population and nearly half of world trade (44 per cent), based on the data for year 2002 (see Table 1.1). Over the past 23 years, with a GDP per capita growth of 2.01 per cent per annum, APEC outperformed the developing (1.47 per cent) and the developed (1.89 per cent) groups, as well as the world average (1.22 per cent), making it the most dynamic region on the globe.

Given the importance of the APEC region to the global trade and economic growth, I believe it is a worthwhile project to analyze the role of telecommunications industry in driving the dynamic economies in this region. Furthermore, the composition of the APEC membership allows me to conduct the analysis for both developed and developing countries in a unified framework. For these reasons, I make APEC region the subject of my analysis.

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[6] *http://www.apec.org/content/apec/about_apec.html*

Section 5: Structure of the thesis

The main objective of this thesis is to examine telephone penetration and economic growth, barriers and trade liberalization in telecommunications in the APEC region. In particular, this thesis is structured to embody three research projects, which respectively deal with the relationship between economic growth and telecommunications infrastructure, the measurement of barriers to trade and investment, and the impact of trade and investment liberalization on economic growth.

Table 1.7
Member economies of APEC

		Developed countries	OECD	Developing countries	Asian
1	Australia	x	x		
2	Brunei Darulssalam	x			
3	Canada	x	x		
4	Chile			x	
5	China			x	x
6	Hong Kong, China	x			
7	Indonesia			x	x
8	Japan	x	x		
9	Korea	x	x		
10	Malaysia			x	x
11	Mexico		x	x	
12	New Zealand	x	x		
13	Papua New Guinea			x	
14	Peru			x	
15	Philippines			x	x
16	Russia			x	
17	Singapore	x			
18	Chinese Taipei	x			
19	Thailand			x	x
20	United States	x	x		
21	Viet Nam			x	x
	Total	10	7	11	6

Note: Mexico is a member of OECD but classified as developing economies.

Source: APEC (2005)

The thesis is organized as follows. Chapter 2 reviews the literature on economic growth, the measures of trade liberalization and the impact of trade liberalization,

all in the context of telecommunications. Chapter 3 investigates the relationship between telephone penetration and economic output. Measurement of barriers to trade is discussed in Chapter 4 and the impact of trade liberalization on aggregate output is presented in Chapter 5.

CHAPTER 2:
LITERATURE REVIEW

This chapter reviews the relevant economic literature to this thesis. It is organized according to the three projects in this thesis: Section 1 explores previous studies on the relationship between economic growth and telecommunications infrastructure; Section 2 discusses the measurement of openness and liberalization; and Section 3 reviews previous studies on the impact of trade liberalization in telecommunications.

Section 1: Economic growth and telecommunications infrastructure

Growth models

The Neo-classical growth model pioneered by Solow (1956) is often quoted in the literature of the study of economic growth and income disparity within and between countries or regions. The Solow model shows that diminishing returns to accumulation of capital would eventually offset economic growth if there were no technological progress in a country or a region. This implies that long run growth is entirely determined by technological progress, which comes from outside the model. The result is derived on the assumption of constant returns to scale of an aggregate production function.

Since then, convergence issues, both absolute and conditional, have been well explored by Kelly (1982), Kocherlakota and Yi (1995), Leung and Quah (1996), De Long and Summers (1991), Barro and Sala-i-Marin (1992) and Mankiw et al (1992). However, those authors have not been very successful in explaining income disparities across countries or regions.

Romer (1986) casts his doubt about exogenous technological progress by introducing endogenous growth models, which assume that individuals do not internalize externalities, to explain long run economic growth. Romer (1990b) and King and Levine (1994) also show that there is little empirical support for a constant return to physical capital.

Arrow (1962), Lucas (1988) and Romer (1986) explain that growth could be sustained if there were positive externalities or spillovers from investment in inputs such as physical capital or human capital. These could be interpreted as new technologies that improve the productivity of physical and human capital. Issues pertaining to industries and innovations are explored by Rosenberg (1963), Constant (1980), Freeman (1982) and Mowery and Rosenberg (1989); those authors believe that new technologies would be invested by firms if there were potential prospects of future earnings.

Definition of capital

Issues of broad definition of capital which include not only private capital, but also human capital and public infrastructures, are raised and discussed by many theorists, such as Romer (1986), Mankiw, Romer and Weil (1992), Jones and Mannelli (1990), and King and Rebelo (1993), as the neoclassical growth model was unsatisfactory to explain economic growth in the long run. However, by including a human capital variable into the Solow-Swan model, Mankiw, Romer and Weil (1992) claim that their results were consistent with the assumption of diminishing returns and were more reflective of the data.

Achauer (1989) is among the pioneers to extend the output production function to include public capital stock or public infrastructure. He finds a strong positive relationship between public capital and productivity. The result is confirmed by

Canning (1999) who uses telephone per worker as the proxy for infrastructure in his neoclassical growth analysis.

Telecommunications infrastructure

Many authors attempt to distinguish telecommunications infrastructure from other types of infrastructures, such as transportation. According to Cieslik and Kaniesuka (2004), telecommunications infrastructure reduces the "transactions costs of trading ideas", as opposed to trading goods in the transportation infrastructure. By increasing the ability to communicate, the telecommunications system reduces the transaction cost of doing business, such as ordering, gathering information, and searching for information (Roller and Wavemen, 2001); it enhances the ability of engaging in new productive activities (Hardy, 1980) and it creates positive externalities to other sectors in the economy (Leff,1984). Faini (1983) finds that telecommunications infrastructure play a role in regional convergence[7].

Econometrics investigation and telecommunication variables

The relationships between economic performance and telecommunications infrastructure have been investigated by many researchers using different econometric methods, such as Ordinary Least Squares (OLS), Two-Stage Least Squares (2SLS), Three-Stage Least Squares (3SLS), and Generalized Method of Moments (GMM). The causal relationships between telecommunications infrastructure (investment) and economic performance are also discussed by various authors such as Blomstrom et al (1996), Cronin et al (1991), Madden and Savage (1998), and Cronin et al (1993)

[7]The impact of transportation infrastructure is ambiguous.

Various measurements of telecommunications infrastructure or investment have also been used, such as the market value of computer stock (Lichtenberg, 1994), the number of telephones (Hardy, 1980), miles of optical fibre cables and the number of ISDN[8] lines (Greenstein and Spiller (1996)), the number of mainlines per capita (Roller and Waverman, 2001) and both mainlines and mobile penetration rate (Chen, 2006). In fact, it appears that Chen (2006) is the first to use the mobile penetration rate.

Using the number of telephones per capita as telecommunications investment, Hardy (1980) finds a two-way causal relationship in telecommunications investment and GDP; he also finds a positive impact of telecommunications investment on GDP that is larger in the more developed countries than in developing countries. Likewise, Norton (1992) finds significant results in his single equation OLS estimation. He uses mean annual GDP for the sample years (1957-1977) as the dependant variable, while the telecommunication variables are represented by the number of telephones per 100 inhabitants in the beginning period and the average number of telephones for the sample period. The issue of causality is also discussed in that paper. Using the sub-state data of 101 local exchange carriers in the United States for the years 1988-1992, Greenstein and Spiller (1996), by employing 2SLS and 3SLS, show that telecommunications investment, measured by miles of optical fibre cables and number of ISDN lines, have substantial impacts on consumer surplus and telecommunications business revenue.

On the other hand, Pohjola (2002), who uses the share of ICT investment spending in GDP to proxy the investment in ICT capital, fails to observe any significant link between ICT investment and economic growth. He attributes the result to the productivity paradox[9], as the countries made insufficient amount of investment, and

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[8]Acronym for integrated services digital network, see glossary of terms.

[9] Standard measures of labor productivity in the U.S. suggest that computers, at least until 1995, were not improving productivity. The productivity paradox is the question: why, then, were U.S. employers investing more and more heavily in computers?
See *http://economics.about.com/od/economicsglossary/g/productivityp.htm*

he also blames the neoclassical method for the failure of capturing the essence of the ICT. Neither causality nor fixed effects issues are addressed by Pohjola (2002).

Owing to evidence that investment by telecommunication firms is caused by economic growth, Beil, Ford and Jackson (2005) employ the Granger-Sims causality test over a 50-year time series data and find that investing more in ICT does not necessarily yield higher output growth.

Taking advantage of panel data of 49 Polish regions, Cieslik and Kaniesuka (2004) find evidence of a relationship between income per worker and the number of telephones when controlling for individual heterogeneity. Roller and Waverman (2001), employing the more general class GMM estimation method, confirm the existence of a fixed effect in their analysis of 21 OECD countries. Chen (2006), on the other hand, uses a single equation with fixed effects for OECD countries and obtains an estimate comparable to Roller and Waverman (2001).

It is generally observed that any attempt to estimate the output elasticity with respect to inputs is subject to simultaneity bias, that is, the regressors are correlated with the disturbances and are thus generating biased results. Unlike other authors who often apply a single equation to estimate a reduced-form equation, Roller and Waverman (2001) use a simultaneous equation approach to estimate four structural equations. They endogenize the telecommunication variables in a macro output production function and find a more realistic result. However, they do not include mobile phones in their analysis.

In Chapter 3 of this thesis, I adopt the same framework as Roller and Waverman (2001) to examine the impact of telecommunications infrastructure on the output of the APEC region, with the addition that cellular mobile services are included along with fixed or mainline telephone services. This analysis captures the effects of the recent rapid development in the mobile technology.

Section 2: Measurement of openness and liberalization

What is trade liberalization?

Trade liberalization in telecommunications traditionally takes the path of sector reform through privatization, introduction of competition and regulatory reform[10]. Privatization is always interpreted as a process of transforming from state-owned to private ownership. Varoudakis and Rossotto (2004) define a competitive market as one having low barriers to entry, price towards marginal costs and absence of collusive behaviour among the operators. The most common barriers to trade and investment in services are embedded in regulation as suggested by Deardorff and Stern (2003).

Privatization

Various measures have been utilized to proxy the reform variables. Many researchers, such as in Bortolotti et al (2002), Megginson et al (1994), Wallsten (2001) and Fink, Mattoo and Rathindran (2003) use dummy variables to indicate partial or complete privatization. In fact, it is very rare to observe 100 per cent privatization; governments are somehow directly or indirectly involved in the welfare of the privatized incumbents. As noted by many, privatization is always partial and foreign restrictions are always an issue. Ros (1999) uses a benchmark of at least 50 per cent private ownership to indicate if the incumbent is privatized or

[10] Most empirical literature puts it this way, but Manner (2002, p.6-9) defines the process of achieving competition as: privatization+liberalization+effective regulation; in the book, privatization refers to a country eliminating complete or partial government ownership in its telecommunications service providers; liberalization is the process of allowing competitive service providers into a specific sector of the telecommunications industry or into the telecommunications industry as a whole that has formerly been closed to new entrants; effective regulation is the creation of a rational regulatory scheme, which provides for a transparent process and allows the regulator to enforce its rules in an effective manner.

not. Bortolotti et al (2002) use state ownership as an additional variable in their study.

Regulatory reform

Although Levy and Spiller (1994) broadly categorize regulations into governance and content, the existence of an independent regulatory regime is adopted as the proxy for reform in regulation by many researchers, such as Bortolotti et al (2002), Wallsten (2001), Fink, Mattoo and Rathindran (2003) and Estache, Goicoechea and Manacorda (2006). The independent regulatory measure in their studies is a dummy variable indicating whether the country has a separate telecommunications regulatory agency not directly under the control of a ministry. Gauging the independent regulatory authority using a dummy variable may be too simplistic, since there is no such complete independence in the real world.

A few studies have attempted to quantify the degree of independence of regulators. Edwards and Waverman (2006) construct an index for the national regulatory authorities (NRA) which are responsible for the telecommunications industry within the European Union. The index, which measures the regulatory independence from the influence of government, draws upon the NRA characteristics, member appointments and terms of office, resources and experience.

The NRA characteristics are quantified by Edwards and Waverman (2006) through variables such as whether or not the NRA is a single or multi-sector jurisdiction, whether or not it is a single or multi-member body, the source of funding, reporting, power over interconnection issues and shared role with the government.

Gutierrez (2003) focuses on regulatory governance rather than incentive regulation. His regulatory framework index is based on three dimensions, namely

the legal mandate of the NRA, separation of regulatory functions from providing telecommunication services and the independence of the NRA, and four main characteristics, namely autonomy and independence, accountability, clarity of roles and objectives, and transparency and participation. These four characteristics are then formulated into six main factors such as financial and budgetary independence, removal of commissioners, power to set tariffs, power to fine operators, mechanism of solving disputes, and finally, the existence of a public hearing mechanism.

Introducing competition

The number of licensed mobile operators not owned by the incumbent is used as an indicator of competition in the telecommunications market by Bortolotti et al (2002) and Wallsten (2001). Ros (1999) uses a dummy variable to indicate if competition is allowed in the local, long distance or international segments of the telecommunication services, while Fink, Mattoo and Rathindran (2003) only look at the local service to determine if there is competition in a country. ITU considers that a segment of service, such as mobile, is competitive if more than one operator is allowed in the market, while Warren (2000a) considers it competitive only when there are at least three operators.

Trade liberalization

Many who study trade liberalization use dummy variables to indicate market reform in their empirical analysis. Some use an index as a measure of liberalization, but this is far from perfect from the perspective of the WTO.

In the context of the WTO on trade liberalization, quantification of the GATS schedules commences with the pioneering work of Hoekman (1995) who develops

a three-category weighting method: "none" if no restrictions are applied on either market access or national treatment; "unbound" if no policies are bound for a given mode of supply/sector; "other" – if restrictions are listed for a mode of supply/sector.

With the implementation of ABT, Marko (1998) sets out various impediments covered by the agreement using a standard framework of market access and national treatment to examine the four modes of supply (cross-boarder, consumption abroad, commercial presence and presence of natural persons). A frequency measure of the telecommunication impediments is calculated for each country based on its commitments.

On the other hand, Warren (2000a) comes out with a more comprehensive measure in the context of trade liberalization than other indices computed in the literature. He details a set of frequency indices of impediments to trade in telecommunication services that moves away from the traditional reliance on the GATS or various other trade agreements as the primary source. The indices are constructed from the ITU survey of actual policies, rather than those inferred from commitments made in trade negotiations.

Warren (2000a) attempts to distinguish between market access and national treatment under which a few sub-indices in trade and investment are also created. The indices under market access measure policies that discriminate against both domestic and international potential suppliers who wish to provide cross-border telecommunication services, and also those locals and foreigners who intend to invest in fixed and mobile network services. The indices under national treatment measure the policies that discriminate against potential foreign suppliers of cross-border services, and also those foreigners who intend to operate fixed and mobile services through investment. Warren (2000a) also provides an index of liberalization based on the simple average of the above indices.

Warren (2000a) makes use of the 1997 domestic and international resale data from ITU to capture the restriction on market access of all potential suppliers. The market access index on investment of all potential suppliers is based on data such as whether or not competition exists in the fixed/mobile services; whether or not policy allowed for competition and the percentage of incumbents that are privatized. Different weights have been assigned on these issues. He relies on call-back services data and foreign ownerships for the construction of the national treatment indices. His work, however, is incomplete, as it does not take into consideration the regulatory principles of ABT as specified in the Reference Paper. The concern of the literature not addressing the issue of regulatory principles is expressed by Blouin (2000).

Instead of using dummy variables or a simple index of openness to capture reform as discussed in previous studies, in Chapter 4 of this thesis, I extend the work of Warren (2000a) using the most recent 2005 ITU survey to construct a policy index or a composite index in terms of market access, national treatment and regulatory principles taking into account the status of privatization, competition and regulation of each country. Thus, the policy index is capable to measure the degree of trade liberalization in telecommunications, within the context of WTO.

Section 3: Impact of trade liberalization

Privatization

The impact of privatization has been examined extensively in the business environment, typically at the firm level. The benefits of privatization are shown by Bortolotti et al (2002). Using financial and operating performance data of 31 telecommunication firms in 25 countries, they find significant results in terms of the performance of the firms. Similar results in terms of improved sales, profits, investment and employment are also reported by Megginson et al (1994).

Ambrose et al (1994), however, cast some doubts on the competitive outcome arising from privatization since the privatized firms may still be able to demonstrate some market power, especially in the early stage given their dominant position in the business. Balakrishnan et al (2005) find no evidence of a reduction in market power in the case of trade liberalization in India.

Regulatory reform

Without looking into privatization, using the existence of an independent regulatory authority as a proxy for regulations reform, Estache, Goicoechea and Manacorda (2006), in a cross-country study, find that the reform provides benefits to the telecommunications industry in terms of affordability and labour productivity, but not in terms of the quality of services. Network expansion and efficiency are also found to be positively related to regulatory governance in telecommunications, as shown by Gutierrez (2003). On the other hand, Evans et al (1996) show that the total annual gain from deregulation of the telecommunications in New Zealand is estimated to be NZ$575 million.

Introducing competition

There is no doubt that introducing competition generates lower costs of information and helps push for better internal and technical efficiency, as shown by Levy and Spiller (1996). Ros (1999) finds that, through competition, technical innovation improves network expansion. Varoudakis and Rossotto (2004) suggest that greater competition increases productivity, which reduces costs and helps bring down price. As they observed in the Middle East and North Africa (MENA) countries, full market openness could boost labour productivity by approximately 60 per cent, while lowering the costs by approximately 50 per cent. On the other hand, Wallsten (2005) finds that without the threat of government, telephone penetration in the

European countries is generally higher when competition is allowed amongst the operators.

Performance of reform variables and the sequence

This raises a question amongst the reform variables, which is better and which should be introduced first? Reform in regulations is often given low priority compared to privatization, as privatization is usually motivated by fiscal crisis and people generally believe that it can be implemented more quickly than regulation reform. Also, with regulation, it is feared that the authority will interfere in the market mechanism (Wallsten et al (2004)). In a case study of developing countries, Wellenius et al (1993) find that many countries first choose to privatize the telecommunication firms, and then build up their regulatory capacity in a later stage. Winston (1993) cites the cost of regulation that pushes developed countries to move towards deregulation regimes. These countries are, for example, New Zealand and Australia (Abbot and Brady (1999)). Hahn (2000) sees privatization as an initial stage of deregulation. Huber, Mathew and Thorne (1997) suspect that regulation does not perform efficiently, as it often protects the interest of the industry incumbent from competing with others. They provide evidence of substantial costs associated with telecommunications regulation. Li, Qiang and Xu (2005) argue that regulatory reform is less likely if there is an incumbent which has already incurred a large amount of investment in the telecommunications. Lee and Levendis (2006) suggest that countries that demonstrate inferior sector performance have more incentive to initiate a regulatory reform.

At the firm level, unlike Borolotti et al (2002) who attribute a large portion of the improvements in firms' performance to regulatory changes rather than to privatization, Galal et al (1994) show evidence of welfare effects of privatization, but they are not able to separate the effects from contemporaneous changes in government policies. Levy and Spiller (1996) suggest that without regulation,

privatized firms may be reluctant to roll-out in the unprofitable or high cost areas, and thus depict a negative impact on network expansion. They point out that low penetration in developing countries with unmatched demand may be the result of insufficient supply (or lack of competition). Wallstein (2001) confirms that privatization alone without regulation reform does not provide evidence of improved performance in the telecommunications sector.

The study of the sequence of the reforms, in terms of privatization, regulation and competition, has attracted the attention of many researchers, such as Wallsten (2002) and Fink, Mattoo and Rathindran (2003). Wallstein (2002) shows the improvement in investment and telephone penetration when a regulatory authority is established prior to privatization. Putting regulation in place before privatization seems to create a more competitive environment, minimizing the possible abuse of dominant position by the incumbent. On the other hand, Fink, Mattoo and Rathindran (2003) suggest that competition should be introduced prior to privatization if higher telephone penetration is desired, while Li and Xu (2004) find evidence that competition and privatization are complements as they both lower the price of services and deepen the telephone penetration rate. Supporting the findings of Li and Xu (2004), Parker and Kirkpatrick (2005) conclude that, in order to generate the best outcome of privatization, it has to be complemented by policies that promote competition and effective regulations. However, competition works well and is superior to privatization only in the presence of lower sunk costs and network externalities, as pointed out by Willner (2006). On the other hand, privatization can be facilitated by foreign aid in developing countries, because it has the ability to establish a pro-competitive regulatory authority (Banerjee and Rondinelli, 2003).

Addressing endogeneity of reform variables

As discussed above, trade liberalization is always instrumented by market reforms such as privatization, regulations and competition. People typically expect more competition in a particular market as a result of the reform without defining explicitly what exactly competition is. Although privatization is always seen as a good indicator of introducing competition in a country, many researchers challenge its effectiveness if the government still owns a substantial amount of shares of incumbents in industries such as telecommunications, transportation or electricity. Regulation or an inefficient regulator is also seen as anti-competitive and it poses an impediment to trade.

Privatization alone may not capture the maximum welfare in an economy. Instead, the reform variables of privatization, regulations and competition interact in a very complex way. The literature tends to assume that privatization, regulation or competition is exogenous, but this may be unrealistic. Ros (1999) uses an instrumental variable approach to address the possible endogeneity of the privatization and competition variables, while Gutierrez (2003) addresses the endogeneity of privatization by running a logit[11] model. Others like Fink, Mattoo and Rathindran (2001) and Wallsten (2001) simply create interaction terms of these reform variables. Nevertheless, private ownership and regulation reform in general are still perceived as a positive gesture of a government to promote competition.

Attempting to address the endogeneity of the reform variables, an index of openness is constructed by Mattoo, Rathindran and Subramanian (2001) which uses three parameters: market structure, foreign ownership or investment allowed, and the existence of an independent regulator, where each of these parameters is assigned a binary code such as Yes/No. The authors then ranked the country's

[11] A Logit model is derived from the cumulative logistic probability function which provides the probability that the event will occur while one minus this function provides the probability that it will not occur; see Kennedy (2001), p234.

openness based on a lexicographic scheme from 1 to 9, where a rank of 9 indicates that the market segments are competitive, that foreign direct investment (FDI) is allowed and that there exists an independent regulator in that country, while a rank of 1 is assigned to a country where the market segments of the service are not competitive, FDI is not allowed and an independent regulator does not exist. In cases where the level of competition in more than one of the three market segments or the ownerships in these segments are different, a weighted average method was applied to calculate the index assuming equal weight across segments. Amongst the three parameters in the index, level of competition allowed is ranked highest, followed by foreign ownership, while regulation (which proxies the existence of an independent regulator) is ranked lowest.

Li and Xu (2002) measure the extent of privatization of the telecommunications sector using the observed share of non-state ownership of the sector. Their competition variable is constructed using the principal component analysis of six indicators in a multiple player environment (each for fixed phones and mobile phones), pro-competition initiatives (each for fixed phones and mobile phones) and interconnection charges (each for fixed phones and mobile phones). An indicator of telecommunications liberalization was created by Varoudakis and Rossotto (2004) that takes into consideration degree of competition in different segments of services, openness to foreign direct investment and the presence of an independent regulatory authority. As well, Warren (2000b) uses a set of restrictiveness indices to avoid endogeneity in his policy variable.

Econometric approach

The most common econometric approach for the analysis of the impact of liberalization has been Ordinary Least Squares and most authors, including

Warren (2000b) and Chen (2006), utilize a reduced-form equation[12]. Only a few studies like Ros (1999) and Gutierrez (2003) employ an instrumental variable approach or Two-Stage Least Squares. The causality between income, network expansion and/or investment has not been well addressed by studies on the impact of telecommunications reform. Warren (2000b) assumes that the causality runs from trade liberalization to network penetration. Roller and Waverman (2001) attempt to address the causality issues involving income, network expansion and investment by estimating structural equations simultaneously using a Generalized Method of Moments (GMM) approach in the study of growth and network expansion; the issues of barriers to entry and the recent development in mobile technology, however, are not addressed by them.

Chapter 5 of this thesis extends the work in Chapter 3 with an aim to improve upon Warren (2000b) by carefully entering a policy variable into the system of equations. Not only is Chapter 5 able to examine the relationship between output growth and network infrastructure including mobile technology, but it also manages to analyze and quantify the extent of trade liberalization in telecommunications.

[12] Although the estimation of one equation (reduced-form) has the advantage of computational simplicity, the dependence of the endogenous variables with the disturbances causes the ordinary least squares estimator inconsistent as it ignores the important information embodied in the structural equations, see Greene (2003), p. 379 and p.396.

CHAPTER 3:
TELEPHONE PENETRATION AND ECONOMIC GROWTH

The purpose of this chapter is to examine the growth effect of telecommunications infrastructure on output among the APEC member economies. As explained in the literature review, few studies focus on APEC. Following Roller and Waverman (2001), I endogenize the stock of telecommunications into a macro level of output production function by specifying a micro model of demand and supply for telecommunication services.

The chapter is organized as follows. An analytical framework is introduced in Section 1. Data and methodology are discussed in Section 2. Results of the estimation are presented in Section 3, while Section 4 draws conclusions of the chapter.

Section 1: Model framework

Aggregate economic output

In the neoclassical Solow model, the output (Y) of an economy, in general, is a function of capital (K), labour (L) and knowledge of the effectiveness of labour (A) which can be expressed as

$$Y = f(K, AL) \tag{3.1}$$

Mankiw, Romer and Weil (1992) extended the basic Solow Model to include more than one type of capital stock, which is human capital (H). In their paper, they assume that technical change is labour-augmenting and that there are constant returns to scale in production

$$Y = f(K, H, AL) \tag{3.2}$$

This chapter follows Roller and Waverman (2001) who include telecommunications capital[13] (C) as the fourth input in the production function

$$Y = f(K, H, C, AL) \tag{3.3}$$

Assuming a Cobb-Douglas production function, and adding a time trend variable (t), equation (3.3) can be expressed as

$$Y = K^{a_1} H^{a_2} C^{a_3} (AL)^{a_4} e^{a_5 t} \tag{3.4}$$

Without imposing constant returns to scale in production, equation (3.4) can be rewritten in a logarithmic form

$$\log Y = a_1 \log K + a_2 \log H + a_3 \log C + a_4 \log AL + a_5 t \qquad \text{or}$$

$$\log Y = a_0 + a_1 \log K + a_2 \log H + a_3 \log C + a_4 \log L + a_5 t \tag{3.5}$$

where $a_0 = a_4 \log A$ is the constant term. a_1, a_2, a_3 and a_4 each represents the elasticity of the input with respect to the output. The term A in equation (3.5) not only reflects technology, but also resource endowment, climate, institution, etc.

By incorporating a country-specific shock (ε) into equation (3.5), the estimation of the parameters can be easily implemented. It is important to assume that the shock has conditional expectation equal to zero so that it can be used to form orthogonality conditions to identify the parameter of the model. In a panel data setting country i and period t we can express equation (3.5) as

[13] In this thesis, telecommunications capital, telecommunications infrastructure and telecommunications network are used interchangeably.

$$\log(Y_{it}) = a_{0i} + a_1 \log(K_{it}) + a_2 \log(H_{it}) + a_3 \log(C_{it})$$

$$+ a_4 \log(L_{it}) + a_5 t + \varepsilon_{it}^1 \qquad (3.6)$$

All coefficients, except the time trend, are expected to have positive signs. In other words, the higher the amount of input stocks the higher the aggregate output will be generated. The individual effects a_{0i} are fixed but not common across $i = 1,...N$. To test the fixed and common individual effects, intercept (a_0) can be included as in equation (3.7).

$$\log(Y_{it}) = a_0 + a_1 \log(K_{it}) + a_2 \log(H_{it}) + a_3 \log(C_{it}) \qquad (3.7)$$

$$+ a_4 \log(L_{it}) + a_5 t + \varepsilon_{it}^1$$

For simplicity in my subsequent investigation, I label the model with individual effects but not common as Model with Fixed Effects, while model with fixed and common individual effect is labeled as Model without Fixed Effects.

Demand function of telecommunications

As in Roller and Waverman (2001) the demand for telecommunications capital can be represented as a function of output per capita (GDP/POP) and of the price of telecommunication services $(TELP)$. POP is the population variable.

$$C_{it} = g\left(Y_{it} / POP_{it}, TELP_{it}\right) \qquad (3.8)$$

I expect that the higher the income per capita of a country, the higher the demand for telecommunications (positive relationship). If the telecommunication services are a normal good, it is then reasonable to expect the price to be an inverse impact on demand (negative).

Investment function of telecommunications

Roller and Waverman (2001) specify investment in the telecommunication services (TTI) as a function of price (TELP), the size of a country (GA), government budget deficit (GD) and waiting list (WL)[14].

$$TTI_{it} = h(TELP_{it}, GA_{it}, GD_{it}, WL_{it}) \qquad (3.9)$$

We expect that the higher the price of services, the more the producer is willing to supply or invest (positive). We also predict that the size of a country and hence access to resources has positive impact on the supply of telecommunications. However, the impact of government budget deficit is ambiguous; it may be related to how the investment of the infrastructure is financed. For some countries, investment may be financed through budget deficit. Also, the longer (higher) the waiting list the more investment, whether private or government, can be expected; thus there should be a positive relationship.

Production function of telecommunications

As suggested by Roller and Waverman (2001), the infrastructure production function is given by the change in the stock of telecommunications infrastructure as

[14] The number of applications for a connection to a main telephone line that have had to be held over owing to a lack of technical availability, see glossary of terms in Appendix A.

a function of the investment (TTI) and a vector of exogenous variables affecting the production of telecommunications infrastructure, such as the size of a country.

$$C_{it} - C_{i,t-1} = k(TTI_{it}, GA_{it}) \tag{3.10}$$

The change in telecommunications capital is expected to be positively related to investment and to the size of a country. We expect higher level of investment to lead to higher growth of the telecommunications infrastructure. Also, a larger country (proxy for access to resources) is able to accumulate the stock of telecommunications infrastructure faster than a smaller one (positive).

Section 2: Data and methodology

To date, there are 21 member economies or territories in APEC: Australia, Brunei Darussalam (Brunei), Canada, Chile, People's Republic of China (China), Hong Kong, Indonesia, Japan, Korea, Malaysia, Mexico, New Zealand, Papua New Guinea, Peru, Philippines, Russia, Singapore, Chinese Taipei (Taiwan), Thailand, United States and Viet Nam. In my subsequent discussion, I may use member economy and country interchangeably, although the term country in this paper does not necessarily reflect the sovereignty of a particular member economy.

My data are mainly obtained from two sources: the World Bank's World Development Indicators (WDI) Database and ITU's World Telecommunication Indicators Database (ITU). Macroeconomic data are mainly from WDI, while the ITU database provides data on the telecommunications industry. International Financial Statistics (IFS) and the Asian Development Bank (ADB) provide alternative sources for some macroeconomic data. WDI does not provide any data about Taiwan; thus the data on Taiwan is retrieved from ADB.

I have identified the sample period to be the years 1982 to 2003 for 17 member economies of APEC. The beginning period of the sample is mainly constrained by the telecommunications investment data in the database, where most of the time series data were incomplete until at least 1982. There were 4 countries which had insufficient observations. Thus, after eliminating Brunei, Papua New Guinea, Russia and Viet Nam, there are 17 member economies available from the database. The end period of the sample is determined by the investment and revenue data.

Data on population, geographical areas (in square km), total labour force, Gross Domestic Products (GDP, in constant 2000 US$) and Gross Fixed Capital Formation (GFCF, in constant 2000 US$) are obtained from WDI. For government budget deficits data, I use the IFS dataset. I also utilize the government budget deficit in percentage of GDP from APEC[15] and OECD[16] sources to supplement the IFS dataset. The number of mainlines in operations, the number of cellular mobile subscribers, waiting list, total telecommunications revenue (TTR), telecommunications revenue (TR) (both TTR and TR are in current local currency units, LCU) and annual investment in telecommunications (in current LCU) are obtained from the ITU database.

To ensure data consistency in the APEC member economies, GDP, GFCF, government budget deficit, telecommunications revenue and telecommunications investment data are all standardized and converted into constant 2000 US$ using an official exchange rate (average) in 2000. WDI uses an alternative conversion factor for some countries where the official exchange rates were not reflective of the actual foreign exchange transactions.

[15] APEC Economic Outlook, 2005.
[16] OECD Economic Outlook, 2006.

Capital stocks

The literature often utilizes physical capital stock from the Heston, Summers and Aten (2002) data set. In the data set, the physical capital stock is defined as the cumulated, depreciated sum of past gross domestic investment in producers' durable, non residential construction and other construction using a perpetual inventory method. However, the data are only available until 1992.

By employing the same methodology, I computed capital stock using the perpetual inventory[17] method and assuming that capital stock depreciates at a constant rate of δ. The capital stock available at the beginning of period $t+1$ is the sum of the net capital stock after depreciation at the beginning of time t plus the investment at time t

$$K_{t+1} = (1-\delta)K_t + I_t$$

where K_t is the capital stock at time t, K_{t+1} is the capital stock at time $t+1$ while I_t is the real gross investment. By repeated substitution,

$$K_{t+1} = \sum_{i=0}^{\infty}(1-\delta)^i I_{t-i}$$

In practice,

$$K_{t+1} = (1-\delta)^t K_1 + \sum_{i=0}^{t-1}(1-\delta)^i I_{t-i}$$

where K_1 is the initial capital stock at the beginning of period 1, but I do not have the initial capital stock for 1982. Following Kamps (2003) and Jacob et al (1997), in order to obtain the initial capital stock, I computed an artificial investment (net of investment in telecommunications $(I_t = GFCF - TTI)$ series for each of the 17

[17] See Heston, Summers and Aten (2002).

member economies for 50 years from 1932 to 1981, implying that the service life of physical capital stock is 50 years, on average. Based on the investment data available for 1982-2003, the annual growth rate is 5 percent. Thus, it is reasonable to assume that the investment grow at the same rate per annum during the 1932-1981 periods. I then let the capital stock depreciate at a rate of 10 per cent and finally arrived at its observed level in 1982.

Human capital

The human capital of a typical worker is assumed to be the average years of schooling among the population of age 15 and above, obtained from Barro and Lee (1993, 2001) data set. The data set in Barro and Lee is presented at 5 year intervals until year 2000. Using the cumulative annual growth rate over period of 1980-2000, I estimate the average years of schooling for years 2001-2003.

It is worth mentioning that schooling data used as proxy for human capital may be subject to measurement errors as pointed out by Krueger and Lindahl (2001). More years of schooling does not necessarily associate with higher level of skills in a study on the international immigrants to Canada as found in Coulombe and Tremblay (2005). Cieslik and Kaniewska (2004) enter both human capital of a typical worker and the total labour force into the production function exogenously, while Barro and Sala-i-Martin (2004, p. 240) defines the human capital stock as the average years of schooling multiplied by the total labour force.

Since the pairwise correlation between average years of schooling (HK) and the total labour force (TLF) is small (-0.2188)(see Table 3.2), I treat these two variables separately in my aggregate output equation.

Telecommunications infrastructure

As we have seen from the literature, various measures such as computer stock, number of telephones per capita, number of mainlines per capita, miles of optical fibre cables, number of ISDN lines, as well as the investment data, have been used to proxy the telecommunications stock or capital. Other variables, such as Internet users or the number of computers may be used as part of the measures of infrastructure in the convergence industry. These variables, however, when included together, may over-represent the contribution of telecommunications or ICT in the economy in question.

Table 3.1
Descriptive statistics of variables

Variables	Description	Number of Observations	Mean	Standard Deviation	Minimum	Maximum
GDP	GDP in billions 2000 US$	374	883.44	1,981.60	25.30	10,330.00
KA	Capital stock net of telecom capital in billion 2000 US$	374	1,249.76	2,690.90	30.45	13,488.88
HK	Average years of schooling	374	8.11	2.27	3.80	12.05
TLF	Total labour force in millions	374	65.43	154.78	1.25	759.43
POP	Population in millions	374	124.53	269.39	2.65	1,288.40
GA	Geographical area in thousand km (square)	374	2,532.09	3,567.11	0.61	9,327.42
GD	Government budget surplus(deficit) in billion 2000 US$	374	-25.58	79.75	-383.74	254.62
t	Time trend	374	11.50	6.35	1.00	22.00
GDPPC	GDP per capita (GDP/POP)	374	10,774.77	10,305.81	207.92	37,650.60
MLPC	Number of mainlines per capita (ML/POP)=PEN1	374	0.27	0.22	0.00	0.68
CMPC	Number of cellular mobile subscribers per capita (CM/POP)	374	0.12	0.22	0.00	1.14
WLPC	Number of waiting list per capita (WL/POP)	374	0.00	0.01	0.00	0.03
PEN2	MLPC+CMPC	374	0.38	0.37	0.00	1.73
LOW	Dummy variable =1 if $PEN_i \leq 20$ per cent, and 0 otherwise	374	0.41	0.49	0	1
MED	Dummy variable =1 if <20 $PEN_i < 50$ per cent, and 0 otherwise	374	0.30	0.46	0	1
HIGH	Dummy variable =1 if $PEN_i > 50$ per cent, and 0 otherwise	374	0.29	0.45	0	1
ED01	MLPC+WLPC	374	0.27	0.21	0.00	0.68
ED02	MLPC+CMPC+WLPC	374	0.39	0.37	0.00	1.73
TTI	Investment in telecommunications in billion 2000 US$	374	4.84	8.61	0.01	37.17
TELP1	Price of telephone services in 2000 US$	374	643.28	287.38	91.37	1,744.76
TELP2	Price of telecommunications services in 2000 US$	374	741.46	343.88	69.67	2,907.94
DEVD	Dummy variable for developed countries=1 and 0 otherwise	374	0.53	0.50	0	1

Note:
PEN_i, i=1,2

Source:
WDI, ITU and own calculations

Ideally, we can use an ICT index that combines all these variables, but in reality a long series of the index is difficult to obtain given the fact that other data (than number of mainlines) were made available only recently. Thus, at this moment, I will only focus on the number of mainlines (fixed lines) and mobile phone data. Although there might be some issues like whether there is interplay between fixed

and mobile networks, I assume that both are identical, independent and additive. The number of cellular mobile phone subscribers is generally used by various ITU publications as a proxy for the size of mobile networks or infrastructure. For this chapter, I define telephone penetration rate as mainline per capita and/or cellular mobile phone subscribers per capita.

Correlations matrix and descriptive statistics

Table 3.1 provides the simple descriptive statistics of the variables. It should be noted that there is a huge income per capita disparity in the sample, from a low of $208 (China, 1982) to a high of $37,651 (Japan, 2003), with an average of $10,775. Acknowledging this fact, I have created a dummy variable for developed economies, DEVD=1 and 0 otherwise. Based on the year 2003 data, member economies which earns above average per capita income are treated as developed economies; there are nine of them: Australia, Canada, Hong Kong, Japan, Korea, New Zealand, Singapore, Taiwan and the United States. The remaining eight member economies are then automatically defined as developing economies.

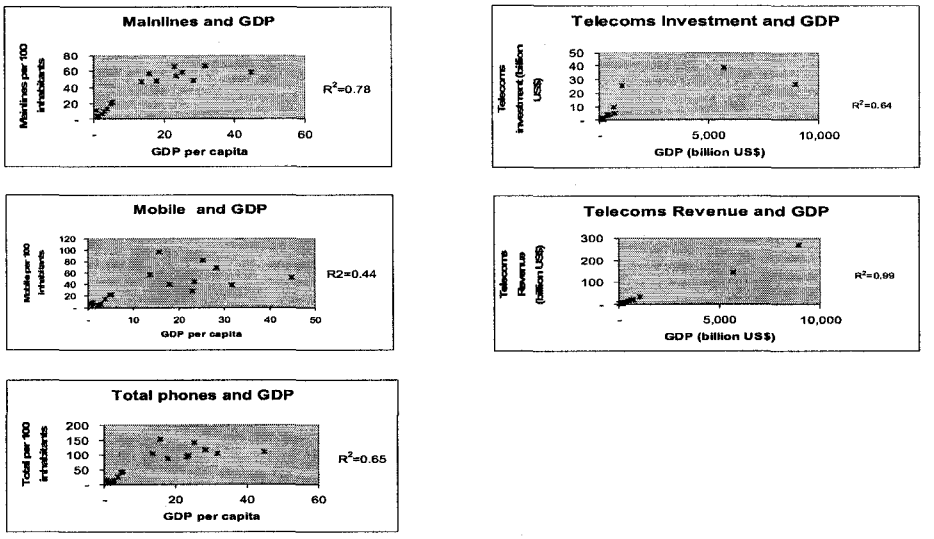
Table 3.2
Pairwise correlations

	GDP	ML	CM	WL	HK	KA	TLF	TTI	GD	GA
GDP	1									
ML	0.9231	1								
CM	0.5887	0.6837	1							
WL	-0.1871	-0.1748	-0.1439	1						
HK	0.4395	0.4423	0.2469	-0.4520	1					
KA	0.9539	0.8102	0.5857	-0.1846	0.3773	1				
TLF	0.1321	0.2838	0.2219	0.3080	-0.2188	0.1146	1			
TTI	0.9125	0.8346	0.5766	-0.1796	0.3930	0.9497	0.2105	1		
GD	-0.4189	-0.5032	0.1272	0.0638	-0.2833	-0.2378	-0.0980	-0.3447	1	
GA	0.3564	0.4999	0.2480	0.0064	0.3458	0.2317	0.5397	0.2880	-0.4022	1

Source:
WDI, ITU and own calculations

Table 3.2 shows the Pairwise Correlations of the data. It can be seen that there are very high correlations between GDP and the number of mainlines, ML (0.9231) which implies possible causality between these two variables. ML in turn is also highly correlated with telecommunications investment, TTI (0.8346). Thus, I suspect that the ML variable may be determined endogenously within a system of equations.

Figure 3.1:
Correlations between telecommunications and GDP



Note:

The graphs are plotted based on the year 2000 data: 17 member economies of APEC. R^2 is computed based on the univariate linear regression with GDP per capital or GDP as the dependent variable.

Figure 3.1 shows the graphical relationship of the telecommunication variables and GDP in 2003. Mainlines per 100 inhabitants can explain 78 per cent of the data variability in GDP per capita, whereas mobile penetration explains about 44 per cent and total penetration explains 65 per cent of the data. On the other hand, the investment and revenue data each explain about 64 and 99 per cent of the GDP in year 2003.

System of equations for econometric estimation

From the output equation (3.6), demand (3.8), supply (3.9) and the production (3.10) functions, we can form a system of equations

$$\log(GDP_{it}) = a_{0i} + a_1 \log(KA_{it}) + a_2 \log(HK_{it}) + a_3 \log(TLF_{it}) + a_4 \log(PEN_{it}) + a_5 t + \varepsilon_{it}^1 \quad (3.6)$$

$$\log(PEN_{it} + WLPC_{it}) = b_0 + b_1 \log(GDPPC_{it}) + b_2 \log(TELP_{it}) + \varepsilon_{it}^2 \quad (3.11)$$

$$\begin{aligned} \log(TTI_{it}) = {} & c_0 + c_1 \log(GA_{it}) + c_2 GD_{it} \\ & + c_3 (1 - DEVD) WLPC_{it} \\ & + c_4 (1 - DEVD) \log(TELP_{it}) \\ & + c_5 DEVD \log(TELP_{it}) + \varepsilon_{it}^3 \end{aligned} \quad (3.12)$$

$$\log(PEN_{it} / PEN_{i,t-1}) = d_0 + d_1 \log(TTI_{it}) + d_2 \log(GA_{it}) + \varepsilon_{it}^4 \quad (3.13)$$

where GDP is Gross Domestic Product in constant 2000 US$; KA is physical capital stock net of telecommunications; TLF is the total labour force and PEN is the proxy variable for telecommunications stock, measured by mainlines per capita (MLPC) and/or cellular mobile subscribers per capita (CMPC); there are two variants: $PEN = PEN1 = MLPC$ and $PEN = PEN2 = MLPC + CMPC$.

$TELP_i (i = 1,2)$ is the price of telecommunication services; I use telephone revenues per mainlines $(TELP_1)$ as a proxy for the price of fixed line services and $TELP_2$ as the price of telephone services using total telecommunications revenue (TTR) per telephone data, where telephone is defined as the number of mainline plus the number of mobile subscribers. GDPPC measures the GDP per capita. WLPC

represents the waiting list per capita; Real investment in telecommunications is TTI; GA is the geographical areas in thousand square kilometers; Government deficit is in constant billion 2000 US$ is given as GD; DEVD represents dummy variable for the developed economies, which is 1, and 0 otherwise (see Table 3.1).

In the investment equation, the developed member economies are dummied out in term of the prices and the waiting list, since these economies possess competitive suppliers in the telecommunications market, and thus a different price elasticity of supply should be expected.

As PEN is bounded between 0 and 1 with a maximum of 0.68, and 1.73 when include CMPC, I transform PEN into an unbounded variable using the formula $PEN = PEN/(a - PEN)$ where $a = 1.8$. This transformation was also used by Roller and Waverman (2001). Similarly, the waiting list per capita $(WLPC)$ with a maximum of 0.032 is recomputed as $WL = WL/(a - WL)$ using $a = 0.1$. Accordingly, the effective demand which is $ED = PEN + WLPC$ is also redefined as $ED = ED/(a - ED)$ where $a = 1.8$.

The specification with fixed and without fixed effects is only applied to the aggregate output equation, all other equations are assumed to have fixed and common intercepts[18]. The error term in each equation is assumed to have conditional expectation that is equal to zero and serially uncorrelated. The system of equations is estimated using the Generalized Method of Moments (GMM) approach[19] and the testing of over-identifying restrictions is explained in Appendix C.

[18] Also see Appendix F.
[19] See Appendix B.

Section 3: Estimation and results

The estimation of the system of equations is undertaken by OLS as well as with nonlinear GMM. Econometric theory predicts that estimation by OLS method is subject to simultaneous bias especially when we have endogenous variables in the model.

Nevertheless, I present the result of OLS in Appendix D for reference. I briefly summarize the result here. There is no clear evidence of fixed effects across models, as the coefficient of the PEN variables vary only slightly once there is control for fixed effects; the worst thing is that the human capital coefficient turns negative (Model A2). Also, once I include cellular mobile, the PEN variable becomes insignificant (Model A3). In fact the magnitude of the PEN coefficients in OLS (for all models) is similar to that of the GMM models (with fixed effects). The price variables in the investment equation are negative across the OLS models; the outcome is worrisome as price is always seen as an incentive for investment.

I now discuss in detail the results generated by the GMM models. There are four models estimated by nonlinear GMM, presented in Table 3.3. Model 3.1 uses PEN1 without controlling for the fixed effects; Model 3.2 uses PEN1 controlling for the fixed effects; Model 3.3 uses PEN2 without controlling for the fixed effects; and Model 3.4 uses PEN2 controlling for the fixed effects.

From Model 3.1, in the output equation, all the coefficients have the expected signs which are positive and significant at either the 1 or 5 per cent level. The elasticity for physical capital, human capital, labour and telecommunications are 0.63, 0.29 and 0.38 and 0.28, respectively. The time trend has a negative coefficient of 0.04. This implies that the major contributors to economic growth can be attributed to physical capital, human capital, labour and telecommunications stock.

The estimate for capital is larger than that of Roller and Waverman (2001), which is 0.40. This shows that capital is still the largest factor of economic growth in APEC, compared to OECD. The elasticity of labour of 0.63 estimated by Roller and Waverman (2001), which they use to proxy human capital, is higher than my estimate of 0.38. However, when I combine human capital and labour, my estimate of 0.67 is larger than theirs.

The elasticity of PEN in APEC (0.28) seems larger than what is observed in the OECD where Roller and Waverman (2001) obtained an estimate of 0.15. As my main focus is the telecommunication variables, I can interpret it as if the telephone penetration rate $[PEN = PEN/(a - PEN)]$ increases by 1 per cent, the output increases by approximately 0.28 per cent.

From the demand equation, I observe evidence of income effects. GDP per capita has a positive impact on the demand for telecommunications infrastructure in that a 1 per cent increase in GDP per capita translates into more than 1 per cent (in fact 1.17 per cent) increase in the demand. Roller and Waverman (2001) observe a 2.38 per cent increase in their model. Together with the output equation, this result shows that the causality between income and telecommunications runs in both directions. On the other hand, it can be inferred that the demand for telecommunications is inelastic as a 1 per cent increase in the price of telecommunications translates into less than a 1 per cent (0.62 per cent) reduction in the demand for telecommunications, while Roller and Waverman (2001) find the elasticity of demand to be larger in the OECD, at 1.13 per cent.

In the investment equation, I find that the larger the country, the more it invests in telecommunications. This is provided by the significant and positive coefficient of GA, which is 0.22. A huge budget deficit is always perceived as a sign of a government's participation in the investment in telecommunications. It is not surprising since in the early years of telecommunications development, most of the telecommunications network were owned by governments or state-owned.

Consistent with the finding of Roller and Waverman (2001), I find that investment is negatively related to the government budget (-0.0063). Roller and Waverman (2001) explain that investment in telecommunications may be associated with a government's other spending programs, which jointly cause large deficits, and that the deficits do not hinder telecommunications investment.

Another interesting observation is that developing economies with longer waiting lists per capita do not necessarily invest more in telecommunications. This indicates that excess demand is not a good indicator for potential service providers to invest, implying supply constraints. This could be explained by the fact that developing economies often face capital, financial and technical and regulatory constraints in matching their excess demand. The coefficient is, however, not statistically significant. Meanwhile, a higher price of the telecommunication services does not seem to provide sufficient incentive for investment in telecommunications, as I found a negative relationship between price and investment for both developing and developed economies. The price variable of developing economies is, however, statistically insignificant.

Although I expected a positive relationship between investment and production of telecommunications in the production equation, I have a negative coefficient for the investment parameter (-0.0841), which implies that there is insufficient evidence in this model that investment is an important factor in the production of telecommunications in the APEC. In other words, investment does not guarantee the accumulation of telecommunications stock. Our outcome is in contrast with the finding of Roller and Waverman (2001), who found a positive relationship. On the other hand, unlike what was found by Roller and Waverman (2001), the positive coefficient (0.0118) for the country size variable suggests that large countries which have better access to resources are able to accumulate more telecommunications capital.

When allowing for fixed effect (Model 3.2), most of the coefficients are still similar to those of the original model (Model 1) in terms of sign and level of significance. The coefficient of interest, PEN, however, shrinks to 0.0751, which is still larger than the one observed by Roller and Waverman (2001) of 0.045.

There are not many differences in the demand equation compared to the earlier model. But as in the investment equation, the price variables for both developing and developed economies now have the right signs and are significant, confirming the fact that higher prices motivate investments by firms for both developed and developing economies.

I now look at Model 3.3 which includes cellular mobile phones data in the PEN variable, but does not control for the fixed effects. Model 3.3 produces a smaller PEN coefficient (0.0930) than Model 1, but it is larger than in Model 3.2. Although I continue to observe a negative sign for the waiting list variable in the investment equation, the coefficient is now statistically significant at the 1 per cent level. In this model, I also notice that the signs for the investment (TTI) and geographical area (GA) variables have been rotated in the production equation, in that the coefficient for TTI is positive and GA is negative, both coefficients being significant. This outcome suggests that large countries must invest more than the smaller counterparts for a given level of telecommunications infrastructure.

With the inclusion of cellular mobile phones and controlling for fixed effects, the results of Model 3.4 are quite similar to those of Model 3.3, but with a few exceptions. The coefficient for PEN is much smaller, 0.0169 as compared to 0.0930 in Model 3.3. The coefficient is also smaller than the 0.0450 observed by Roller and Waverman (2001). This suggests that the impact of the telecommunication variables on aggregate output in APEC, is on average smaller than that in OECD. The time trend (-0.0001) is no longer significant in this model.

Table 3.3
Simultaneous equations: non-linear GMM

			Model 3.1		Model 3.2		Model 3.3		Model 3.4		Model 3.5	
			No Effects		Fixed Effects		No Effects		Fixed Effects		Fixed Effects	
	Equations	Variables	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error
1	Output	Intercept	97.3439	8.2609 ***	-	-	58.7555	8.0288 ***	-	-	-	-
2		KA	0.6290	0.0306 ***	0.9275	0.0180 ***	0.8462	0.0233 ***	0.8623	0.0148 ***	0.8418	0.0156 ***
3		HK	0.2874	0.0809 ***	0.2189	0.0519 ***	0.3948	0.0580 ***	0.5601	0.0486 ***	0.5396	0.0536 ***
4		TLF	0.3804	0.0318 ***	0.1340	0.0184 ***	0.1847	0.0247 ***	0.1338	0.0143 ***	0.1518	0.0153 ***
5		*PEN*	0.2846	0.0323 ***	0.0751	0.0168 ***	0.0930	0.0233 ***	0.0169	0.0105 *	0.0362	0.0127 ***
		MED									0.0337	0.0141 **
		HIGH									0.0018	0.0371
6		t	-0.0473	0.0040 ***	-0.0005	0.0001 ***	-0.0295	0.0039 ***	-0.0001	0.0001	0.0001	0.0001
7	Demand	Intercept	-8.4006	0.2233 ***	-8.1061	0.2245 ***	-7.7940	0.3070 ***	-8.7498	0.3039 ***	-8.8177	0.3052 ***
8		GDPPC	1.1654	0.0148 ***	1.1799	0.0148 ***	1.4076	0.0230 ***	1.4047	0.0234 ***	1.3950	0.0235 ***
9		TELP	-0.6232	0.0374 ***	-0.6894	0.0376 ***	-0.9676	0.0522 ***	-0.8163	0.0514 ***	-0.7928	0.0516 ***
10	Investment	Intercept	19.1727	0.7357 ***	14.1305	0.5637 ***	15.7318	1.2383 ***	15.1178	1.3434 ***	15.9618	1.0811 ***
11		GA	0.2225	0.0244 ***	0.3438	0.0219 ***	0.2117	0.0335 ***	0.2050	0.0362 ***	0.2256	0.0298 ***
12		GD	-0.0063	0.0006 ***	-0.0027	0.0005 ***	-0.0075	0.0010 ***	-0.0076	0.0011 ***	-0.0075	0.0009 ***
13		(1-DEVD)*WLPC	-3.3928	3.0599	-0.1563	2.3068	-17.5001	4.7998 ***	-20.5667	5.1988 ***	-14.2971	3.6967 ***
14		(1-DEVD)*TELP	-0.2720	0.1477 *	0.2906	0.1064 ***	0.4731	0.2532 *	0.6162	0.2748 **	0.3648	0.2083 *
15		DEVD*TELP	-0.0831	0.1169	0.4461	0.0840 ***	0.4449	0.1982 **	0.5538	0.2152 **	0.3878	0.1681 **
16	Production	Intercept	0.6329	0.0595 ***	1.1267	0.0640 ***	-0.0514	0.0846	-0.0872	0.0821	-0.0058	0.0820
17		TTI	-0.0341	0.0030 ***	-0.0648	0.0031 ***	0.0130	0.0045 ***	0.0152	0.0043 ***	0.0103	0.0043 **
18		GA	0.0118	0.0019 ***	0.0236	0.0024 ***	-0.0055	0.0025 **	-0.0063	0.0024 ***	-0.0046	0.0024 **
Function Value			817.22		1020.52		829.39		856.87		925.37	

Notes:

Function value is the minimized value of the GMM criterion function, Singleton (2006, p. 71)

The first four models use all the 11 exogenous variables as instruments while Model 5 includes additional dummy variables, MED and HIGH
All the variables are in logarithmic form, except GD, DEVD WLPC, MED and HIGH
The instruments list includes KA, HK, TLF, GA, 1/POP, TELP, GD, DEVD and lag one period of PEN, GDP and TTI

* Significant at 10 per cent level
** Significant at 5 per cent level
*** Significant at 1 per cent level

Of the four models just presented, in terms of the number of correct signs, the models which include cellular mobile (Models 3.3 and 3.4) seem to produce superior results to those without them. As for whether fixed effects models produce superior results, obviously Model 3.2 dominates Model 3.1. One may infer from the above analogy that Model 3.4 should be superior to Model 3.3. In fact Models 3.3 and 3.4 look very similar to each other, except that Model 3.4 has a smaller magnitude for the variable of interest PEN than Model 3.3. We can check the superiority between Models 3.3 and 3.4 by using the growth effect of the PEN variable. With a coefficient of 0.0450, in fact Roller and Waverman (2001) acknowledge that their estimate is still large. This seems to imply that we should have a smaller coefficient in this variable of interest.

Growth effect for APEC

Table 3.4 provides the growth effect for each of the member economies using two sets of PEN coefficients from Models 3.3 and 3.4. The averages for all of APEC as well as the two subgroups (developed and developing) are also presented.

To interpret the result, I first choose Canada which has a telephone penetration rate of 41.87 per 100 inhabitants in year 1982 and of 105.27 per 100 inhabitants in year 2003; this translates into a compounded annual growth rate (CAGR) of 6.31 per cent. Using the coefficient of PEN $(\beta_3 = 0.0930)$ from Model 3 and the definition of $PEN = PEN/(a - PEN)$, the growth effect of Canada turns out to be 1.38 per cent over the period 1982 - 2003. This suggests that for every 1 per cent investments in the telecommunications infrastructure, the aggregate output of Canada grows by 1.38 per cent; this growth effect explains about 71 per cent of Canada's GDP annual growth of 1.94 per cent.

In terms of the average at the APEC level, the growth effect is 6.02 per cent; 7.25 per cent for developing countries and 4.92 for their more developed counterparts;

these numbers are obviously unrealistically large when I attempt to match the GDP growth of 3.17, 3.09 and 3.25 respectively. Even if outliers are excluded (see Table 3.4), the growth effect is still large on average. This indicates that my estimate of 0.0930 for PEN variable is larger than we can reasonably expect.

However, when allowing for fixed effects as in Model 3.4, with a smaller elasticity of telecommunication variable, the growth effect decreases substantially across the countries in the sample. In the case of Canada, the growth effect reduces to 0.28 per cent, now explaining about 15 per cent of the GDP growth[20]. This estimate sounds more reasonable than the earlier one. The explanatory power is lower than the 44 per cent observed by Roller and Waverman (2001).

Table 3.4
Compounded annual growth rates (CAGR) and growth effect

Member economies	GDP Per capital in 2000 US$		CAGR	PEN1 Per 100 inhabitants		CAGR	PEN2 Per 100 inhabitants		CAGR	Growth Effect (%) PEN2	
	1982	2003	%	1982	2003	%	1982	2003	%	β_3 =0.0930	β_4=0.0169
1 Australia	13,421	21,696	2.31	35.24	55.18	2.16	35.24	127.37	6.31	2.79	0.64
2 Canada	16,190	24,254	1.94	40.87	63.45	2.12	40.87	105.27	4.61	1.38	0.28
3 Chile	2,296	5,205	3.98	3.51	20.39	8.73	3.51	67.53	15.11	6.14	1.84
4 China	208	1,209	8.74	0.23	20.39	23.76	0.23	41.35	28.00	15.18	7.48
5 Hong Kong	12,195	25,676	3.61	28.06	55.95	3.34	28.06	163.98	8.77	8.54	3.01
6 Indonesia	418	874	3.58	0.31	3.95	12.90	0.31	12.71	19.37	7.61	2.52
7 Japan	25,169	37,651	1.94	35.17	47.20	1.41	35.19	115.13	5.81	2.12	0.46
8 Korea	3,562	12,245	6.06	10.38	53.78	8.15	10.38	123.98	12.54	6.82	2.14
9 Malaysia	1,986	4,079	3.49	4.04	18.71	7.58	4.04	64.23	14.08	5.36	1.51
10 Mexico	5,282	5,803	0.45	4.40	15.96	6.33	4.40	45.39	11.75	3.56	0.87
11 New Zealand	11,066	14,583	1.32	37.65	44.85	0.84	37.65	109.67	5.22	1.72	0.36
12 Peru	2,280	2,136	(0.31)	1.82	6.77	6.45	1.82	17.56	11.39	2.94	0.68
13 Philippines	1,010	1,041	0.15	0.95	4.17	7.28	0.95	32.24	18.26	7.31	2.38
14 Singapore	9,558	22,583	4.18	24.29	45.32	3.01	24.29	128.40	8.25	4.04	1.03
15 Taiwan	4,544	14,306	5.61	17.50	59.09	5.97	17.50	173.25	11.54	15.34	7.60
16 Thailand	865	2,238	4.63	0.90	10.48	12.38	0.90	49.86	21.05	9.90	3.79
17 United States	22,198	35,521	2.26	46.55	62.94	1.45	46.57	117.52	4.51	1.57	0.33
APEC Average	7,779	13,594	3.17	17.17	34.62	6.70	17.17	87.97	12.15	6.02	2.17
Developing	1,793	2,823	3.09	2.02	12.60	10.68	2.02	41.36	17.38	7.25	2.63
Developed	13,101	23,168	3.25	30.63	54.19	3.16	30.64	129.40	7.51	4.92	1.76
APEC Average #	9,164	15,986	3.70	20.55	38.66	6.76	20.56	94.38	11.82	5.63	1.95
Developing #	1,154	2,721	4.88	1.80	14.78	13.07	1.80	47.13	19.52	8.84	3.43
Developed #	14,170	24,276	2.95	32.28	53.58	2.81	32.28	123.91	7.00	3.62	1.03

Notes:
1 PEN1 is defined as the number of mainlines per 100 inhabitants
2 PEN2 is defined as the number of mainlines per 100 inhabitants plus the number of cellular mobile subscribers per 100 inhabitants
3 The contribution of telecommunications to GDP is calculated using the formula below:

$$\left[\left(\frac{\frac{PEN_{2003}}{a - PEN_{1983}} - \frac{PEN_{1982}}{a - PEN_{1982}}}{\frac{PEN_{1982}}{a - PEN_{1982}}}\right)\beta_i + 1\right]^{1/22}$$

where β_i= 3 and 4 and a=1.8
β_3 is the estimated coefficient for PEN2 in the model without fixed effects (Model 3.3)
β_4 is the estimated coefficient for PEN2 in the fixed effects model (Model 3.4)
4 We do not compute growth effects for Models 1 and 2 as there were proved to be inferior to Models 3.3 and 3.4 as discussed.
Exclude those registered less than 1 per cent CAGR in GDP per capita; also Taiwan - with highest PEN in 2003

[20] Calculated as (0.28/1.94)=14.43%

In terms of the APEC average, the telecommunication variable is able to explain about 68 per cent of the GDP growth; 85 per cent for developing countries and 54 per cent for developing countries. Excluding the outliers, the explanatory power is further reduced to 53, 70 and 35 per cent, respectively. The estimate of 0.0169 which translates into the growth effect may be still larger when compared to the OECD average, with 30 per cent of explanatory power in Roller and Waverman (2001). On the other hand, however, our result suggests that investment in telecommunications in APEC is more productive which causes larger growth effect compared to OECD.

Up to this point, overall, it may be concluded that models with fixed effects always perform better than the models without them, and models which include cellular mobile are always superior to models which only use fixed lines. In other words, of the 4 models, Model 3.4 is superior. This conclusion is important as I will use Model 3.4 for the subsequent analysis in Chapter 5[21].

Network externalities and nonlinearities

According to Rolller and Waverman (2001), the existence of externalities in the telecommunications network can be justified by testing the nonlinearities in telecommunications network. Following Roller and Waverman (2001), I re-specify the output equation as

$$\log(GDP_{it}) = a_{0i} + a_1 \log(K_{it}) + a_2 HK + a_3 \log(L_{it}) \qquad (3.14)$$

$$(a_4 + a_5 MED + a_6 HIGH) \log PEN_{it} + a_7 t + \varepsilon_{it}^1$$

where HIGH and MED are dummy variables for the penetration rate; HIGH equals 1 if the penetration rate is 50 and above, and 0 otherwise; MED equals to 1 for a

[21] In fact, in Chapter 5, I show that the pooled intercept is rejected, see Appendix F.

penetration rate of 20 and above but less than 50, and 0 otherwise; If MD=0 and HIGH=0, then we have a penetration rate of less than 20 per 100 inhabitants which is identified as LOW. Of the 374 observations, LOW comprises 41 per cent of the observations, followed by MED, 30 per cent and 29 per cent for HIGH.

The result is presented in Table 3.3, Model 3.5. In general, the result is not much different from that of Model 3.4. I find that the HIGH level penetration rate in the model is not statistically significant at 10 per cent level, though all three parameters of penetration levels show positive signs. The parameters for LOW and MED are significant at the 1 and 5 per cent level respectively. In Roller and Waverman (2001), MED level is not significant. The coefficient for LOW, a_4 is 0.0362 whereas a_5 and a_6 are 0.0337 and 0.0018, respectively, in my analysis. This seems to suggest that the economic gains from telecommunications infrastructure roll-out extend up to the medium level of penetration, but there is no evidence of further growth beyond that (above 50 per cent of penetration rate).

In contrast to Roller and Waverman (2001), my results imply that countries with lower telephone penetration rate tend to have larger growth effects compared to those countries with MED and HIGH. Notably, the impact of telecommunications with low penetration levels is respectively 1.1 and 20 times larger than the MED and HIGH levels[22].

Based on the 2003 data, all countries in the developed category have a penetration rate of more than 100 per cent, to be exact 1.29. In other words, each person in the developed countries has access to at least one telephone, whether it is a fixed line or a mobile phone. While in developing countries, on average, for every 5 people, 4 will have an access to a telephone, whether it is a fixed line or a mobile phone.

As a low penetration rate is always associated with developing countries in the data, along with the findings which suggest that a low penetration rate tends to

[22] Calculated as (0.0362/0.0337)=1.07 and (0.0362/0.0018)=19.87.

have higher growth effect, I predict that countries with low penetration rates will be able to catch up (converge) with their more advanced counterparts in terms of economic growth through investment in telecommunications infrastructure.

Section 4: Conclusions

Given the rapid developments in the telecommunications, mobile telecommunication devices have become part of our daily life. The number of mobile phone users has grown by more than 30 per cent per annum in developing countries during the last decade, surpassing their wealthier counterparts which only grew at about 20 per cent during the same period. This seems to imply that it is possible that the developing countries will soon catch up with the developed nations, which may contribute to convergence in economic performance.

I have examined the contribution of telecommunications to GDP in 17 out of 21 countries in APEC, taking into account fixed effects and causality of the telecommunication variables and income, with four structural equations estimated simultaneously. In other words, the telecommunication variables were endogenized in a macro aggregate output function. The study suggests that models with fixed effects perform better than those without, and models which include cellular mobile phones as proxy for telecommunications infrastructure outperform those which only use fixed lines.

My results further suggest that countries with lower penetration rates record a higher impact of telecommunications on aggregate output. Network externalities exist in those countries that achieve penetration rate of up to 50 per cent, while there is no evidence beyond this level. Therefore, given the less expensive mobile technology, it is possible that the developing countries can just aggressively roll-out their telecommunications infrastructure to increase the penetration rate, and thus achieve higher economic growth. In fact many developing countries, as reported by

ITU (2003a), have committed themselves to outline a comprehensive universal plan in order to provide access to telecommunications network in the underserved communities and geographical areas. According to Roller and Waverman (2001), the universal service level of penetration rate is approximately 40 per cent.

In the analysis of the supply equation, investment in telecommunications does not seem to respond positively to the waiting list (the excess demand). One of the explanations for this result is the presence of barriers to entry in the telecommunications market, especially in the developing countries. The barriers to entry can take various forms such as political stability, government policy, capital and technical constraints, corruption, imperfect market structure, and protectionism.

I have assumed that there is no interplay between fixed lines and mobile phones. In reality, many people might have chosen a mobile phone over a fixed line service for convenience reasons; for example, they can stay connected with anybody regardless of location, unlike fixed phones. Those who choose not to be contacted frequently (feel unpleasant - disutility) or believe in quality may still stick to the traditional fixed line. Those who see benefits from these two services or the wealthier group may choose to have both services. Thus, it is difficult to determine whether these two products are substitutes or complements, or are independent. Ideally, a composite index which represents various services, such as Internet, should be used as a proxy; however, given that the development of mobile technology and Internet services took place around a decade ago, the study of a longer period will be constrained by these data.

CHAPTER 4:
MEASURING TRADE LIBERALIZATION IN TELECOMMUNICATIONS

In this chapter, I construct a set of indices to measure the degree of openness in the telecommunications industry across APEC countries. To be more specific, I make use of the most recent 2005 ITU survey to construct indices to measure openness in terms of market access, national treatment and regulatory environment. These indices, in turn, will be used in an econometric model to estimate the impact of trade liberalization in the telecommunications industry.

This chapter is organized as follows. Section 1 discusses data and methodology. Section 2 presents the analysis and Section 3 summarizes the chapter and draws conclusions.

Section 1: Data and methodology

The main source of data used in this chapter comes from the ITU World Telecommunications Regulatory Database. The ITU conducts an annual Telecommunication Regulatory Survey (the ITU survey) by sending out a questionnaire to all its members, which are mainly the regulators of the industry in member countries. The coverage of the survey in telecommunications is more comprehensive than other databases from other organizations such as the OECD or APEC. I believe that the survey data have a high degree of cross-country consistency because the answers to the survey were prepared by its members in a telecommunications-working group.

The survey is divided into six main sections: Section I is about a member country's legislative framework; Section II asks questions concerning regulatory institution; Section III surveys the regulatory issues and processes; Section IV asks about the universal access/service policy; Section V investigates the sector structure; and Section VI seeks responses about the future plans of each member country.

The responses and the feedback received by ITU are then processed and maintained in the regulatory database. The database can be accessed by the public on-line or through direct request from ITU[23]. Some of the information is also published annually in ITU publications such as *Trends in Telecommunications Reform* and *World Telecommunication Development Report* series.

The Composite Index (CI) of Liberalization in this chapter consists of three main components: Market Access (MA), National Treatment (NT) and Regulatory Principles (RP). Within each component, sub-indices are also created. In general, higher scores imply higher degree of market liberalization. At the later part of this section, variations of weighted RP and CI are also created. Unless otherwise specified, the equally weighted RP and CI are used as a representative throughout this chapter.

I construct these indices for 19 of the 21 APEC member economies. The remaining two APEC members, Hong Kong and Taiwan, are excluded because they are not included in the 2005 ITU Survey data. In addition, the data on market share, the restriction on foreign shareholdings, the adoption of the Reference Paper by member economies and policy pertaining to number portability and pre-selection[24] are extracted from the APEC (2005).

Market Access Index

In the area of market access (MA), I construct two sub-indices: MA/Trade and MA/Invest[25]. MA/Trade measures the degree of openness to market access through trade in telecommunication services. Warren (2000a) uses policy data on

[23] I thank Ms. Nancy Sundberg of ITU for her kind assistance. Also, see the ITU website: *http://www.itu.int/ITU-D/treg/Events/Survey/2005Userguide_En.pdf*
[24] See footnote 29 and 30. The definition of terms is also available in Appendix A.
[25] The exact definitions of these and other indices are presented in the Appendix E.

resale and leased line to proxy the extent of the restrictions on MA/Trade. In this study, I use the most recent ITU survey data on resale of voice service[26] for both domestic and international calls or services, and both fixed line and mobile services. I assign a score of one (1) if resale of voice services is permitted and 0 otherwise, for each of the four (4) questions. The total possible maximum score is four (4), and lowest score is zero (0). The first four columns of Table 4.1 provide the scores of each country on resale of voice services.

The second sub-index MA/Invest measures the extent of openness in market access through investment. I utilize survey data such as the number of fixed-line and mobile services operators, level of competition allowed in the telecommunication services. I categorize the services into seven segments: local, domestic, international, data, leased lines, mobile services and Internet services. I also use the percentage of incumbents privatized as well as the market shares[27] of largest operators in domestic, long distance and mobile services markets. Following Warren (2000a), I rank the number of operators that are actually operating in the market as the most important indicator of competition (weight=3), followed by the level of competition allowed by the regulator (weight=2), and the percentage of shares owned by government in the incumbent operator (weight=1).

There is no fixed rule as to how many market players should exist to constitute a competitive market in fixed line and mobile. Many, including Warren (2000a), suggest that if a market has at least 3 players, it is sufficiently competitive; while ITU defines that the mobile service market is sufficiently competitive if it has at least one mobile operator. Following Warren (2000a), I determine that if a country has at least three operators, a score of three (3) is assigned, a score of two (2) for two operators, and a score of one (1) is for monopoly. Since the weight for each of

[26] The ability of an entity that has not constructed a network of its own to offer to end users services located on a network built by another. See *http://www.eschelon.com/glossary*

[27] Market shares data on local access line, long distance and mobile are extracted from APEC (2005).

fixed line and mobile service is three (3), the maximum score is thus nine (9), and the minimum score is three (3).

Table 4.1
Resale of voice services, callback services and FDI

	Country	Resale of voice services				Total	Callback	FDI
		Domestic		International				
		Fixed lines	Mobile	Fixed lines	Mobile			
1	Australia	1	1	1	1	4	1	0.3500
2	Brunei	1	0	0	0	1	0	0.3000
3	Canada	1	1	1	1	4	1	0.3200
4	Chile	1	1	1	1	4	0	1.0000
5	China	0	0	0	0	0	0	0.2500
6	Indonesia	1	0	1	0	2	0	0.3500
7	Japan	1	1	1	1	4	1	1.0000
8	Korea	1	1	1	0	3	1	0.5000
9	Malaysia	1	1	1	1	4	0	0.4900
10	Mexico	0	0	0	0	0	0	0.5000
11	New Zealand	1	1	1	1	4	1	1.0000
12	Papua NG	0	0	0	0	0	0	0.0000
13	Peru	1	0	1	0	2	0	1.0000
14	Philippines	0	0	0	0	0	0	0.3500
15	Russia	0	0	0	0	0	0	0.0000
16	Singapore	1	1	1	1	4	1	0.7000
17	Thailand	0	0	0	0	0	0	0.2500
18	United States	1	1	1	1	4	1	1.0000
19	Viet Nam	0	0	0	0	0	0	0.0000

Notes:
1 Resale of voice service: Score of 1 if Yes, and 0 otherwise.
2 Callback services: Score of 1 if allowed, and 0 otherwise.
3 FDI: percentage of foreign direct investment allowed.

Sources:
1 ITU World Telecommunication Regulatory Database (2005).
2 APEC (2005).

The survey data by ITU provide the level of competition allowed in each country. I assign a score of one (1) if the service is competitive, 0.5 for partial competitiveness, 0.2 for duopoly, and zero (0) for monopoly. As there are seven segments of services in the study, the maximum score is thus seven (7) if all segments of services are competitive, and the minimum score is zero (0) if all the services are monopoly. With the assigned weight of two for the level of competition allowed, I could have a maximum score of fourteen (14).

Table 4.2
Number of oprators, level of competition and market shares

		Number of operators			Level of competition allowed in the services								Market shares not owned by government or largest operator				
	Country	Fixed lines	Mobile	Total	Local	Long distance	International	Data	Leased lines	Internet	Mobile	Total	Incumbent	Local	Long distance	Mobile	Total
1	Australia	3	3	6	1	1	1	1	1	1	1	7	0.49	0.10	0.32	0.48	1.39
2	Brunei	1	1	2	0.5	0.5	0.5	0.5	0.5	0.5	0	3	0.00	0.00	0.00	0.00	0.00
3	Canada	3	3	6	1	1	1	1	1	1	1	7	1.00	0.04	0.26	0.65	1.95
4	Chile	3	3	6	0.5	1	1	1	0.5	1	1	6	1.00	0.08	0.67	0.77	2.52
5	China	3	2	5	0.5	0.5	0.5	0.5	0.5	1	0.5	4	0.89	0.00	0.66	0.34	1.89
6	Indonesia	2	3	5	0.5	0.5	0.5	1	1	1	1	5.5	0.49	0.05	0.15	0.42	1.11
7	Japan	3	3	6	1	1	1	1	1	1	1	7	0.54	0.16	0.53	0.43	1.66
8	Korea	3	3	6	1	1	1	1	1	1	1	7	1.00	0.06	0.15	0.59	1.80
9	Malaysia	3	3	6	1	1	1	1	1	1	1	7	0.33	0.05	0.10	0.59	1.07
10	Mexico	3	3	6	1	1	1	1	1	1	1	7	1.00	0.03	0.32	0.22	1.57
11	New Zealand	3	2	5	1	1	1	1	1	1	1	7	1.00	0.05	0.25	0.43	1.73
12	Papua NG	1	1	2	0	0	0	0	0	0.5	0	0.5	0.00	0.00	0.00	0.00	0.00
13	Peru	3	3	6	1	1	1	1	0	0	1	5	1.00	0.01	0.25	0.48	1.74
14	Philippines	3	3	6	1	1	1	1	1	1	1	7	1.00	0.37	0.30	0.56	2.23
15	Russia	1	3	4	0.2	0.2	0.2	1	0	0	1	2.6	0.49	0.07	0.12	0.63	1.31
16	Singapore	2	3	5	1	0	1	1	1	1	1	6	0.20	0.30	0.22	0.55	1.27
17	Thailand	1	3	4	0.5	0	0	0	1	1	0.5	3	0.00	0.48	0.00	0.35	0.83
18	United States	3	3	6	1	1	1	1	1	1	1	7	1.00	0.11	0.65	0.77	2.53
19	Viet Nam	3	3	6	1	1	1	1	1	1	1	7	0.00	0.02	0.00	0.40	0.42

Notes:
1 Number of operators: score of 3 if there are three or more than three operators operating in the market; score of 2 if two operators, and score of 1 if monopoly.
2 Level of competition allowed: Score of 1 if competitive, score of 0.5 if partical competitive, score of 0.2 if duopoly, and score of 0 if monopoly.
3 For those member economies reported domestic and international separately as % of market shares in long distance, the average number is used here.
4 Market shares of long distance for Philiphines is estimated as 70% based on fixed line business, see PLDT News, www.pldt.com.ph

Sources:
1 ITU World Telecommunication Regulatory Database (2005).
2 APEC (2005).

As the number of players in the market is not a perfect indicator of the existence of a competitive market, I include a market share element to measure the market power of the largest operator, which is usually the incumbent. This includes market shares of local access line, and long distance and mobile services not owned by the largest operator. Following privatization, I use the shares not owned by the government in the privatized incumbent. Thus, I have a total maximum score of four (4) given a weight of one (1). Table 4.2 provides the scores of each country on the number of operators, level of competition and market shares. As such, the total possible score for Market Access Index is 36, for the most liberalized market, and the minimum score is three (3) for the least liberalized market.

Each of the MA/Trade and MA/Invest indices is normalized to one. The overall Market Access Index is constructed from the simple average of these two normalized sub-indices.

National Treatment Index

For the National Treatment (NT) Index, I also have two sub-indices: NT/Trade and NT/FDI. The NT/Trade Index measures the degree of openness to foreign entrants through trade. Following Warren (2000a), I utilize data on call-back services[28]. I assign a score of one (1) if a call-back service is allowed, and a score of zero (0) if not.

The second sub-index NT/FDI Index is a direct measure of openness to foreign ownership of domestic service providers. For this sub-index, I use data on foreign ownership allowed in percentage. The score of zero (0) is given to those member

[28] Call-back or international call-back occurs when the originator of a call is immediately called back in a second call as a response. A call-back is perceived as a method of making low-cost international calls via a third country, where call charges are relatively lower. See http://wikipedia.org/wiki/

economies that do not allow foreign ownership. Obviously, the higher the percentage, the more open that economy is to foreign investors.

The total possible score for each of the sub-indices is one (1) for the most open economy and zero (0) for a closed economy. Columns 4 and 5 of Table 4.1 provide the score of each country on call-back services and FDI, respectively. The overall National Treatment (NT) Index is calculated the same way as the overall Market Access Index, by taking the average of the two normalized sub-indices namely NT/Trade and NT/FDI.

Regulatory Principle Index

The Regulatory Principle Index (RP) is built on the regulatory principles outlined in the WTO Reference Paper. Accordingly, there are five sub-indices representing the five principles: Competitive Safeguard (CS), Interconnections Policy (IC), Universal Service Index (US), Licensing (LS) and Independent Regulator (IR). The summary of the methodology of the indices is provided in Appendix E.

It is difficult to measure each principle individually and independently. In fact, these principles may be interrelated and/or overlapped. For example, the competitive safeguard may be related to the independence of the regulator; interconnections policy is related to universal service and licensing; universal service is related to licensing, etc. To refrain from overlapping wherever possible, I do not use the same survey question (data) twice, even though a given question may also be relevant to the other regulatory principles. After obtaining the respective scores, each of the sub-indices is normalized to one (1), giving a total maximum score of five (5) for the main index.

(a) Competitive safeguard

The sub-index, RP/CS, aims to measure the competitiveness of the environment provided and committed by a country. The principle of competitive safeguard specifies the prevention of anticompetitive activities such as cross subsidization, use of information obtained by competitors, and withholding of technical or commercial information.

Cross-subsidization refers to the practice of charging higher prices for a service or a sector and using these surpluses to subsidize other services or sectors that are priced below cost. For instance, the incumbent can overcharge customers for services over which it still has a *de facto* monopoly, such as local residential service, in order to cut rates in competitive markets. The practices of anti-competitive acts which depress demand in one market (or a supplier) and induce demand in the other market promote inefficiency in the economic system. Thus, the existence of regulations or competition laws provides some safeguards against these practices.

Most countries use measures such as accounting separation, separation of non-competitive activities, tariff rebalancing, price cap, license conditions and regulations to prevent activities such as cross-subsidization, use of information from competitors and use of information for anti-competitive purposes. These measures are however qualitative in nature and are difficult to quantify.

In fact, many countries have the competitive safeguards in place in terms of laws and regulations, but the effectiveness and the efficiency of the mechanism of enforcement is difficult to measure. The number of violations or disputes amongst the market players could be a good indicator for the enforcement variable, but it is ambiguous because it may be lower in countries with more efficient laws and regulations.

Table 4.3
Measuring competitive safeguard

	Country	Q1	Q2	Q3	Q4	Q5	Total
1	Australia	1	0	1	1	1	4
2	Brunei	1	0	0	0	0	1
3	Canada	1	0	1	1	1	4
4	Chile	1	0	1	1	0	3
5	China	1	0	0	0	0	1
6	Indonesia	1	0	1	0	0	2
7	Japan	1	0	0	0	0	1
8	Korea	1	1	1	1	1	5
9	Malaysia	0	1	0	1	1	3
10	Mexico	1	0	1	1	1	4
11	New Zealand	1	1	1	0	1	4
12	Papua NG	1	0	0	0	0	1
13	Peru	1	0	1	1	1	4
14	Philippines	0	1	0	0	0	1
15	Russia	0	0	0	0	0	0
16	Singapore	1	0	1	1	1	4
17	Thailand	1	0	0	0	0	1
18	United States	1	1	1	0	0	3
19	Viet Nam	0	0	0	0	0	0

Notes:
Q1: Have your country adopted the WTO Reference Paper in full?
Q2: Does the regulatory authority have the enforcement powers?
Q3: Does a competition authority exist in your country?
Q4: Are appeals to the decision of the regulatory authority allowed?
Q5: Are public consultations mandatory before regulatory decisions are made?
For Q1-Q5: Score of 1 if Yes, 0 otherwise.

Sources:
1 ITU World Telecommunication Regulatory Database (2005).
2 APEC (2005).

Nevertheless, APEC (2005) suggests that the adoption of the WTO Reference Paper by member economies is a good measure for the competitive safeguard. Apart from this, I make use of the ITU survey data on the existence of a competition authority. I also include survey data on factors such as enforcement power of the regulatory body, whether or not appeals to decision are allowed and whether or not public consultations process is mandatory. I assign a score of one (1) if the response is "yes" and zero (0) otherwise. Thus, I obtain a total possible

score of five (5) and a minimum of zero (0). Table 4.3 provides the score of each country pertaining to the competitive safeguard measure.

Table 4.4
Measuring interconnections policy

	Country	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Total
1	Australia	0	0	1	1	1	1	1	1	6
2	Brunei	0	0	1	0	0	0	0	0	1
3	Canada	0	1	0	1	1	1	1	1	6
4	Chile	0	0	0	1	1	1	0	0	3
5	China	0	1	1	0	0	0	0	0	2
6	Indonesia	0	0	1	0	0	0	0	0	1
7	Japan	1	1	1	1	1	0	1	1	7
8	Korea	1	1	0	1	0	1	1	1	6
9	Malaysia	0	1	1	1	1	0	1	0	5
10	Mexico	0	0	0	0	0	1	1	0	2
11	New Zealand	0	1	1	1	1	1	1	1	7
12	Papua NG	1	1	0	0	1	0	0	0	3
13	Peru	1	1	1	0	1	1	1	0	6
14	Philippines	0	1	0	0	1	0	0	0	2
15	Russia	0	0	0	0	0	0	0	0	0
16	Singapore	1	0	1	1	1	1	1	1	7
17	Thailand	0	0	0	0	0	0	0	0	0
18	United States	1	0	0	1	1	1	1	1	6
19	Viet Nam	0	1	1	1	0	0	0	0	3

Notes:

Q1 Are interconnections agreements made public?Are interconnections agreements made public?
Q2 Are interconnections prices made public?Are interconnections prices made public?
Q3 Are the operators required to publish Reference Interconnection Offer?
Q4 Is unbundled access required?
Q5 Is infrastructure sharing for mobile operators permitted?
Q6 Are decisions on dispute resolution reported on the regulatory authority's website?
Q7 Is pre-selection available?
Q8 Is number portability available?

For Q1-Q8: Score of 1 if Yes, 0 otherwise.

Source:
ITU World Telecommunication Regulatory Database (2005).

(b) Interconnections policy

The degree of transparency and effectiveness of interconnections policy is measured by the sub-index, RP/IC. The interconnection regime is the main subject of the Reference Paper. Most potential new entrants face large capital expenditures constraints to build their own full telecommunications network and facilities. As a result, they need to be able to interconnect with the incumbents to provide services.

According to the Reference Paper, interconnection with the major supplier should be made available at any technically feasible point in the network, under nondiscriminatory terms, conditions and fair quality. The interconnection should also be provided in a timely fashion, on terms, conditions and cost-oriented rates. It also calls for the interconnection agreement to be transparent and for an independent body to be responsible for dispute settlement.

Although interconnection policy has become a benchmark for many member countries, it has some drawbacks because the Reference Paper only provides the general principles. Translating these principles into interconnection agreements that comply with the WTO commitments is a new challenge for many countries, especially the developing countries. Nowadays, in most member countries, governments have taken the initiative to set up the terms for interconnection since the incumbents have no incentives to interconnect with the new entrants.

I use the ITU survey data on whether or not interconnection agreements and prices are publicly available, whether or not there is a requirement to publish reference interconnection offers and the reporting of decisions on dispute resolutions. I also include the response if unbundled access is required for interconnections, as well as whether there is a policy on infrastructure sharing for mobile operators.

I assign a score of one (1) if the answer is "yes" for each of the six (6) responses, and a score of zero (0) otherwise. There is a range of six (6) for the maximum score and zero (0) for the minimum score. Table 4.4 shows the score of each country in terms of interconnection policy.

The policies of number portability[29] and pre-selection[30] are expected to affect the competitiveness of the mobile and long distance markets. I assume that the availability of number portability and pre-selection is the result of interconnection. There are generally three types of number portability: local/fixed, mobile and non-geographic. Pre-selection is usually implemented for long distance, international, fixed to mobile and all geographic calls. The data on these policies are extracted from APEC (2005).

A score of one (1) is allocated for each of number portability and pre-selection if it is available in a country and a score of zero (0) is allocated otherwise. In total, the maximum score for this index is eight (8), with a minimum of zero (0).

(c) Universal service

This sub-index, RP/US, measures the competitiveness of the universal service policy. Under the principle of universal service, member countries are encouraged to develop their universal service program provided it is administered in a transparent, nondiscriminatory and competitively neutral manner. In fact, the efficient interconnection regime will help to achieve the objective of universal service – to enable greater access to the largest group of people and users.

The main objective of universal service is a social one, that is, to ensure access to telecommunication services by all its citizens in a country. However, OECD (1995) challenges that universal service and competition are not mutually exclusive. OECD (1995) spells out the principles and framework of universal services and argues that universal service and competition can be achieved together.

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[29] Number portability refers to the ability of a customer to transfer an account from one service provider to another without requiring a change in number.

[30] Pre-selection is the mechanism by which end users can designate the carrier that they prefer to carry all or a certain segment (e.g. long distance) of their calls, the pre-selected carrier becomes the default carrier for all such calls.

Table 4.5
Measuring universal service

Country	Q1	Q2	Q3	Q4	Total
1 Australia	1	0	1	0.8	2.8
2 Brunei	1	0	1	0	2
3 Canada	1	0	0	0.8	1.8
4 Chile	1	0	0	1	2
5 China	1	0.5	1	0.5	3
6 Indonesia	1	0	1	0.8	2.8
7 Japan	1	0	1	0	2
8 Korea	1	0.5	1	0.8	3.3
9 Malaysia	1	1	1	0.8	3.8
10 Mexico	1	0	0	0.5	1.5
11 New Zealand	1	0	0	0	1
12 Papua NG	1	0	0	0.5	1.5
13 Peru	1	0.5	1	0.8	3.3
14 Philippines	1	0	0	0	1
15 Russia	0	0	0	0	0
16 Singapore	1	0	1	0	2
17 Thailand	0	0	0	0	0
18 United States	1	0	0	0.8	1.8
19 Viet Nam	1	0.5	1	1	3.5

Notes:

Q1: Has your country defined universal access or services?
Score of 1 if Yes, 0 otherwise.Score of 1 if Yes, 0 otherwise.

Q2: Do you require any operators to provide the services?
On a competitive basis, score=1;
All operators/all network/facilities-based/all service based operators, score=0.5;
Others, score=0

Q3: Do you require any operators to offer below cost prices to any subscribers?
Score of 1 if Yes, 0 otherwise.

Q4: How the costs of universal service are funded?
If by Unversal Service Fund,
Fund contributed by government/operators/others, score=1
Fund operators only, score=0.8
If by governement/operators/international agencies, score=0.5
If by operators only, score=0

Source:
ITU World Telecommunication Regulatory Database (2005).

The ITU survey lacks measurable variables pertaining to the definition, identification, delivery, costing, funding and monitoring of universal service. The survey data tend to skew towards funding issues. Nevertheless, I make use of the survey data on whether or not there is a definition for universal service, obligation of operators to provide the services below cost as well as responsible for the cost.

I assign a score of one (1) if the particular country has a definition of universal service and zero (0) otherwise. In principle, the universal service obligations should be allocated on a competitive basis, meaning that all potential suppliers are free to submit their bids to serve the universal target (which can be an area or a group of people); thus I assign a score of one (1) for this answer; a score of 0.5 is assigned if all operators, or all network/facilities-based operators, or all service-based providers are obligated to provide the access or service; a score of zero (0) is assigned if only the incumbent and/or some operators are obliged to provide universal service. On the other hand, in a competitive environment, the universal services should not be provided below cost; thus I assign a score of one (1) if it is not and a score of zero (0) if it is provided below cost.

Pertaining to funding issues, for countries which have an operational universal service fund, where the source of fund comes from government and operators and/or other institutions, I assign a score of one (1); however, if the contribution comes solely from operators, I assign a score of 0.8.

According to OECD (1995), direct funding from government is the best in principle as it avoids distortionary effects associated with incorrect pricing of services. Typically, the government's subsidy comes through a universal service fund; some countries impose levies on subscribers to avoid barriers to entry to potential service providers.

For countries without an operational universal service fund, I assign a score of one (1) if the cost of universal service comes from government, 0.5 if the obligation is financed through a combination of government and operators and/or any other institutions, and zero (0) if it is solely financed by operators because the operators would most likely resort to cross-subsidy between their own services.

In other words, the existence of an operational universal service fund (though entirely funded by operators) is still superior to direct funding from operators in cases without a universal service fund. The maximum score for this index is four (4) and the minimum is zero (0). Table 4.5 provides the score of each country in terms of universal service.

(d) Licensing/authorization regime

The sub-index, RP/LA, measures the ease of market entry under various licensing regimes. While serving as a tool of allocation of scarce resources, licenses are also used by governments to raise revenues. Thus, licensing criteria can be barriers to market entry if not handled with a proper and transparent process. The Reference Paper calls for the commitments of member countries on the licensing process. Where a license is required, the criteria, terms and conditions of individual licenses, and reasons for denial of a license, should be provided.

ITU (2004, p.39) classifies market entry restrictions into four main modes: license, authorization, registration, and notification. A license (or individual license), usually customized and detailed, is issued to a single service provider through some competitive selection process; Authorization (or class license) normally contains general conditions, issued without a competitive selection; Registration requires the submission of more information than Notification before commencing operations and the regulator may reject registration.

I make use of the survey data on licensing/authorization regime for each of the seven services discussed above. Since the notification mode is the easiest way to enter the market, I thus assign a score of three (3) if the market entry requires a "notification"; a score of two (2) if it requires a "registration"; a score of one (1) if it requires an "authorization"; and a score of zero (0) if a license is required. In other words, license is the most restrictive requirement on prospective entrants. As these

apply to the seven segments of the services under study, the total possible score for this response is twenty one (21) if market entry requires a "notification", and the minimum score is zero (0) if it requires a license.

In addition, in countries where licensing agreements are publicly available, I assign a score of one (1) and a score of zero (0) otherwise. In this case, I also assign a score of one (1) to Japan and New Zealand since none of their services requires a license to operate. The score of each country in terms of licensing is presented in Table 4.6.

Table 4.6
Measuring licensing conditions

		Q1: Licensing conditions in services							Q2	Total
	Country	Local	Long distance	International	Data	Leased lines	Internet	Mobile		
1	Australia	0	0	0	0	0	0	0	1	1
2	Brunei	0	0	0	0	0	0	0	0	0
3	Canada	1	2	0	2	0	2	2	1	10
4	Chile	1	1	1	1	1	2	1	1	9
5	China	0	0	0	0	0	0	0	1	1
6	Indonesia	0	0	0	0	0	0	0	0	0
7	Japan	2	2	2	3	2	3	2	1	17
8	Korea	0	0	0	3	0	3	0	0	6
9	Malaysia	0	0	0	0	0	0	0	1	1
10	Mexico	0	0	0	0	0	0	0	0	0
11	New Zealand	3	3	3	3	3	3	3	1	22
12	Papua NG	0	0	0	0	0	0	0	0	0
13	Peru	0	0	0	0	0	1	0	1	2
14	Philippines	0	0	0	0	0	3	0	1	4
15	Russia	0	0	0	0	0	0	0	0	0
16	Singapore	0	0	0	0	0	0	0	1	1
17	Thailand	0	0	0	0	0	0	0	0	0
18	United States	0	0	0	0	0	0	0	1	1
19	Viet Nam	0	0	0	0	0	0	0	1	1

Notes:
Q1: What is the licensing/authorization regime for each of the 7 services?
Score of 3 if "notification", 2 if "registration", 1 if "authorization", and 0 if "licence"
Q2: Are licensing agreements publicly available?
Score of 1 if Yes, 0 otherwise.Score of 1 if Yes, 0 otherwise.

Source:
ITU World Telecommunication Regulatory Database (2005).

(e) Independence of regulators

The sub-index, RP/IR, measures the degree of independence of regulators in telecommunications. Member countries which committed themselves according to the principles of the Reference Paper are to ensure the independence of their regulators. The Reference Paper specifies that the regulatory body has to be separated from, and not accountable to, any supplier of telecommunication services and that the decisions and procedures used by regulators must be impartial with respect to all market participants.

It is widely believed that weak regulators are less able to promote competition policies, and thus new entrants may be unable to compete in a fair market environment. For example, Fink, Matoo and Ranthidran (2003) argue that independent regulator is a necessary condition for effective regulations.

Many member countries in the WTO are aware of the close relationship between market liberalization and the independence of regulators. In the past, the provision of telecommunication services in many developing countries was the sole responsibility of the government, which at the same time was responsible for regulating prices and formulating policies. According to a survey by the International Telecommunication Union (ITU), there are currently at least 101 member countries which have separate functions for the telecommunications regulator and for the provision of services, and 52 of them are also separated from their sector minister (ITU, 2002, p.13). However, governments in developing countries are less inclined to empower regulatory function to these regulatory agencies.

Whenever the data allow it, I adopt the methodologies used by Edwards and Waverman (2006) and Gutierrez (2003). As discussed in Chapter 2, Edwards and Waverman (2006) draw upon the NRA characteristics, member appointments and

term of office, resources and experience, while Gutierrez (2003) works on the regulatory governance[31]. In fact, ITU (2002b) suggests that the efficiency of a regulator can be evaluated through its functions like rulemaking, enforcement, dispute resolution as well as reviewing regulatory decisions[32].

According to the ITU survey, four member economies do not have a separate regulatory authority. They are China, Japan, Russia and Viet Nam. Some regulators (Chile and Indonesia), although separated from the ministry, are not autonomous in decision making. Thus, I assign a score of one (1) to each if (a) the NRA is separated from the ministry and telecommunication operations; (b) it is a collegial body[33]; and (c) it is autonomous in decision making, and a score of zero (0) if otherwise.

I also make use of the survey responses on the legal mandate of the regulatory authority. If the NRA is created by laws, a score of one (1) is assigned, and a score of zero (0) if it is not. Further, if the NRA reports to the legislature or parliament, a score of one (1) is assigned, and a score of zero (0) if it reports to Ministry or Minister. Many, including Edward and Waverman (2006), have suggested multi-sector agencies enjoy a greater degree of independence from their sector ministries. Some of the reasons are that a multi-sector agency has the ability to access pooled resources and information, as well as to minimize political interference. In cases where the NRA has multi-sector jurisdiction, a score of one (1) is assigned, and a score of zero (0) otherwise. If the existence of the NRA is at least two years, a score of one (1) is assigned, and a score if zero (0) otherwise.

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[31] His index is based on three dimensions and four characteristics. Also, see Chapter 2 for the literature review.

[32] ITU (2002c), Trends *in Telecommunication Reform 2002*, p. 45-54.

[33] According to the ITU, there are two types of decision-making bodies within the regulator are predominant: a single regulator in the form of a director, director-general or chairman which has quick decision-making process in a fast changing industry but can be more subject to political influences or interferences; a collegial body on the other hand is a quasi-judicial board or commission led by a chairman and usually assisted by a secretariat has the advantage of offering a participatory approach and a sharing of responsibility but slower in decision-making process. See Reference on web resources: ITU Training Workshop on licensing (2005).

There are various sources of NRA funding such as regulatory fees, license fees, auctions of licenses, numbering fees, contributions from operators and government appropriations. Since I am interested in the degree of independence of the regulator, I believe that the higher the government appropriation, the less independent the regulator. For this, I make use of the percentage of the budget not funded by government. The total maximum score for the sub-index is eight (8), and zero (0) is the minimum. The responses are presented in Table 4.7.

Table 4.7
Measuring independence of regulatory authority

Country	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Total
1 Australia	1	1	1	1	0	0	1	1	6
2 Brunei	1	1	0	1	0	0	0	1	4
3 Canada	1	1	1	1	1	1	0	1	7
4 Chile	1	0	0	0	0.46	0	0	1	2
5 China	0	0	0	0	0	0	0	1	1
6 Indonesia	1	0	0	1	0	0	0	1	3
7 Japan	0	0	0	0	0	0	0	1	1
8 Korea	1	1	1	1	0	0	1	1	6
9 Malaysia	1	1	1	1	1	1	0	1	7
10 Mexico	1	0	1	1	0	0	1	1	5
11 New Zealand	1	1	1	1	0.36	1	1	1	7
12 Papua NG	1	0	0	0	1	0	0	1	3
13 Peru	1	0	1	1	1	0	1	1	6
14 Philippines	1	1	1	1	0	0	0	1	5
15 Russia	0	0	0	0	0	0	0	1	1
16 Singapore	1	1	1	0	0	0	0	1	4
17 Thailand	1	1	1	1	0	0	1	0	5
18 United States	1	1	1	1	0.964	0	1	1	7
19 Viet Nam	0	0	0	0	0	0	0	1	1

Notes:
1 Australia and Japan: financed by only gov appropritions.
http://www.oecd.org/dataoecd/56/11/35954786.pdf
2 Papua NG only financed by licensed fee.

Q1: Is the NRA separated from the ministry as well as telecoms operations? Score of 1 if Yes, 0 otherwise.
Q2: What is the legal mandate of the NRA? Score of 1 if by law, 0 otherwise.
Q3: Is the NRA autonomous in decision making? Score of 1 if Yes, 0 otherwise.
Q4: Is the NRA a collegial body? Score of 1 if Yes, 0 otherwise.
Q5: What is the percentage of budget not financed by the government?
Q6: Does the NRA have multi-sector jurisdiction? Score of 1 if Yes, 0 otherwise.
Q7: Does the NRA report only to legislative or parliament? Score of 1 if Yes, 0 otherwise.
Q8: Is the existence of the NRA is at least two years? Score of 1 if Yes, 0 otherwise.

Source:
ITU World Telecommunication Regulatory Database (2005).

The main RP index is calculated by assuming equal weight, that is, 20 per cent for each of the five regulatory principles. It can be argued that universal service should be given a smaller weight because this requirement does not deal with market openness directly. For this reason, apart from the equal weighted RP (identified as RP1), two variations of weighted RP, namely RP2 and RP3 are computed. In RP2, the weight for RP/US is assumed to be 10 per cent, while the balance is shared equally among the other four regulatory principles. This means that the other four principles have a weight of 22.5 per cent each. On the other hand, RP3 is constructed based on the zero-weight assumption for the RP/US, that is, the other four principles are weighted 25 per cent each.

Composite Index

With the three main indices, namely Market Access, National Treatments and Regulatory Principle constructed, I compute the Composite Index (CI). Corresponding to the variations in the RP Index, variations of weighted CI are also constructed. Accordingly, CI1 is based on equal weight of each MA, NT and RP1; CI2 uses the same weight for each of the main indices, that is, MA, NT and RP2. Similarly, CI3 makes use of RP3, together with MA and NT. In addition, a fourth variation, CI0, is computed based on equal weight for MA and NT but zero weight for RP (all its variations). The last variation corresponds to the one in Warren (2000a).

Section 2: Analysis

Descriptive statistics

The descriptive statistics and correlations between indices for the APEC countries are presented in Tables 4.8 and 4.9.

Table 4.8
Descriptive statistics

Variable	Mean	Median	Maximum	Minimum	Std. Dev.	Obs
MA/Trade	0.53	0.50	1.00	0.00	0.46	19
MA/Invest	0.78	0.90	0.96	0.19	0.23	19
MA	0.65	0.66	0.98	0.10	0.31	19
NT/Trade	0.37	0.00	1.00	0.00	0.50	19
NT/FDI	0.49	0.35	1.00	0.00	0.36	19
NT	0.43	0.25	1.00	0.00	0.36	19
RP/CS	0.48	0.60	1.00	0.00	0.32	19
RP/IC	0.48	0.38	0.88	0.00	0.31	19
RP/US	0.51	0.50	0.95	0.00	0.27	19
RP/LS	0.18	0.05	1.00	0.00	0.29	19
RP/IR	0.54	0.63	0.92	0.13	0.28	19
RP	0.44	0.44	0.77	0.03	0.21	19
CI	0.51	0.60	0.90	0.09	0.28	19

Source: ITU World Telecommunication Regulatory Database (2005) and own computations.

From Table 4.8, there is some indication of policy variations amongst the APEC member economies as shown by the large standard deviations across the indices. This is not surprising since APEC comprises both developed (OECD) and developing countries, with different perceptions about trade negotiation and liberalization. The degree of openness as reflected in the Market Access Index (MA) ranges from a minimum of 0.10 (Papua New Guinea) to a maximum of 0.98 (the United States). The National Treatment Index covers the whole range between 0 and 1, demonstrating the extreme between allowing 100 per cent foreign ownership (and call-back services) in some countries, and foreign ownerships (and call-back services) are not allowed at all in some other countries in the APEC. The range of the Regulatory Principle (RP) index is between 0.03 (Russia) and 0.77 (New Zealand), with a standard deviation of 0.21. The gap is also seen in the Composite Index (CI) which stretches from 0.09 (Russia) to 0.90 (New Zealand), with a ratio of standard deviation to mean of 54 per cent.

Table 4.9 provides Pearson correlation coefficients. The correlation coefficient between MA/Trade and NT/FDI is 0.69 and is significant at the 1 per cent level.

This suggests that allowing higher limits on foreign ownership is likely to be associated with the removal of some trade restrictions such as the resale policy of voice services. The low correlation (0.52) between MA/Invest and NT/FDI provides weak evidence that allowing higher foreign ownership enhances market access (through investment) in the telecommunications market, and vice versa. A correlation of 0.73 between RP/CS and RP/IR suggests the importance of independent regulators in enhancing competitive safeguards, and vice versa.

Among the main indices, MA, NT and RP seem to be highly correlated with each other, with coefficients of approximately 0.80. It may be inferred that countries that have better regulatory principles tend to be more competitive in the market access and national treatment, and vice versa.

Figure 4.1 shows the main indices of liberalization in telecommunications, namely Market Access, National Treatment, Regulatory Principle, as well as the Composite Index for the 19 member economies in APEC. Recall that the higher the index value, the more liberalized the economy is.

It is generally perceived that developed countries are more liberalized than their less developed counterparts. Thus, my analysis will focus on those developed countries that do not score higher than some of the developing countries based on the performances of the main indices and their respective sub-indices.

Table 4.9
Pearson correlation coefficients

	MA/Trade	MA/Invest	MA	NT/Trade	NT/FDI	NT	RP/CS	RP/IC	RP/US	RP/LS	RP/IR	RP	CI
1 MA/Trade	1												
2 MA/Invest	0.54 ***	1											
3 MA	0.95 ***	0.77 ***	1										
4 NT/Trade	0.74 ***	0.44 ***	0.72 ***	1									
5 NT/FDI	0.69 ***	0.52 ***	0.71 ***	0.45 ***	1								
6 NT	0.84 ***	0.55 ***	0.84 ***	0.90 ***	0.79 ***	1							
7 RP/CS	0.65 ***	0.53 ***	0.69 ***	0.56 ***	0.54 ***	0.65 ***	1						
8 RP/IC	0.81 ***	0.55 ***	0.81 ***	0.81 ***	0.64 ***	0.86 ***	0.67 ***	1					
9 RP/US	0.29 **	0.37 ***	0.35 ***	0.03	0.10	0.07	0.29 **	0.38 ***	1				
10 RP/LS	0.52 ***	0.36 ***	0.53 ***	0.53 ***	0.57 ***	0.64 ***	0.25 ***	0.54 ***	-0.14	1			
11 RP/IR	0.46 ***	0.34 ***	0.47 ***	0.41 ***	0.35 ***	0.45 ***	0.73 ***	0.47 ***	0.05	0.15	1		
12 RP	0.80 ***	0.63 ***	0.83 ***	0.69 ***	0.65 ***	0.79 ***	0.86 ***	0.89 ***	0.45 ***	0.52 ***	0.70 ***	1	
13 CI	0.93 ***	0.69 ***	0.95 ***	0.84 ***	0.78 ***	0.95 ***	0.76 ***	0.91 ***	0.27 **	0.61 ***	0.55 ***	0.91 ***	1

Notes:

*** Significant at 1 percent level

** Significant at 5 percent level

Source:

ITU World Telecommunication Regulatory Database (2005) and own computations.

Figure 4.1: Index of liberalization in APEC countries

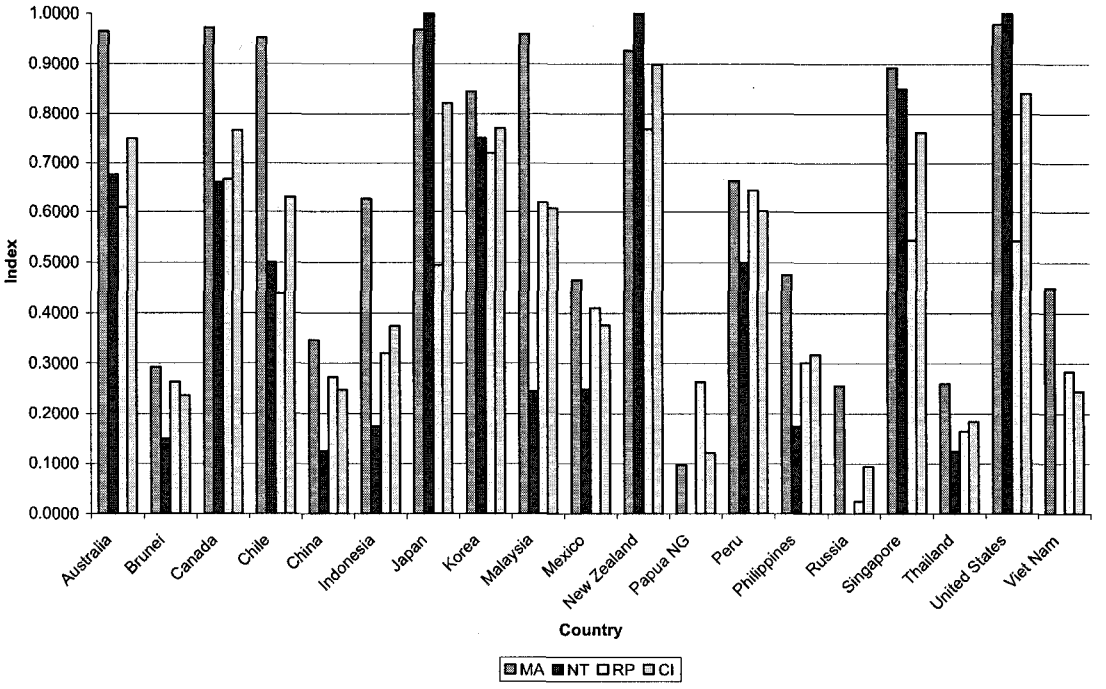

Table 4.10
Quantifying market access and national treatment policies

	Country	MA/Trade	MA/Invest	**MA**	NT/Trade	NT/FDI	**NT**
1	Australia	1.0000	0.9275	0.9638	1	0.3500	0.6750
2	Brunei	0.2500	0.3333	0.2917	0	0.3000	0.1500
3	Canada	1.0000	0.9431	0.9715	1	0.3200	0.6600
4	Chile	1.0000	0.9033	0.9516	0	1.0000	0.5000
5	China	0.0000	0.6914	0.3457	0	0.2500	0.1250
6	Indonesia	0.5000	0.7531	0.6265	0	0.3500	0.1750
7	Japan	1.0000	0.9350	0.9675	1	1.0000	1.0000
8	Korea	0.7500	0.9389	0.8444	1	0.5000	0.7500
9	Malaysia	1.0000	0.9186	0.9593	0	0.4900	0.2450
10	Mexico	0.0000	0.9325	0.4663	0	0.5000	0.2500
11	New Zealand	1.0000	0.8536	0.9268	1	1.0000	1.0000
12	Papua NG	0.0000	0.1944	0.0972	0	0.0000	0.0000
13	Peru	0.5000	0.8261	0.6631	0	1.0000	0.5000
14	Philippines	0.0000	0.9508	0.4754	0	0.3500	0.1750
15	Russia	0.0000	0.5142	0.2571	0	0.0000	0.0000
16	Singapore	1.0000	0.7853	0.8926	1	0.7000	0.8500
17	Thailand	0.0000	0.5231	0.2615	0	0.2500	0.1250
18	United States	1.0000	0.9592	0.9796	1	1.0000	1.0000
19	Viet Nam	0.0000	0.9006	0.4503	0	0.0000	0.0000

Source: ITU World Telecommunication Regulatory Database (2005) and own calculations.

Market Access

In this section, I discuss the performance of the sub-indices as well as that of the main index. The indices are reported in Table 4.10. The rankings of the top 5 and the bottom 5 countries of each category are listed on Table 4.11[34].

It is not surprising to observe that most developed countries and just a few developing countries perform well in the MA/Trade Index, as they adopt a very open policy (which is measured by the resale of voice services in both the domestic and international calls regardless of whether the calls are executed through a fixed line or mobile phone). In the MA/Invest Index, the United States maintains a leading position in providing the best market access through investment. Canada, however, ranks number 3, behind the Philippines, see Table 4.11.

The high score of the Philippines is mainly due to the fact that the remaining market shares not owned by the largest operator are significantly larger in the Philippines than in Canada, Japan and Australia. In Canada, for instance, the main operator in the fixed-line services controls about 96 per cent of the local access lines and 74 per cent of the long distance market. This potentially causes barriers to entry to new entrants seeking to penetrate the Canadian markets. In the Philippines, the respective market shares are only 63 per cent and 70 per cent.

While the United States, Canada, Japan and Australia maintain their status as the most liberalized markets as measured by the main Market Access Index, New Zealand (0.9268), drops behind less developed countries such as Malaysia (0.9593) and Chile (0.9516), owing to the existence of a duopoly in the mobile market.

[34] In some indices, there are more than one country having the same score, in this case more than 5 are reported.

Table 4.11
Ranking of Market Access and National Treatment Indices

MA/Trade

Top	Country	MA/Trade
1	Australia	1.0000
2	Canada	1.0000
3	Chile	1.0000
4	Japan	1.0000
5	Malaysia	1.0000
6	New Zealand	1.0000
7	Singapore	1.0000
8	United States	1.0000

Bottom	Country	MA/Trade
1	China	0.0000
2	Mexico	0.0000
3	Papua NG	0.0000
4	Philippines	0.0000
5	Russia	0.0000
6	Thailand	0.0000
7	Viet Nam	0.0000

MA/Invest

Top	Country	MA/Invest
1	United States	0.9592
2	Philippines	0.9508
3	Canada	0.9431
4	Korea	0.9389
5	Japan	0.9350

Bottom	Country	MA/Invest
1	China	0.6914
2	Thailand	0.5231
3	Russia	0.5142
4	Brunei	0.3333
5	Papua NG	0.1944

MA

Top	Country	MA
1	United States	0.9796
2	Canada	0.9715
3	Japan	0.9675
4	Australia	0.9638
5	Malaysia	0.9593

Bottom	Country	MA
1	China	0.3457
2	Brunei	0.2917
3	Thailand	0.2615
4	Russia	0.2571
5	Papua NG	0.0972

NT/Trade

Top	Country	NT/Trade
1	Australia	1
2	Canada	1
3	Japan	1
4	Korea	1
5	New Zealand	1
6	Singapore	1
7	United States	1

Bottom	Country	NT/Trade
1	Brunei	0
2	Chile	0
3	China	0
4	Indonesia	0
5	Malaysia	0
6	Mexico	0
7	Papua NG	0
8	Peru	0
9	Philippines	0
10	Russia	0
11	Thailand	0
12	Viet Nam	0

NT/FDI

Top	Country	NT/FDI
1	Chile	1.0000
2	Japan	1.0000
3	New Zealand	1.0000
4	Peru	1.0000
5	United States	1.0000

Bottom	Country	NT/FDI
1	China	0.2500
2	Thailand	0.2500
3	Papua NG	0.0000
4	Russia	0.0000
5	Viet Nam	0.0000

NT

Top	Country	NT
1	Japan	1.0000
2	New Zealand	1.0000
3	United States	1.0000
4	Singapore	0.8500
5	Korea	0.7500

Bottom	Country	NT
1	China	0.1250
2	Thailand	0.1250
3	Papua NG	0.0000
4	Russia	0.0000
5	Viet Nam	0.0000

Source: ITU World Telecommunication Regulatory Database (2005) and own calculations.

National Treatment

The National Treatment Index and its sub-indices for all the countries are presented in Table 4.10. As all the developed countries allowed call-back services, they obtain a perfect score in the area of NT/Trade. Chile, Japan, New Zealand, Peru and the United States allow 100 per cent foreign direct investment and they are the most foreign investment-friendly nations as measured by NT/FDI. Canada, however, with a foreign investment cap at 32 per cent, falls far behind many developing countries like Mexico (8^{th}, 50 per cent), Malaysia (9^{th}, 49 per cent), Indonesia (11^{th}, 35 per cent) and the Philippines (12^{th}, 35 per cent). Canada ranks 13^{th} in terms of the NT/FDI Index.

In terms of the overall National Treatment (NT) Index, Japan, New Zealand and the United States score perfectly. In fact, most advanced economies are fairly open to foreign service providers. Although Chile does not impose any limits on foreign direct investment, the policy that prohibits call-back services causes its ranking to fall behind many of its developed counterparts[35]. Canada, on the other hand, ranks seven in the overall National Treatment Index.

Regulatory Principe Index

The performance of the sub-indices and the main index is depicted in Table 4.12. As expected, three out of the four member countries that do not fully adopt the WTO Reference Paper and/or are not members of WTO rank in the bottom 5 in the RP/CS Index. The exception is Malaysia. As Japan does not have a separate regulator, it performs poorly in the RP/CS Index and ranks far behind many developing countries like Chile and Malaysia. On the other hand, the United States

[35] Chile and Russia did not response to the ITU survey, by default; I assume that it was disallowed.

ranks lower than Peru[36]. In terms of interconnections policy (RP/IC), Peru performs as well as its more developed counterparts like Australia and Canada. Japan, New Zealand and Singapore have the best interconnections policy among the APEC members.

Table 4.12
Quantifying regulatory principles

	Country	CS	IC	US	LS	IR	RP1	RP2	RP3
1	Australia	0.8000	0.7500	0.7000	0.0455	0.7500	0.6091	0.5977	0.5864
2	Brunei	0.2000	0.1250	0.5000	0.0000	0.5000	0.2650	0.2356	0.2063
3	Canada	0.8000	0.7500	0.4500	0.4545	0.8750	0.6659	0.6929	0.7199
4	Chile	0.6000	0.3750	0.5000	0.4091	0.3075	0.4383	0.4306	0.4229
5	China	0.2000	0.2500	0.7500	0.0455	0.1250	0.2741	0.2146	0.1551
6	Indonesia	0.4000	0.1250	0.7000	0.0000	0.3750	0.3200	0.2725	0.2250
7	Japan	0.2000	0.8750	0.5000	0.7727	0.1250	0.4945	0.4939	0.4932
8	Korea	1.0000	0.7500	0.8250	0.2727	0.7500	0.7195	0.7064	0.6932
9	Malaysia	0.6000	0.6250	0.9500	0.0455	0.8750	0.6191	0.5777	0.5364
10	Mexico	0.8000	0.2500	0.3750	0.0000	0.6250	0.4100	0.4144	0.4188
11	New Zealand	0.8000	0.8750	0.2500	1.0000	0.9200	0.7690	0.8339	0.8988
12	Papua NG	0.2000	0.3750	0.3750	0.0000	0.3750	0.2650	0.2513	0.2375
13	Peru	0.8000	0.7500	0.8250	0.0909	0.7500	0.6432	0.6205	0.5977
14	Philippines	0.2000	0.2500	0.2500	0.1818	0.6250	0.3014	0.3078	0.3142
15	Russia	0.0000	0.0000	0.0000	0.0000	0.1250	0.0250	0.0281	0.0313
16	Singapore	0.8000	0.8750	0.5000	0.0455	0.5000	0.5441	0.5496	0.5551
17	Thailand	0.2000	0.0000	0.0000	0.0000	0.6250	0.1650	0.1856	0.2063
18	United States	0.6000	0.7500	0.4500	0.0455	0.8705	0.5432	0.5548	0.5665
19	Viet Nam	0.0000	0.3750	0.8750	0.0455	0.1250	0.2841	0.2102	0.1364

Notes:

1 RP1: Equal weight of 0.20 for each of the 5 principles; including weight for US is 0.20.
2 RP2: Equal weight of 0.225 for each of the 4 principles; weight for US=0.1.
3 RP3: Equal weight of 0.25 for each of the 4 principles; weight for US is 0.
4 CI0: Equal weight for MA and NT; RP is excluded.
5 CI1: Equal weight for MA, NT and RP1.
6 CI2: Equal weight for MA, NT and RP2.
7 CI3: Equal weight for MA, NT and RP3.

Source: ITU World Telecommunication Regulatory Database (2005) and own calculations.

However, according to the RP/US Index, many developing economies, especially Malaysia and Viet Nam, move against the trend by securing the top two highest rankings while New Zealand ranks in the bottom five under the same category. The United States and Canada also rank far behind many developing economies. The

[36] This is by default as the United States does not in the ITU survey explicitly indicate if appeals to the decision of the regulatory authority are allowed, and if it makes public consultations a mandatory process.

poor rankings of these developed countries are attributable to the funding issues and to the obligation to provide universal service; both of which make these countries less competitive. In developed economies like the United States, Canada and New Zealand, the regulators require that the operators provide universal service at below costs. Also, instead of requiring the obligations to be allocated on a competitive basis or make all operators obliged, many developed economies require only some operators to provide the services.

New Zealand has the best licensing regime in the APEC as reflected by the RP/LC Index. This is because all its seven segments of services in the study do not require a license to commence operation. Chile is much ahead of Australia and the United States. This is because most services in Chile only require registration while Australia and the United States require licenses for all services in order to enter the markets.

As for the RP/IR Index, a developing country, Malaysia, which does not fully commit to the adoption of WTO's Reference Paper, appears on the top 5 of the index (see Table 4.13). This is partly due to the fact that the regulators in many developed countries are financed through government appropriation, as in Australia (100 per cent), New Zealand (64 per cent) and the United States (3.6 per cent). The funding from government potentially makes those regulators less independent from political influences in the decision making process. One may argue that, although some developing countries do not rely on government funding, their decision making process is more likely to subject to political influences and corruption.

Given their high scores in the RP/US Index, Peru and Malaysia outperform their more developed counterparts, like Australia and the United States, although in general, developed countries still perform better (in terms of ranking) than developing countries in the main RP index.

Weighted Regulatory Principle Index

Table 4.14 shows the ranking of each country using the variations of weighted RP. Based on the top-5 list, Malaysia slips one level below, to sixth place, swapping position with Australia when RP2 is used as compared to RP1. Other top four positions remain unchanged. When the weight for RP/US reduces to zero, the ranking for Malaysia falls further to eighth, behind Singapore. Meanwhile, Canada and Korea switch positions, with Canada now ranking second, and Korea third.

On the bottom-5 list, the ranking of Papua New Guinea improves. It disappears from the list when the weight for RP/US reduces from 20 to 10 per cent and zero, subsequently. Instead, Viet Nam is added to the list. Russia is not affected by the change in the weight for RP/US, it consistently ranks at the bottom while other bottom-5 countries stay in tact on the list.

Weighted Composite Index

The weighted CI is presented in Table 4.15. New Zealand is on the top of the list as the most liberalized economy in the region based on CI1, while Russia scores the lowest as the least liberalized economy. Chile is the most liberalized economy amongst the developing countries, even more liberalized than some of the OECD countries like Mexico.

The United States, which is perceived by many as the most liberalized country, fails to receive the top ranking in CI1; it ranks after New Zealand due to its lower score in the Regulatory Principle Index (RP1). Canada, on the other hand, loses to Japan and Korea because of its low score in the National Treatment Index.

Table 4.13
Ranking of Regulatory Principle Sub-indices

RP/CS

Top	Country	CS
1	Korea	1.0000
2	Australia	0.8000
3	Canada	0.8000
4	Mexico	0.8000
5	New Zealand	0.8000
6	Peru	0.8000
7	Singapore	0.8000

Bottom	Country	CS
1	Brunei	0.2000
2	China	0.2000
3	Japan	0.2000
4	Papua NG	0.2000
5	Philippines	0.2000
6	Thailand	0.2000
7	Russia	0.0000
8	Viet Nam	0.0000

RP/IC

Top	Country	IC
1	Japan	0.8750
2	New Zealand	0.8750
3	Singapore	0.8750
4	Australia	0.7500
5	Canada	0.7500
6	Korea	0.7500
7	Peru	0.7500
8	United States	0.7500

Bottom	Country	IC
1	China	0.2500
2	Mexico	0.2500
3	Philippines	0.2500
4	Brunei	0.1250
5	Indonesia	0.1250
6	Russia	0.0000
7	Thailand	0.0000

RP/US

Top	Country	US
1	Malaysia	0.9500
2	Viet Nam	0.8750
3	Korea	0.8250
4	Peru	0.8250
5	China	0.7500

Bottom	Country	US
1	Mexico	0.3750
2	Papua NG	0.3750
3	New Zealand	0.2500
4	Philippines	0.2500
5	Russia	0.0000
6	Thailand	0.0000

RP/LS

Top	Country	LS
1	New Zealand	1.0000
2	Japan	0.7727
3	Canada	0.4545
4	Chile	0.4091
5	Korea	0.2727

Bottom	Country	LS
1	Brunei	0.0000
2	Indonesia	0.0000
3	Mexico	0.0000
4	Papua NG	0.0000
5	Russia	0.0000
6	Thailand	0.0000

RP/IR

Top	Country	IR
1	New Zealand	0.9200
2	Canada	0.8750
3	Malaysia	0.8750
4	United States	0.8705
5	Australia	0.7500
6	Korea	0.7500
7	Peru	0.7500

Bottom	Country	IR
1	Chile	0.3075
2	China	0.1250
3	Japan	0.1250
4	Russia	0.1250
5	Viet Nam	0.1250

Source: ITU World Telecommunication Regulatory Database (2005) and own calculations.

Table 4.14
Ranking of weighted Regulatory Principles Index

	Country	RP1	Rank	RP2	Rank	RP3	Rank
1	New Zealand	0.7690	1	0.8339	1	0.8988	1
2	Korea	0.7195	2	0.7064	2	0.6932	3
3	Canada	0.6659	3	0.6929	3	0.7199	2
4	Peru	0.6432	4	0.6205	4	0.5977	4
5	Malaysia	0.6191	5	0.5777	6	0.5364	8
6	Australia	0.6091	6	0.5977	5	0.5864	5
7	Singapore	0.5441	7	0.5496	8	0.5551	7
8	United States	0.5432	8	0.5548	7	0.5665	6
9	Japan	0.4945	9	0.4939	9	0.4932	9
10	Chile	0.4383	10	0.4306	10	0.4229	10
11	Mexico	0.4100	11	0.4144	11	0.4188	11
12	Indonesia	0.3200	12	0.2725	13	0.2250	14
13	Philippines	0.3014	13	0.3078	12	0.3142	12
14	Viet Nam	0.2841	14	0.2102	17	0.1364	18
15	China	0.2741	15	0.2146	16	0.1551	17
16	Brunei	0.2650	16	0.2356	15	0.2063	15
17	Papua NG	0.2650	17	0.2513	14	0.2375	13
18	Thailand	0.1650	18	0.1856	18	0.2063	16
19	Russia	0.0250	19	0.0281	19	0.0313	19

Notes:

1 RP1: Equal weight of 0.20 for each of the 5 principles; including weight for US is 0.20.

2 RP2: Equal weight of 0.225 for each of the 4 principles; weight for US=0.1.

3 RP3: Equal weight of 0.25 for each of the 4 principles; weight for US is 0.

Source: ITU World Telecommunication Regulatory Database (2005) and own calculations.

A small country and a newly industrialized economy, Singapore, is seen to be more liberalized than its larger and advanced counterparts like Australia. Although Australia has a more competitive market access policy and a better regulatory principle than Singapore, that effect is offset by the less favorable national treatment policy, especially pertaining to foreign direct investment.

When the weight for RP/US reduces to 10 per cent as in the case of CI2 in Table 4.15, Canada moves one level up to the fourth on the top-5 list as compared to the CI1 list, switching position with Korea, while the other top three countries are unaffected by the change. Meanwhile, Korea slips further to 6th place when RP/US is given a zero weight (CI3). New inclusion to the top-5 list is Singapore. However,

when RP is totally excluded from the weighted CI as in CI0, New Zealand has to give way to the United States and Japan, to rank third while Canada and Korea both fall off the chart, ranking sixth and seventh, respectively.

Table 4.15
Ranking of Composite Index

	Country	CI1	Rank	CI2	Rank	CI3	Rank	CI0	Rank
1	New Zealand	0.8986	1	0.9202	1	0.9419	1	0.9634	3
2	United States	0.8409	2	0.8448	2	0.8487	2	0.9898	1
3	Japan	0.8207	3	0.8205	3	0.8202	3	0.9838	2
4	Korea	0.7713	4	0.7669	5	0.7625	6	0.7972	7
5	Canada	0.7658	5	0.7748	4	0.7838	4	0.8158	6
6	Singapore	0.7622	6	0.7641	6	0.7659	5	0.8713	4
7	Australia	0.7493	7	0.7455	7	0.7417	7	0.8194	5
8	Chile	0.6300	8	0.6274	8	0.6248	8	0.7258	8
9	Malaysia	0.6078	9	0.5940	10	0.5802	10	0.6022	9
10	Peru	0.6021	10	0.5945	9	0.5869	9	0.5815	10
11	Mexico	0.3754	11	0.3769	11	0.3783	11	0.3581	12
12	Indonesia	0.3738	12	0.3580	12	0.3422	12	0.4008	11
13	Philippines	0.3173	13	0.3194	13	0.3215	13	0.3252	13
14	China	0.2483	14	0.2284	14	0.2086	15	0.2353	14
15	Viet Nam	0.2448	15	0.2202	16	0.1955	17	0.2251	15
16	Brunei	0.2356	16	0.2258	15	0.2160	14	0.2208	16
17	Thailand	0.1838	17	0.1907	17	0.1976	16	0.1933	17
18	Papua NG	0.1207	18	0.1162	18	0.1116	18	0.0486	19
19	Russia	0.0940	19	0.0951	19	0.0961	19	0.1285	18

Notes:

1 CI0: Equal weight for MA and NT; RP is excluded.
2 CI1: Equal weight for MA, NT and RP1.
3 CI2: Equal weight for MA, NT and RP2.
4 CI3: Equal weight for MA, NT and RP3.

Source: ITU World Telecommunication Regulatory Database (2005) and own calculations.

Among the bottom five, both Papua New Guinea and Russia are constantly on the list across CI0, CI1, CI2 and CI3. Brunei improves its ranking if a smaller weight for RP/US is used. Other countries are quite constant in their ranking across the various variations of weighted CI.

Section 3: Conclusions

Departing from the traditional method of measuring market reform, I make use of the most recent ITU survey data to construct indices of trade liberalization in terms of market access, national treatment, and the regulatory principles, all within the context of WTO.

There is evidence that developed countries do not always have higher levels of market liberalization. Some developing countries may be more open than their developed counterparts. I have shown that liberalization is not just about privatization, competition or purely regulation, as it also involves the regulatory principles of a country. Weak regulatory principles may pose as a barrier to entry to potential entrants. By taking into accounts these factors, I now have a better-represented index of market liberalization.

In the construction of the indices, I have used subjective weights for variables. For example, I treat market access, national treatment and regulatory principles as having equal weights. In reality, the effects of policy reforms in these three areas may be of different magnitudes, which would call for different weights. In the measure of openness of market access through investment in fixed line and mobile service, I place the existence of competition higher than the level of competition allowed, and both are placed higher than the privatization and market shares. These weighting schemes may be subject to debate.

Yet, the composite index of liberalization and its sub-indices are still useful for gauging the impact of liberalization. Countries can choose the desired level of liberalization in telecommunications sector in order to enhance telecommunications network and to achieve higher economic output.

CHAPTER 5:
THE OUTPUT IMPACT OF TRADE LIBERALIZATION

In this chapter, I estimate the impact of trade liberalization in telecommunications on output through investment. I also test empirically how different income groups react towards liberalization and quantify the impact of full liberalization on output when barriers to entry are hypothetically removed from each country. To do so, I expand the model in Chapter 3 to include a policy variable which is represented by indices computed from Chapter 4.

This chapter is organized as follows: Section 1 discusses the model framework. Section 2 explains the data and methodology. The estimation and results are presented in Section 3. Section 4 summarizes the research findings and concludes the chapter.

Section 1: Model framework

Chapter 3 shows that models with fixed effects perform better than models that do not control for fixed effects, and also those models with both fixed telephone lines and mobiles are superior to models that only use fixed lines. In this chapter, I adopt the same four structural equations as in Chapter 3, namely output, demand, investment and telecommunications production, but with some modifications.

In particular, the framework in Chapter 3 is extended to include a variable that measures a country's openness to trade and investment. Specifically; the policy variable enters the investment equation explicitly, while the other equations are similar to Chapter 3. The indices computed in Chapter 4 are used as proxies for this policy variable.

I specify that investment in telecommunications (TTI) as a function of price $(TELP)$, the size of a country (GA), government budget deficit (GD), waiting list (WL) and trade policy (RR). Note that RR is a new variable that was not present in Chapter 3.

$$TTI_{it} = h(TELP_{it}, GA_{it}, GD_{it}, WL_{it}, RR_{it}) \qquad (5.1)$$

I expect that improving trade policy or a greater degree of trade liberalization stimulates investment in telecommunications. However, not all policy variables are expected to have positive impact on both developing and developed countries. Some variables may be more pronounced in developed countries than in the less developed counterparts, and vice versa. In practice, certain policies in relation to reform may not bring as much benefits to developing countries as to their more developed counterparts. Some policies may have a more detrimental effect to some countries than to others.

The relationships between TTI and other variables in equation (5.1) are expected to be the same as in Chapter 3. That is, I expect the higher the price of services, the more producers are willing to supply or invest (positive relationship). I also predict that the size of a country (in terms of geographical areas), and hence access to resources, has a positive impact on the supply of telecommunications. However, the impact of government budget deficit is ambiguous, as it may be related to how the investment of the infrastructure is financed. Also, the longer (or higher) the waiting list the more investment (whether through private sector or government) can be expected; thus there would be a positive relationship.

System of equations for econometric estimation

As the four structural equations are to be estimated simultaneously, the fixed effect is only introduced in the investment equation to avoid correlation between fixed

effects in the equations[37] and the loss of degree of freedom. This means that in the output equation as well as the other two equations, the intercepts are assumed to be common across countries. In other words, I no longer examine the fixed effects in output equation as in Chapter 3.

The policy variable (RR), which measures the degree of market liberalization, enters the investment equation in equation (5.4) below. I assume the policy variable (RR) to be exogenous. RR is proxied by the nine indices created in Chapter 4, namely Market Access Index, National Treatment Index, three variations of Regulatory Principles Index and four variations of the Composite Index.

Since I expect the developing and developed countries to have different responses with respect to policy towards liberalization, interaction terms are created. Accordingly, I modify equations (5.4) and (5.5) to allow different responses for developing and developed countries, with respect to investment.

In addition to this, a dummy variable (STR) that represents years before and after the implementation of ABT is added to the investment equation. STR=1, for years 1998-2003; and takes the value of 0 for years 1982-1997. In other words, STR is intended to capture possible structural break caused by the implementation of ABT.

Equations (5.2) and (5.3) are based on Chapter 3. The complete system of equations is shown below:

$$\log(GDP_{it}) = a_0 + a_1 \log(KA_{it}) + a_2 \log(HK_{it}) + a_3 \log(TLF_{it})$$

$$+ a_4 \log(PEN_{it}) + a_5 t + \varepsilon_{it}^1 \qquad (5.2)$$

[37] See Gujarati (2003), p. 302. Also see Appendix F on treatment of fixed effects.

$$\log(PEN_{it} + WLPC_{it}) = b_0 + b_1 \log(GDPPC_{it}) + b_2 \log(TELP_{it}) + \varepsilon_{it}^2 \quad (5.3)$$

$$\begin{aligned}\log(TTI_{it}) = c_{0i} &+ c_1 \log(GA_{it}) + c_2 GD_{it} \\ &+ c_3(1 - DEVD)WLPC_{it} \\ &+ c_4(1 - DEVD)\log(TELP_{it}) \\ &+ c_5 DEVD \log(TELP_{it}) \\ &+ c_6 STR \\ &+ c_7(1 - DEVD)RR_{it} \\ &+ c_8(DEVD)RR_{it} + \varepsilon_{it}^3 \end{aligned} \quad (5.4)$$

$$\begin{aligned}\log(PEN_{it} / PEN_{i,t-1}) = d_0 &+ d_1(1 - DEVD)\log(TTI_{it}) + d_2 DEVD \log(TTI_{it}) \\ &+ d_3 \log(GA_{it}) + \varepsilon_{it}^4 \end{aligned} \quad (5.5)$$

Section 2: Data and methodology

The data are extracted mainly from Chapter 3. Chapter 4 provides the policy indices of 19 countries excluding Hong Kong and Taiwan. Therefore, the number of countries that can be used for this Chapter is 15 as compared to 17 in Chapter 3.

The policy variables constructed in Chapter 4 are based on the 2005 ITU survey. Although obtaining or computing time series of the policy variables would have been desirable, the ITU did not compile such data set until 1997, and also the questions in the surveys varied from year to year. Therefore, the policy variables are assumed to be constant for each country over the study period[38]. The above assumption is the same as that of Li and Xu (2002) and Mattoo et al (2001) and is

[38] Because of this, the estimated result may be subject to bias if some slow-growing countries rank high in 2005, while they could have ranked low in the early years of the study if the time series data had been available. To alleviate this problem, I conduct an additional set of estimations for a short period from 1994-2003.

based on the fact that trade policies changed slowly. Taking into account a structural break, the analysis on both whole sample (1982-2003) and sub-sample (1994-2003) periods is performed.

The policy variable is represented by Market Access Index, National Treatment Index, Regulatory Principles Index and Composite Index. The Market Access Index (MA) measures the degree of market access (or barriers to entry) a domestic or foreign firm faces if it wishes to provide telecommunication services in a member countries. The higher the Market Access index, the lower the barriers to entry. The National Treatment Index (NT) measures the degree of discrimination a foreign firm faces compared to a domestic firm if it wishes to provide services in a member country. The higher the NT Index, the lower the barriers of entry.

Table 5.1
Descriptive statistics of policy variables (RR)

Vector of Policy Variables (RR)	Description	Mean	Median	Maximum	Minimum	Std. Dev.	Obs
MA/Trade	Measures degree of market access through trade	0.65	1.00	1.00	0.00	0.44	15
MA/Invest	Measures degree of market access through investment	0.86	0.92	0.96	0.52	0.12	15
MA	Measures degree of national treatment through trade	0.75	0.89	0.98	0.26	0.26	15
NT/Trade	Measures degree of national treatment through FDI	0.47	0.00	1.00	0.00	0.52	15
NT/FDI	Measures degree of competitive safeguards	0.60	0.50	1.00	0.25	0.31	15
NT	Measures the quality of interconnections policy	0.54	0.50	1.00	0.13	0.34	15
RP/CS	Measures quality of universal service	0.59	0.60	1.00	0.20	0.28	15
RP/IC	Measures the quality of lisencing criteria	0.55	0.75	0.88	0.00	0.31	15
RP/US	Measures the degree of independence of a regulator	0.54	0.50	0.95	0.00	0.26	15
RP/LS	Market Access Index (average of MA/Trade and MA/Inv)	0.23	0.05	1.00	0.00	0.31	15
RP/IR	National Treatment Index (average of NT/Trade and NT/FDI)	0.61	0.63	0.92	0.13	0.27	15
RP	Regulatory Principle Index (average of CS, IC, US, LS and IR)	0.50	0.54	0.77	0.17	0.18	15
CI	Composite Index (average of MA, NT and RP)	0.60	0.63	0.90	0.18	0.24	15

Note:
Only equal-weigted RP and CI are reported (RP1 and CI1)

Source:
ITU World Telecommunication Regulatory Database (2005) and Chapter 4.

The Regulatory Principles Index (RP), on the other hand, measures the overall strength of the regulatory principles in competitive safeguards, interconnections policy, universal service, licensing conditions and the independence of the regulator. A higher index represents lower degree of barriers to entry and thus higher quality of the regulatory principles. There are three variations of RP using different weights assigned for universal service policy as discussed in Chapter 4.

The Composite Index (CI) measures the overall degree of trade liberalization taking into account market access, national treatment as well as regulatory principles. Four variations of CI are used from Chapter 4, arising from the three different weights assigned to universal service policy in RP above and a zero weight for RP.

Descriptive statistics and correlation

The descriptive statistics of the policy variables for the 15 countries in this study are in Table 5.1. The standard deviation to mean ratio is quite large across the policy variables, 35 per cent for MA, 63 per cent for NT, 36 per cent for RP and 40 per cent for CI. This reflects a wide dispersion in the degree of market liberalization, especially between the poor and the rich countries.

Table 5.2 provides the correlation of telecommunication variables and the policy indices. Since the correlations among the main indices are generally high, approximately 0.80, I enter each index into the investment equation one at a time to avoid multicollinearity. The correlation between PEN and NT/Trade is reasonably high, approximately 0.75; but the correlation between PEN and RP/US is negative, implying that universal service policy may pose an obstacle to network roll-outout. Nevertheless, the correlation between investment and each of the policy variables is weak and three out of five regulatory principles have negative correlation with the investment variable.

Table 5.2
Pairwise correlations

	TTI	PEN	MA/Trade	MA/Inv	NT/Trade	NT/FDI	RP/CS	RP/IC	RP/US	RP/LS	RP/IR	MA	NT	RP	CI
TTI	1														
PEN	0.4251	1													
MA/Trade	0.2177	0.5910	1												
MA/Inv	0.2524	0.3598	0.4901	1											
NT/Trade	0.3916	0.7524	0.6897	0.3934	1										
NT/FDI	0.3439	0.2572	0.5318	0.3416	0.2857	1									
RP/CS	-0.2556	0.3379	0.4844	0.4388	0.4454	0.2359	1								
RP/IC	0.2824	0.6258	0.8017	0.5439	0.8038	0.5695	0.5774	1							
RP/US	-0.0105	-0.0348	0.2915	0.2748	-0.0375	0.0021	0.3161	0.2988	1						
RP/LS	0.1636	0.3545	0.4490	0.2919	0.4705	0.5128	0.0686	0.4842	-0.2526	1					
RP/IR	-0.1960	0.2504	0.2640	0.3052	0.2829	0.0208	0.6094	0.3489	-0.0468	0.0005	1				
MA	0.2478	0.5948	0.9779	0.6615	0.6878	0.5395	0.5220	0.8202	0.3167	0.4563	0.3004	1			
NT	0.4583	0.6946	0.7731	0.4586	0.8972	0.6795	0.4497	0.8778	-0.0277	0.5966	0.2262	0.7751	1		
RP	0.0120	0.5062	0.7431	0.5940	0.6496	0.4519	0.8059	0.8796	0.3891	0.4587	0.5942	0.7818	0.7055	1	
CI	0.3109	0.6735	0.9092	0.6074	0.8397	0.6326	0.6060	0.9363	0.1994	0.5647	0.3660	0.9279	0.9344	0.8707	1

Note:
Only equal-weigted RP and CI are reported (RP1 and CI1)

Source:
1. ITU World Telecommunication Regulatory Database (2005)
2. ITU World Telecommunication Indicators Database (2002)
3. Chapter 4

Section 3: Estimation and results

Table 5.3
Function value of simultaneous GMM estimation

Period of sample	Models	RR used in simultaneous GMM	Function Value (FV)	Sample size (S)	Ratio=FV/S
1982-2003 (22 years)	1	MA	543.44	315	1.73
	2	NT	515.83	315	1.64
	3	RP1	592.18	315	1.88
	4	RP2	588.68	315	1.87
	5	RP3	570.03	315	1.81
	6	CI0	542.72	315	1.72
	7	CI1	563.01	315	1.79
	8	CI2	562.97	315	1.79
	9	CI3	561.74	315	1.78
1994-2003 (10 years)	1	MA	233.42	135	1.73
	2	NT	236.28	135	1.75
	3	RP1	235.13	135	1.74
	4	RP2	234.68	135	1.74
	5	RP3	234.52	135	1.74
	6	CI0	233.00	135	1.73
	7	CI1	233.50	135	1.73
	8	CI2	233.51	135	1.73
	9	CI3	233.57	135	1.73

Note:

The sample size used is 315 (instead of 330) for the 22-year period and 135 (instead of 150) for the 10-year period analysis. This is because there is a skipped 15 observations due to the lag-one period in PEN variable.

Given the large number of models (18 in total) for this study, a criterion is needed to select the "best" model. I use a measure of goodness-of-fit proposed by Singleton (2006), namely the minimized value of the GMM criterion function (FV) scaled by sample size (S) or the FV/S ratio. As can be seen from Table 5.3, the FV/S ratios in the whole sample period are generally higher than those ratios in the sub-sample period. The average ratio in the whole sample period is 1.78, and is 1.73 in the sub-sample. Singleton (2006) suggests that a smaller ratio is superior to the larger ones. Amongst the models in the sub-sample, models with variations of

CI seem to have the lowest ratios (1.73). Thus, the discussion of this chapter will focus on these models and the results are provided in Table 5.4[39].

As presented in Table 5.4, the PEN variable has the right sign (i.e. positive) across all 4 models. Amongst them, PEN variable in Model 5.4 is the most significant, at 1 per cent level as compared to the other three variations that are all significant at 5 per cent level. On the other hand, the structural break variable introduced in the investment equation is positive and significant at 1 per cent level across all models.

The interaction term (1-DEVD)*RR, which represents trade policy in developing countries, is negative and significant at 5 per cent level across all 4 models. This suggests that a higher degree of liberalization in the telecommunications sector has a negative impact on developing countries.

The other interaction term (DEVD)*RR, which represents trade policy in developed countries is positive but statistically insignificant at 10 per cent across the 4 models, indicating there may be some benefits but no compelling evidence is found.

The differences in results among models using variations of CI, in terms of goodness-of-fit, the signs of other coefficients and their levels of significance, are minimal. This suggests that the estimation results are fairly robust, insensitive to the variations in CI.

Models 5.1 and 5.2, respectively, have the lowest and second lowest function value, but for interpretation purposes, Model 5.2 is preferred to Model 5.1 as I believe that a policy variable without taking into account of regulatory principles is somewhat incomplete. In addition, the CI1 (the policy proxy in Model 5.2) is an

[39] For completeness, results from all remaining models are presented in Appendices G, H and I. Specifically, the results for models using MA, NT and RP as policy variable are presented in Appendix G for the whole period (22 years) and in Appendix H for the sub-sample period (10 years), while Appendix I provides the results of those models using CI0, CI1, CI2 and CI3 as policy variable for the whole period (22 years).

equally weighted index of market access, national treatment and regulatory principles; it can serve as a baseline model.

Interpretations

From Model 5.2, the coefficient for PEN in the output equation is slightly larger (0.1168 as compared to 0.0930) than in that of Chapter 3 (Model without fixed effects). There is also a higher coefficient for KA (0.8602 versus 0.8462), but a lower coefficients for HK (0.1971 versus 0.3948) and TLF (0.1737 versus 0.1847). As in Chapter 3, the magnitudes of these coefficients are higher than that of PEN, this reinforce the importance of physical capital, human capital and labour force relative to telecommunications stock.

From the demand equation, together with the output equation, the results show the existence of a bilateral causal relationship between telecommunications stock and income, that is, the relationship runs from telecommunications stock to income and from income to telecommunications stock. The positive and statistically significant income effect of 1.4024 is lower than 1.4076 in Chapter 3. I interpret it as for every 1 per cent increase in GDP per capita, the demand for telecommunications increases by more than 1 per cent (to be exact, 1.40 per cent). With a negative coefficient of 1.3557, the demand function is elastic. Chapter 3 finds the demand to be inelastic (0.9676).

As for the investment equation, larger countries (in square kilometers) seem to be investing more in telecommunication services, as shown by a coefficient of 0.3646 (0.2117 in Chapter 3). In contrast to Chapter 3, with a positive sign of 0.0021, budget surplus tend to induce larger investment in telecommunications infrastructure, as evident in the coefficient for the budget variable (GD), however, the coefficient is not statistically significant at 10 per cent level. Similarly to Chapter 3, I still find a negative sign for WLPC. This suggests that the issue of supply

constraints still faces the APEC countries, apart from trade barriers. The supply of telecommunication services in developing countries in APEC could still be subject to many other challenges such as those in the financial sector and/or the technical environment. In terms of price elasticity, Chapter 3 finds that the price is inelastic in the investment equation, (0.4731 and 0.4449 for developing and developed countries respectively). In contrast, I find that the prices in both developed and developing countries are elastic. They are significant at the 1 and 10 per cent level, respectively; the elasticity in developing countries (2.8193) is generally higher than that in developed countries (2.1046). The STR variable is significant at 1 per cent level indicating a structural break during the period of the analysis.

The sign of the policy variable, CI1 in this case, is negative for developing countries and positive for developed countries. The pairs of opposite signs (developed versus developing countries) observed in the coefficients of the policy variables in Model 5.2 (in fact, across all models) seem to suggest that pursuing high degree of market liberalization does not necessarily lead to increases in investment in developing countries, as it does in developed countries. The result seems to be consistent with Warren (2000b) who finds a negative relationship between degree of market openness (measured by MA/Trade) and investment in telecommunications. His analysis, however, does not differentiate between developing and developed countries.

As such, full liberalization may provide less incentive for economic growth, especially for developing countries. In the developed countries, the more open the policy, and the more investment can be expected. However, the policy variable for developed countries is not statistically significant.

Table 5.4
Simultaneous equations: non-linear GMM using CI (10 years)

	Equations	Variables	CI0		CI1		CI2		CI3	
			Model 5.1		Model 5.2		Model 5.3		Model 5.4	
			Coeff	Std Error	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error
1	Output	Intercept	200.7761	43.0512 ***	187.3613	42.6139 ***	190.3477	43.1571 ***	193.5397	43.8234 ***
2		KA	0.8569	0.0480 ***	0.8602	0.0491 ***	0.8576	0.0497 ***	0.8550	0.0506 ***
3		HK	0.1413	0.1080 ##	0.1971	0.1100 *	0.1972	0.1109 *	0.1965	0.1119 *
4		TLF	0.1783	0.0496 ***	0.1737	0.0496 ***	0.1770	0.0503 ***	0.1805	0.0511 ***
5		PEN	0.1312	0.0591 **	0.1168	0.0586 **	0.1200	0.0593 **	0.1235	0.0602 ***
6		t	-0.1004	0.0213 ***	-0.0937	0.0211 ***	-0.0952	0.0213 ***	-0.0968	0.0217 ***
7	Demand	Intercept	-5.1022	0.3530 ***	-5.0879	0.3539 ***	-5.0906	0.3541 ***	-5.0931	0.3542 ***
8		GDPPC	1.4015	0.0332 ***	1.4024	0.0333 ***	1.4023	0.0333 ***	1.4022	0.0333 ***
9		TELP	-1.3522	0.0774 ***	-1.3557	0.0775 ***	-1.3552	0.0775 ***	-1.3546	0.0775 ***
10	Investment	GA	0.3992	0.1110 ***	0.3646	0.1043 ***	0.3596	0.1028 ***	0.3552	0.1013 ***
11		GD	0.0033	0.0025 ##	0.0022	0.0022	0.0021	0.0022	0.0020	0.0022
12		(1-DEVD)*WLPC	-35.2427	9.5459 ***	-35.0324	9.1193 ***	-33.6118	8.8786 ***	-32.1249	8.6371 ***
13		(1-DEVD)*TELP	2.7229	0.3419 ***	2.8193	0.3433 ***	2.8101	0.3395 ***	2.7989	0.3350 ***
14		DEVD*TELP	1.1394	1.1466	2.1046	1.2049 *	2.1549	1.0672 **	2.1864	0.9513 **
15		STR	4.7352	0.8643 ***	4.7842	0.8699 ***	4.7987	0.8535 ***	4.8077	0.8401 ***
16		(1-DEVD)*RR	-4.0638	1.7808 **	-4.5644	1.9487 **	-4.4717	1.9430 **	-4.3666	1.9332 **
17		DEVD*RR	7.4642	7.8584	0.8315	9.6499	0.4647	8.4510	0.2496	7.4393
18	Production	Intercept	-2.3514	1.1318 **	-2.4119	1.1419 **	-2.4253	1.1445 **	-2.4411	1.1467 **
19		(1-DEVD)*TTI	0.1721	0.0611 ***	0.1746	0.0618 ***	0.1750	0.0619 ***	0.1754	0.0620 ***
20		DEVD*TTI	0.1780	0.0587 ***	0.1802	0.0594 ***	0.1806	0.0595 ***	0.1812	0.0597 ***
21		GA	-0.1067	0.0347 ***	-0.1059	0.0349 ***	-0.1056	0.0349 ***	-0.1052	0.0349 ***

Function Value	233.00	233.50	233.51	233.57

Note:

*** significant at 1 per cent level

** significant at 5 per cent level

* significant at 10 per cent level

1 CI0: Equal weight for MA and NT; RP is excluded.

2 CI1: Equal weight for MA, NT and RP1.

3 CI2: Equal weight for MA, NT and RP2.

4 CI3: Equal weight for MA, NT and RP3.

In the production equation, the signs for the interaction terms with TTI are positive, as predicted, for both developing and developed countries. This means that investment is a good indicator for telecommunications stock accumulation. The negative coefficient of GA simply implies that large countries invest more for a given level of telecommunications infrastructure.

Quantifying the impact of trade liberalization

Unlike Mattoo et al (2001), who rely on a dummy variable for the openness measure (1 for complete openness and 0 otherwise), I follow Warren (2000b) and Chen (2006) by using the openness indices to estimate the impact of further liberalization on output. To be more specific, I calculate the effect of a larger value of the openness index (brought about by liberalization) on output.

To determine whether or not the estimated effects of openness in telecommunications are likely, in whole or in part, driven by the overall openness of the economy, a simple correlation is performed. Deardorff defines the overall openness of the economy (OPEN) as the ratio of a country's trade (export plus import) to its GDP[40]. The data for OPEN for 2005 is obtained from the WDI. The correlations between the index of openness in telecommunications (represented by 9 indices as discussed) and OPEN are: MA=0.0197; NT=-0.0575; RP1=-0.0453; RP2=-0.0478; RP3=-0.0490; CI0=-0.0256; CI1=-0.0317; CI2=-0.0325; CI3=-0.0332. The result shows that there is barely any correlation between them, suggesting that the estimated effects are not likely to be driven by the overall openness of the economy.

For illustration purpose, I take Canada as an example. Canada's level of openness is 0.7658 as reflected in CI1 as in Chapter 4. To fully liberalize the CI1 Canada has to reduce its trade barriers by 23 per cent.

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[40] See Deardorff's Glossary of International Economics at:
http://www-personal.umich.edu/~alandear/glossary/o.html#OpennessIndex

From Model 5.2, with the coefficient of 0.8315 for developed countries in the investment equation, the logTTI (log investment in equation (5.4)) would grow by 0.1947 (or the TTI would grow by 0.2150 per cent). From equation (5.5), the investment coefficient for developed countries is 0.1802; multiplying by this factor (0.1947) leads to a growth factor of 0.0351 per cent. Accordingly, from the output equation (equation (5.2)), I know that the elasticity of GDP with respect to PEN is 0.1168; thus the impact of CI1 liberalization on Canadian GDP is 0.41 per cent[41]. In other words, if Canada fully liberalizes its CI1 policy, the GDP would grow by 0.4 per cent; this amount is however much lower than the 3.5 per cent estimated by Warren (2000b).

Alternatively, using Equation (E) in Appendix J and dropping all the subscripts for simplicity, from Model 5.2, $a_4 = 0.1168; d_2 = 0.1802; c_8 = 0.8315; \delta RR = 0.23$

$$\Rightarrow \delta \log GDP = a_4 * d_2 * c_8 * \delta RR$$

$$\Rightarrow \delta \log GDP = 0.1168 * 0.1802 * 0.8315 * 0.23$$

$$\Rightarrow \delta \log GDP = 0.0041$$

$$\Rightarrow \delta GDP = \exp(0.0041) - 1 = 0.41\%$$

The quantity impact for all countries is provided in Table 5.5. When the degree of barriers to entry is measured by CI1, the average impact on output of full trade liberalization on developed countries is approximately 0.3 per cent[42], while the adverse impact on developing countries is approximately 5.3 per cent.

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[41] The growth factor is calculated as 0.1802*0.1947=0.0351 and the impact on logGDP in equation (5.2) is given as 0.1168*0.0351=0.0041. In other words, the impact on GDP is exp(0.0041)-1 which is approximately 0.41 per cent.

[42] Statistically, this estimate is not significantly different from zero because the coefficient for developed countries is not statistically significant.

Section 4: Conclusions

In the literature of trade liberalization in telecommunications, dummy variables have traditionally been used to represent privatization, regulatory reform or existence of competitive environment. Although there have been attempts to use indices to represent the level of liberalization, it has often been incomplete as the authors did not actually measure the level of liberalization in the context of market access, national treatment and regulatory principles in the spirit of WTO. I make use of the indices from Chapter 4, which is a series of policy variables that attempt to capture the extent of barriers to entry in the context of WTO. Furthermore, instead of estimating a reduced-form equation, I formulate the model in four structural equations, taking into account the causality between income and network expansion and between network expansion and investment.

Table 5.5
Quantity impact of full trade liberalization

Countries	CI1	Impact on log TTI	Impact on logPEN	Impact on GDP (%)
Chile	0.6300	-1.6889	-0.2949	-3.3856
China	0.2483	-3.4312	-0.5991	-6.7582
Indonesia	0.3738	-2.8580	-0.4990	-5.6619
Malaysia	0.6078	-1.7902	-0.3126	-3.5849
Mexico	0.3754	-2.8508	-0.4978	-5.6480
Peru	0.6021	-1.8163	-0.3171	-3.6362
Philippines	0.3173	-3.1163	-0.5441	-6.1574
Thailand	0.1838	-3.7253	-0.6504	-7.3156
Australia	0.3500	0.2085	0.0376	0.4397
Canada	0.3200	0.1947	0.0351	0.4107
Japan	1.0000	0.1491	0.0269	0.3143
Korea	0.5000	0.1901	0.0343	0.4010
New Zealand	1.0000	0.0843	0.0152	0.1776
Singapore	0.7000	0.1977	0.0356	0.4170
United States	1.0000	0.1323	0.0238	0.2788

Note: The upper panel are those developing economies while the lower panel are developed economies.

I find some evidence that a greater degree of market liberalization harms developing countries at the expense of lower investment in telecommunications. I estimate that the quantity impact of full trade liberalization is a negative 5.3 per cent for the developing countries. One possible explanation for this phenomenon is that, as price takers, developing countries are more vulnerable to world markets and less able to respond to the anti-competitive behaviour of large multinational corporations. As such, competition policy and regulatory framework with respect to telecommunications liberalization within the WTO context need to be carefully addressed, given the different market structures of the various countries, especially the developing countries.

References:

Abbott, A., & Brady, G. (1999). "The Liberalization of the Telecommunications Sector: A rent-seeking perspective". *European Journal of Law and Economics*, 8(1), 63-77.

Ambrose, William, Paul Hennemeyer, and Jean-Paul Chapon (1990). "Privatizing Telecommunications Systems: Business Opportunities in Developing Countries". IFC Discussion Paper 10. Washington, D.C.: International Financial Corporation, World Bank.

Andews, Donald W.K. (1999). "Consistent Moment Selection Procedures for Generalized Method of Moments Estimation". *Econometrica*, 67(3), May, 543-564.

Arrow, Kenneth J. (1962). "The Economic Implications of Learning by Doing". *Review of Economic Studies*, 29, June, 155-173.

Asia-Pacific Economic Cooperation (APEC, 2005). *Stocktake of Progress Toward the Key Elements of a Fully Liberalized Telecommunications Sector in the APEC Region.*

Aschauer, David Alan (1989). "Is Public Expenditure Productive?". *Journal of Monetary Economics*, 23(2), March, 177-200.

Balakrishnan, P., Parameswaran, M., Pushpangadan, K., & Suresh Babu, M. (2006). "Liberalization, Market Power, and Productivity Growth in Indian Industry". *Journal of Policy Reform, 9*(1), 55-73.

Barro, R.J., and Xavier Sala-i-Martin (1992). "Convergence". *Journal of Political Economy*, 100, April, 223-251.

Barro, Robert J., and Lee Jong-Wha (1993). "International Comparisons of the Educational Attainment". *Journal of Monetary Economics*, 32, 363-94.

Barro, Robert J., and Lee Jong-Wha (2001). "International Data on Educational Attainment: Updates and Implications". *Oxford Economic Papers*, 53(3), July, 541-563.

Beil, Richard O., George S. Ford and John D. Jackson (2005). "On the Relationship Between Telecommunications Investment and Economic Growth in the United States". *International Economic Journal*, 19(1), 3-9.

Blomstrom, M., R. Lipsey, and M. Zejan (1996). "Is Fixed Investment the Key to Economic Growth?'. *Quarterly Journal of Economics*, 111 (1): 269–76.

Blouin, C. (2000). "The WTO Agreement on Basic Telecommunications: a reevaluation". *Telecommunications Policy,* 24(2), 135-142.

Bortolotti, Bernardo, Juliet D'Souza, Marcella Frantini and William L. Megginson (2002). "Privatization and the Source of Performance Improvement in the Global Telecommunications Industry". *Telecommunications Policy,* 26(5-6), p.243-268.

Canning, David (1999). "Telecommunications Infrastructure, Human Capital, and Economic Growth". CAER II Discussion Paper No. 55. Cambridge, MA: Havard Institute for International Development.

Cieslik, Andrzej and Magdalena Kaniewska (2004). "Telecommunications Infrastructure and Regional Economic Development: The Case of Poland". *Regional Studies*, 38(6), 713-725.

Chen, Zhiqi (2006). "Liberalization of Trade and Investment in Telecommunication Services: A Canadian Perspective" in Richard G. Lipsey and Alice O. Nakamura, ed., *The Implications of Knowledge-based Growth for Microeconomic Policies.* Calgary: The University of Calgary Press, 405-439.

Coulombe, Serge, and Jean-Francois Tremblay (2006). "Migration, Human Capital, and Skills Redistribution Across the Canadian Provinces". HRSDC-IC-SSHRC Working Paper 2006-D07.
Downloadable from http://aix1.uottawa.ca/~scoulomb/pages/Publications.htm

Constant, Edward W. (1980). "*The Origins of the Turbojet Revolution*". Baltimore: Johns Hopkins University Press.

Cronin, Francis J., Edwin B. Parker, Elisabeth K. Colleran and Mark A. Gold (1991). "Telecommunications Infrastructure and Economic Growth: An Analysis of Causality". *Telecommunications Policy*, 15(6), December, 529-534.

Cronin, Francis J., Edwin K. Colleran, Paul L. Herbert, and Steven Lewitzky, (1993), "Telecommunications Infrastructure Investment and Economic Development". *Telecommunications Policy,* 17(6), August, 415-430.

Deardorff, Alan V. and Robert M. Stern (2003). "Trade in Service and International Trade Agreements: The Development Dimension", A World Bank Course. Downloadable from www.umich.edu/~rmstern/

DeLong, J.B., and Summers, L.H. (1991). "Equipment Investment and Economic Growth". *Quarterly Journal of Economics*, 106(2), May, 445-502.

Donald, Stephen G. and Whitney K. Newey (2001). "Choosing the Number of Instruments". *Econometrica*, 69(5), Sept, 1161-1191.

Edwards, G. and Leonard Waverman (2006). "The Effects of Public Ownership and Regulatory Independence on Regulatory Outcomes". *Journal of Regulatory Economics*, 29(1), 23-67.

Evans, Lewis, Arthur Grimes, Bryce Wilkinson, and David Teece (1996). "Economic Reform in New Zealand 1984-95: The Pursuit of Efficiency". *Journal of Economic Literature,* 34 (December), 1856-1902.

Estache, Antonio, Ana Goicoechea and Marco Manacorda (2006). "Telecommunications Performance, Reforms, and Governance". World Bank Policy Research Working Paper 3822. Washington, D.C.: World Bank.

Faini, R. (1983). "Cumulative Process of Deindustrialization in an Open Region: the Case of Southern Italy". *Journal of Development Economics*, 12, 277-301.

Fink, C., Additya Mattoo and Randeep Rathindran (2001). "Liberalizaing Basic Telecommunications – the Asian Experience". World Bank Policy Research Working Paper 2718. Washington, D.C.: World Bank.

Fink, C., Additya Mattoo and Randeep Rathindran (2003). "An Assessment of Telecommunications Reform in Developing Countries". *Information Economics and Policy*, 15(4), 443-466.

Freeman, Christopher (1982). "*The Economics of Industrial Innovation*". 2nd Ed. London: Francis Pinter.

Galal, Ahmed, Leroy Jones, Pankaj Tandom, and Ingo Vogenlsang (1994). "Welfare Consequences of Selling Public Enterprises: An Empirical Analysis. Washington, D.C.: Oxford University Press for World Bank.

Greene, William H. (2003). *Econometrics Analysis,* International 5th Edition. New Jersey: Prentice Hall.

Greenstein, Shane and Pablo T. Spiller (1995). "Estimating the Welfare Effects of Digital Infrastructure". National Bereau of Economic Research (NBER) Working Paper No. 5770. Washington, D.C.: NBER.

Gujarati, Damodar N (2003). *Basic Econometrics*, International Edition, 4th Edition. Singapore: McGraw Hill.

Gutierrez, Luis H. (2003). "Regulatory Governance in the Latin American Telecommunications Sector". *Utility Policy*, 11, 225-240.

Hahn, Robert W. (2000), *Reviving Regulatory Reform: A Global Perspective.* Washington DC: The AEI Press.

Hansen, Lars Peter (1982). "Large Sample Properties of Generalized Method of Moments Estimators". *Econometrica*, 50, July, 1029-1054.

Hardy, Andrew (1980). "The Role of Telephone in Economic Development". *Telecommunications Policy*, 4(4), 278-86.

Harvey, A. (1990). The Econometric Analysis of Time Series, 2nd Edition. Cambridge, MA: MIT Press.

Hausman, J.A. (1978). "Specification Test in Econometrics". *Econometrica*, 46, 1251-1271.

Hausman, J.A. (1983). "Specification and Estimation of Simultaneous Equation Models" in Z. Grillches and M.D. Intriligator ed., *Handbook of Econometrics*, Volume I. Netherlands: North Holland, 392-448.

Heston, A., Robert Summers and Bettina Aten (2002). *Penn World Table Version 6.1*. Center for International Comparisons at the University of Pennsylvania, CICUP.

Hoekman, B. (1995). "Assessing the General Agreement on Trade in Services" in W. Martin and L.A. Winters, eds, The Uruguay Round and the Developing Economies, World Bank Discussion Paper 307, Washington DC: World Bank, 327-64.

Huber, Peter W., Boban Mathew, and John Thorne (1997), "Estimating the Costs of Telecommunications Regulation," in *The Unpredictable Certainty: White Papers*, by NII 2000 Steering Committee, Commission on Physical Sciences, Mathematics, and Applications, National Research Council. Washington DC: National Academy Press, 292-303.

International Monetary Funds, *International Financial Statistics 2004 Database*.

International Telecommunication Union (ITU)(1996). *World Telecommunication Development Report 1996/1997.*

ITU (1998). *General Trends in Telecommunication Reform, various volumes.*

ITU (2001). *Trend in Telecommunications Reform 2000-2001: Interconnection Regulation*, 3rd Ed.

ITU (2002a). *ITU World Telecommunication Indicators Database.*

ITU (2002b). *World Telecommunication Development Report 2002: Reinventing Telecoms*, 6th Ed.

ITU (2002c). *Trends in Telecommunication Reform 2002: Effective Regulation.*

ITU (2003a). *Trends in Telecommunication Reform 2003: Promoting Universal Access to ICTs - Practical Tools for Regulators.*

ITU (2003b). *World Telecommunication Development Report 2003: Access Indicators for the Information Society..*

ITU (2004). *Trends in Telecommunication Reform 2004/05: Licensing in an Era of Convergence.*

ITU (2005). *ITU World Telecommunication Regulatory Database.*

ITU (2006). *Trends in Telecommunication Reform: Regulating in the Broadband World.*

Jacob, V., S.C. Sharma, and R. Grabowski (1997). "Capital Stock Estimates for Major Sectors and Disaggregated Manufacturing in Selected OECD Countries". *Applied Economics*, 29 (5), 563-579.

Jones, L. E., and R.E. Manuelli (1990). "A Convex Model of Equilibrium Growth: Theory and Policy Implications". *Journal of Political Economy*, 98(5), part 2, 1008-1038.

Kamps, C (2003). "New Estimates of Government Net Capital Stocks for 22 OECD Countries 1960-2001". Kiel Institute for World Economics, 24100 Kiel, Germany. Retrieved December 19, 2005 from Website: *http://www.warwick.ac.uk/res2003/papers/Kamps.pdf*

Kelly, M. (1992). "On endogenous Growth with Productivity Shocks". *Journal of Monetary Economics*, 30(1), 47-56.

Kennedy, Peter (2001). *A Guide to Econometrics*, 4th Edition. Cambridge, MA: MIT Press.

King, R.G. and R. Levine (1994). "Capital Fundamentalism, Economic Development, and Economic Growth". *Carnegie-Rochester Conference Series on Public Policy,* 40, 259-292.

King, R.G. and S. Rebelo (1993). "Transitional Dynamics and Economic Growth in the Neoclassical Model". *American Economic Review*, 83(4), 908-931.

Kochelarkota, N.R. and K.M. Yi (1995). "Can Convergence Regressions Distinguish Between Exogenous and Endogenous Growth Models?". *Economics Letters*, 49, 211-215.

Krueger, A. B., and M. Lindahl (2001). "Education for Growth: Why and for Whom?". *Journal of Economic Literature*, 39(4), 1101-1136.

Lee, SH and J. Levendis (2006). "Creation of a Separate Telecommunications Regulatory Agency: A Duration Analysis of Its Time Pattern". *Contemporary Economic Policy,* 24(3), 407-417.

Leff, Nathaniel H. (1984). "Externalities, Information Costs, and Social Benefit-Cost Analysis for Economic Development: An Example from Telecommunications". *Economic Development and Cultural Change*, 32(2), January, 255-276.

Levy, Brian and Pablo T. Spiller (1996). *Regulation, Institution and Commitment: Comparative Studies of Telecommunications*. Cambridge (UK): Cambridge University Press.

Leung, C., and D.T. Quah (1996). "Convergence, Endogenous Growth, and Productivity Disturbances". *Journal of Monetary Economics*, 38(3), 535-547.

Li, W. and Lixin Colin Xu (2002). "The Political Economy of Privatization and Competition: Cross Country Evidence from the Telecommunications Sector". *Journal of Comparative Economics*, 30, 439-62.

Li, W. and L.C. Xu (2004). "The Impact of Privatization and Competition in the Telecommunications Sector Around the World". *Journal of Law and Economics,* 47(2), 395-430.

Li, W, C.Z. Qiang and L.C. Xu (2005). "Regulatory Reforms in the Telecommunications Sector in Developing Countries: The Role of Democracy and Private Interest". *World Development,* 33(8), 1307-1324.

Lichtenberg, Frank R. (1995). "The Output Contributions of Computer Equipment and Personnel: A Firm-level Analysis". *Innovation and New Technology*, 3, 201-217.

Liu, T. (1960). "Underidentification, Strutural Estimation, and Forecasting". *Econometrica*, 28, 855-865.

Lucas, R.E. (1988). "On the Mechanics of Economic Development". *Journal of Monetary Economics*, 22(1), 3-42.

Madden, G., and S.J. Savage (1988). "CEE Telecommunications Investment and Economic Growth". *Information Economics and Policy*, 10, 173-195.

Mankiw, N. Gregory, David Romer and David N. Weil (1992). "A Contribution to the Empirics of Economic Growth". *Quartrely Journal of Economics*, 107(2), 407-437.

Manner, Jennifer A. (2002). *Global Telecommunications Market Access*. Norwood (Boston): Artech House.

Marko, M. (1998). "An Evaluation of the Basic Telecommunication Services Agreement". CIES Policy Discussion Paper 98/09. Adelaide, Australia: Centre for International Economic Studies, University of Adelaide.

Mattoo, A., Randeep Rathindran and Arvind Subramanian (August 2001). "Measuring Service Trade Liberalization and Its Impact on Economic Growth: An Illustration". World Bank Working Paper 2655, Washington DC: World Bank.

Megginson, William L., Robert C. Nash, and Mattthias van Randenborgh (1994). "The financial and Operating Performance of Newly Privatized Firms: An International Empirical Analysis". *Journal of Finance,* 49(2), pp. 403-52.

Mowery, David C., and Nathan Rosenberg (1989). *Technology and the Pursuit of Economic Growth*. Cambridge: Cambridge University Press.

Norton, Seth W. (1992). "Transaction Costs, Telecommunications, and the Microeconomic Growth". *Economic Development and Cultural Change*, 41(1), 175-196.

Organization for Economic Co-operation and Development (OECD, 1995). *Universal Service Obligations in a Competitive Telecommunications Environment.*

Parker, D and C. Kirkpatrick (2005). "Privatization in Developing Countries: A Review of the Evidence and the Policy Lessons". *Journal of Development Studies,* 41(4), 513-541.

Pindyck, Robert S., and Daniel L. Rubinfeld (1997). *Econometric Model and Economic Forecast*, 4th Edition. Singapore: McGraw-Hill.

Pohjola, Matti (2002). "The New Economy in Growth and Development". *Oxford Review of Economic Policy*, 18(3), 380-396.

Roller, Lars-Hendrik and Leonard Waverman (2001). "Telecommunications Infrastructure and Economic Development: A Simultaneous Approach". *American Economic Review*, 91(September), 909-923.

Romer, P.M. (1986). "Increasing Returns and Long Run Growth". *Journal of Political Economy*, 94(5), 1002-1037.

Romer, P.M. (1990). "Capital, Labor and Productivity". Brookings Papers on Economic Activity, Microeconomics Special Issue, 337-367.

Ros, A.J. (1999). "Does Ownership or Competition Matter? The Effects of Telecommunications Reform on Network Expansion and Efficiency". *Journal of Regulatory Economics*, 15, 65-92.

Rosenberg, Nathan (1963). "Technological Change in the Machine Tool Industry: 1840-1910". *Journal of Economic History*, 23(4), December, 414-446.

Singleton, Kenneth J. (2006). *Empirical Dynamic Asset Pricing.* New Jersey: Princeton University Press.

Stock, James H., Jonathan H. Wright and Motohiro Yogo (2002). "A Survey of Weak Instruments and Weak Identification in Generalized Method of Moments". *Journal of Business & Economic Statistics*, 20(4), 518-529.

Staiger, Douglas and James H. Stock (1997). "Instrumental Variables Regression with Weak Instruments". *Econometrica*, 65(3), 557-586.

Solow, R.M. (1956). "A contribution to the Theory of Economic Growth". *Quarterly Journal of Economics,* 70(1), 65-94.

Varoudakis, A., & Rossotto, C. M. (2004). "Regulatory Reform and Performance in Telecommunications: Unrealized Potential in the MENA Countries". *Telecommunications Policy,* 28(1), 59-78.

Wallsten, S.J. (2001). "An Econometrics Analysis of Telecommunications Competition, Privatization and Regulation in Africa and Latin America". *Journal of Industrial Economics*, 49(1), 1-19.

Wallsten, S. (2002). "Does Sequencing Matter? Regulation and Privatization in Telecommunications Reform". World Bank Policy Research Working Paper 2817. Washington, D.C.: World Bank.

Wallsten, S., George Clarke, Luke Haggarty, Rosario Kaneshiro, Roger Noll, Mary Shirly, Lixin Collin Xu (2004). "New Tools for Studying Network Industry reform in Developing Countries: The Telecommunications and Electricity Regulation Database". World Bank Policy Research Paper 3286. Washington, D.C.: World Bank.

Wallsten, S. (2005). "Returning to Victorian competition, ownership and regulation: An empirical study of European telecommunications at the turn of the twentieth century". *Journal of Economic History,* 65(3), 693-722.

Warren, Tony (2000a). "The Identification of Impediments to Trade and Investment in Telecommunication Services" in Chrisopher Findlay and Tony Warren, eds, *Impediments to trade in Services: Measurement and Policy Implications*. New York: Routledge, 71-84.

Warren, Tony (2000b). "The Impact on Output of Impediments to Trade and Investment in Telecommunication Services" in Chrisopher Findlay and Tony Warren, eds, *Impediments to trade in Services: Measurement and Policy Implications*. New York: Routledge, 85-100.

Wellenius, Bjorn (1993). "Telecommunications: World Bank Experience and Strategy". World Bank Discussion Paper. Washington DC.

Willner, J. (2006). "Privatization and Liberalization in an Industry with Network Externalities". *Economics Letters,* 91(2), 197-203.

Windmeijer, Frank (2002). "ExpEnd, A Gauss Programe for Non-linear GMM: Estimation of Exponential Models with Endogenous Regressors for Cross-section and Panel Data". CeMMAP Working Paper CWP14/02. London: Centre for Microdata Methods and Practice (CeMMAP), The Institute for Fiscal Studies.

Wooldridge, Jeffrey M. (2001). *Econometric Analysis of Cross Section and Panel Data*. Cambridge, MA: MIT Press.

World Bank (2003). *World Development Indicators Database*.

Web Resources:

Asia-Pacific Economic Cooperation (APEC).
Retrieved January 10, 2006 from Website:
http://www.apec.org/content/apec/about_apec.html

APEC Economic Outlook, 2005
Retrieved July 25, 2006 from Website:
apec.org/etc/medialib/apec_media_library/.../05_EC_outlook05.pdf

Asian Development Bank (ADB)
Asian Development Bank, Key Indicators 2004,
Retrieved January 10, 2006 from Website:
http://www.adb.org/Statistics/ki.asp

ITU (2005).
Training Workshop on licensing available at:
Retrieved July 25, 2006 from Website:
http://www.itu.int/ITU-D/hrd/tc/ec-ecowas/DOCS/E/Workshops/Workshop%208_Licensing/2.%20Conferences/Doc%201.1%20Institutional%20Framework%20Banjul%20September%20rev%202005.ppt#256,1

OECD Economic Outlook No. 79, May 2006.
Retrieved July 25, 2006 from Website:
http://www.oecd.org/document/18/0,2340,en_2649_33733_20347538_1_1_1_1,00.html or from OECDdirect.

World Trade Organization
WTO reference paper on basic telecommunications,
Retrieved July 25, 2006 from Website:
http://www.itu.int/newsarchive/press/WTPF98/WTORefpaper.html

Appendix A:
Glossary of terms*

3G: Third-generation mobile network or service. Generic name for mobile network/service based on the IMT-2000 family of global standards.

Broadband: Although there exist various definitions of broadband that have assigned a minimum data rate to the term, it may be defined as transmission capacity with sufficient bandwidth to permit combined provision of voice, data and video, with no lower limit.

Bandwidth: The range of frequencies available to be occupied by signals.

Data services: The transmission of non-voice services such as data communications (e.g. packet switching) but not telegram or telex.

Fixed line: Or main telephone line. A physical line connecting the subscriber to the telephone exchange. Typically, fixed line network is used to refer to the PSTN.

IMT-2000: International Mobile Telecommunications – 2000. Third-generation (3G) "family" of mobile cellular standards approved by ITU. See website at: *http://itu.int/imt.*

Interconnection: The physical connection of separate telephone networks to allow users of those networks to communicate with each other. Interconnection ensures interoperability of services and increases end users' choice of network operators and service providers.

ISDN: Integrated services digital network. A digital switched network, supporting transmission of voice, data and images over conventional telephone lines.

Leased line: A point–to-point communication channel or circuit that is committed by the network operator to the exclusive use of an individual subscriber. Under national law, leased lines may or may not be permitted to interconnect with the public switched network.

Market access: The extent of market access is being given, e.g. whether there are any restrictions on foreign ownership.

National Regulatory Authority (NRA): The regulatory agency of official at the central or federal government level that is charged with implementing and enforcing telecommunication rules and regulations.

National treatment: Whether some rights granted to local companies will not be granted to foreign companies.

Number portability: The ability of a customer to transfer an account from one service provider to another without requiring a change in number. Other form of portability allows end users to change residence or subscribe to a new form of service (e.g. ISDN) while retaining the same telephone number for their main telephone lines.

Penetration: A measurement of access to telecommunications. Also referred to as teledensity (for fixed-line network) or mobile density (for cellular ones) or total density (fixed and mobile combined).

Pre-selection: The mechanism by which end users can designate the carrier that they prefer to carry all or a certain segment (e.g. long distance) of their calls, he pre-selected carrier becomes the default carrier for all such calls.

Private ownership/privatization: The transfer of control of ownership of a state enterprise to private parties, generally by organizing the enterprise as a share company and selling the shares to investors.

PSTN: Public switchcd telephone network. The public telephone network that delivers fixed telephone service.

Reference Interconnection Offer (RIO): A standardized outline of a carrier's offering. Including rates and terms of interconnection, often required to be made publicly available. The RIO may be the starting point for negotiations leading up to a specific interconnection agreement between two carriers.

Short Message Service (SMS): A service available on digital mobile cellular networks and even landline telephone, typically enabling end users to send and receive messages with up to 160 characters.

Trade in telecommunications: A term defined in ITU's 1997 "World Telecommunication Development Report: Trade in Telecommunications" as *"Sales of telecommunications equipment or services that cross national borders*". Trade in telecommunication services also covers "transactions" that cross national borders which would cover foreign investment, such as the acquisition of shares in telephone companies by foreign investors, or joint ventures between local and foreign partners to establish new telecommunication companies.

Universal Access: Usually describes a situation in which every person has a reasonable means to access a publicly available telephone – in their community, but not necessarily in their home.

Universal Service: Universal Service Policies generally focus on achieving or maintaining "universal" availability of connections from individual households to public telecommunications network. The objective of connecting all (or nearly all)

households to telecommunication capabilities is often referred to as the "Universal Service Obligation" (USO).

VOIP: Voice over Internet Protocol (IP). A generic term used to describe the techniques used to carry voice traffic over IP.

Waiting list: The number of applications for a connection to a main telephone line that have had to be held over owing to a lack of technical availability. It should be noted that the waiting list refers to applications received; it does not include figures for those desire a telephone line but have not submitted an application.

*Sources from:

ITU, *General Trends in Telecommunication Reform*, various issues.
ITU, *Trends in Telecommunication Reform*, various issues.
ITU, *World Telecommunication Development Report*, various issues.

WTO websites.
http://www.itu.int/sancho/index.asp

Appendix B:
Generalized Method of Moments (GMM)(Chapters 3 and 5)

Although the estimation of one equation at a time has the advantage of computational simplicity, the dependence of the endogenous variables with the disturbances causes the ordinary least squares estimator to be inconsistent as it ignores the important information embodied in the other equations[43]. If there is no simultaneity, the OLS estimator is efficient and consistent, but the instrumental variable estimator will be consistent but inefficient[44].

A method of instrumental variables, specifically the generalized method of moments (GMM), is adopted to obtain consistent estimators from the structural equations in this study. One of the many advantages of using GMM is that we do not need to worry much about the distribution of the error terms as it allows for arbitrary heterocedasticity and also arbitrary serial dependence[45]. In fact, it can be proved that OLS, 2SLS and 3SLS are special cases of GMM.[46] Also, the GMM estimator is the most efficient estimator, asymptotically, amongst the system instrumental variable (SIV) estimators.[47]

Consider a regression model

$$f(y, x, \beta) = u$$

where y is the vector of endogenous variable, x is the vector of exogenous variables, β is the parameter we want to estimate and the residual vector is given as u. With Z being the vector of instruments, the orthogonality conditions of GMM can be expressed as

[43] Greene (2003), p.396
[44] Pinkdyck and Rubinfeld (1997), p. 353.
[45] Wooldridge (2001), p. 192
[46] Greene (2003), p. 410.
[47] See Wooldrigde (2001), p. 196.

$$E[Zf(y,x,\beta)]=0$$

and let $G(\beta)=u\otimes Z$, where $\otimes$ represents the Kroneker product of Z and u. The Generalized Method of Moments solves

$$\min_{\beta} G(\beta)'[SW]G(\beta)$$

where SW represents the weighting matrix. Given a set of instruments, there will be a different GMM estimator for each choice of the SW matrix. There are actually a few cases in Hansen's (1982) study. However, for the purpose of Chapters 3 and 5, I only focus on the one where u is assumed to be serially uncorrelated and independent of the instrument z.

Appendix C:
Testing of over-identifying restrictions (Chapters 3 and 5)

If the number of moment conditions (MC) is the same as the number of parameters (k) to be estimated, the parameters are exactly identified and thus $G(\beta) = 0$ we have a unique solution. However, when over-identifying restrictions exist (MC-k), we have to test whether the additional instruments are uncorrelated with the error term u. The rejection of the null hypothesis of over-identifying restrictions may cast some doubts on the validity of instruments used in the model, thus need to be reexamined.

Theoretically, the miss-specification of equation and the treatment of lagged endogenous variables as if they were exogenous may lead to the rejection of over-identification restrictions[48]. In the literature, there are debates on the instrument exogeneity after Hansen's (1982) original work on GMM. Among them are Stock, Wright and Yogo (2002), Andrew (1999) and Donald and Newey (2001) and Windmeijer (2002).

The choice of instrumental variables was somewhat arbitrary pertaining to weak and strong instruments[49], and thus Wooldridge (2001) suggested that all the exogenous variables that appear in the system should be used as instruments for each equation. Given the fact that over-identifying restrictions cannot be separated from the identifying restrictions (see Kennedy, 2001), many economists, including Roller and Waverman (2001), often abandon this test.

For the purpose of Chapters 3 and 5, without getting too much into the debate, I follow Wooldridge's recommendation and assume that all the potential instruments are valid instruments in GMM[50]. Thus, the list of the potential instrument variables (Z) in this study includes the exogenous variables and the predetermined variables:

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[48] Greene (2003), p. 415.
[49] Wooldridge (2001), p. 235.
[50] I also explore the validity of the instruments using some common tests; the results are included in Appendix C.

$\log(KA)$, $\log(HK)$, $\log(TLF)$, $\log(GA)$, $1/\log(POP)$, $\log(TELP)$, GD, $DEVD$ and the lag one period of PEN, GDP and TTI.

While acknowledging the fact that the test may lead to the rejection of the hypothesis as predicted by Kennedy (2001), I use the test proposed by Hausman (1983 p.433) who adopted the Lagrange multiplier principle. The statistics is referred to as TR^2 (T multiplied by the uncentred R^2) where T is the total number of observations and the uncentred R squares is generated from the regression of $\hat{\varepsilon}_j (= y_j - Z_j \hat{\delta}_j)$ on all predetermined variables in the model. TR^2 follows a chi-square distributions with the degrees of freedom equals to the number of over-identifying restrictions.

Following Hausman (1983), we first obtain the second stage least square (2SLS) residuals by employing all instrumental variables (Z), say $\hat{\varepsilon}$. Then regress $\hat{\varepsilon}$ on Z to obtained R^2 we have TR^2 where T is the total number of observations.

$$TR^2 \sim \chi^2_{df}$$

where df is the degree of overidentifications - the number of instruments minus the number of exogenous variables. The TR^2 when PEN1 and PEN2 are used in the model is generated as below, given the high value of TR^2, we therefore reject the null hypothesis of over-identifying restrictions, which implies that some of the instrument variables may be invalid. However, the results do not indicate which instrument variables are invalid.

	TR^2	TR^2	
	$PEN1$	$PEN2$	df
Equation 1	168.80	250.32	8
Equation 2	285.21	287.31	9
Equation 3	97.56	160.29	7
Equation 4	145.24	136.50	6

Testing the validity of instruments

We can test the subsets of orthogonality conditions, say $\text{cov}(Z,\varepsilon)$ using a subset of instruments. Consider a simple model:

$$y_1 = \beta_0 + \beta_1 y_2 + e$$

where y_2 is the endogenous variable and let z_2 be its instrument variable. We then have

$$\hat{\beta}_1 = (z_2' y_2)^{-1} z_2' y_1$$

$$= \beta_1 + (z_2' y_2)^{-1} z_2' e$$

$$p\lim \hat{\beta}_1 = \beta_1 + \frac{\text{cov}(z_2, e)}{\text{cov}(z_2, y_2)}$$

$$= \beta_1 + \left(\frac{\sigma_u}{\sigma_{y2}}\right) \frac{corr(z_2, e)}{corr(z_2, y_2)}$$

Therefore, good instruments should satisfy the following requirements:

(1) $p\lim\hat{\beta}_1 = \beta_1$ if $\text{cov}(z_2, e) = 0$

(2) $corr(y_2, z_2) \neq 0$ or should be large

But it is not so easy to check $\text{cov}(Z, \varepsilon) = 0$, however, we can check the significance of partial correlations from the first stage reduced-form equation (Staiger and Stock, 1997). This can be demonstrated.

$$y_2 = x_1\gamma_1 + z_2\gamma_2 + v$$

Using the F-test, if we reject the null hypothesis of $\gamma_2 = 0$, then z_2 is a good instrument. Using the same methodology, given the large F-statistics, the results show that we reject the null hypothesis, which implies I actually do have good instruments.

DF is the degree of freedom. In F(x,y), x denotes the number of instruments being tested while y is the number of usable observations net of the total number of instruments.

A test of simultaneity

Following Pindyck and Rubinfeld (1997), in the context of Hauman specification test, we first regress each of the endogenous variable (PEN, WL and TTI) in reduced-form, on KA, HK, TLF, TELP, POP, GA, GD, DEVD and PEN(1) to obtain 3 estimated residuals, namely resid1, resid2 and resid3. In the second stage, we plug in these three estimated results into main equation – the output equation.

Under the null hypothesis of no simultaneity, the coefficients for the estimated residuals should be statistically zero or in other words – not statistically significant. As our model involves more than one endogenous variable, we perform an F-test

on the said coefficients. The F-statistics shows that we reject the null hypothesis at the 5 per cent level for model with PEN1, and 1 per cent for model with PEN2.

	Variable	PEN1		PEN2	
		Coeff	T-Stat	Coeff	T-Stat
1	Constant	21.5586	3.6267 ***	18.0461	2.5239 **
2	KA	0.9125	22.2175 ***	0.9529	25.4540 ***
3	HK	0.4117	4.9413 ***	0.4590	5.7807 ***
4	TLF	0.0814	2.2221 **	0.0445	1.3509
5	PEN	-0.0011	-0.0332	-0.0318	-1.1542
6	TLF	-0.0110	-3.8093 ***	-0.0095	-2.7546 ***
7	resid1	0.3589	1.6536 *	0.3309	1.8433 *
8	resid2	-0.0122	-1.0362	-0.0042	-0.3637
9	resid3	0.0247	0.9230	0.0374	1.5925
	F-statistics		2.31 *		3.16 **
	R Squares (%)		96.21		96.28

*** Significant at 1 per cent level

** Significant at 5 per cent level

* Significant at 10 per cent level

Appendix D:
Simultaneous equations: Ordinary Least Squares (OLS)(Chapter 3)

			Model C1			Model C2			Model C3			Model C4		
			No Effects			Fixed Effects			No Effects			Fixed Effects		
	Equations	Variables	Coeff	Std Error		Coeff	Std Error		Coeff	Std Error		Coeff	Std Error	
1	Output	Intercept	24.3312	3.1483	***	-	-		23.9342	4.4304	***	-	-	
2		KA	0.8596	0.0186	***	0.6664	0.0351	***	0.8900	0.0176	***	0.7447	0.0323	***
3		HK	0.4462	0.0539	***	-0.0248	0.1601		0.5132	0.0508	***	0.3146	0.1475	**
4		TLF	0.1531	0.0186	***	0.4085	0.0999	***	0.1220	0.0179	***	0.4047	0.1032	***
5		*PEN*	0.0577	0.0184	***	0.0870	0.0168	***	0.0194	0.0157		0.0234	0.0110	**
6		t	-0.0122	0.0015	***	-0.0045	0.0025	*	-0.0123	0.0022	***	-0.0088	0.0026	***
7	Demand	Intercept	-8.2252	0.2271	***	-8.2252	0.2271	***	-5.7464	0.3504	***	-5.7464	0.3504	***
8		GDPPC	1.1734	0.0148	***	1.1734	0.0148	***	1.3991	0.0241	***	1.3991	0.0241	***
9		TELP	-0.6638	0.0383	***	-0.6638	0.0383	***	-1.2759	0.0592	***	-1.2759	0.0592	***
10	Investment	Intercept	21.2100	0.8226	***	21.2100	0.8226	***	21.5618	0.8105	***	21.5618	0.8105	***
11		GA	0.2286	0.0226	***	0.2286	0.0226	***	0.2305	0.0224	***	0.2305	0.0224	***
12		GD	-0.0083	0.0008	***	-0.0083	0.0008	***	-0.0082	0.0008	***	-0.0082	0.0008	***
13		(1-DEVD)*WLPC	-1.3363	1.0575		-1.3363	1.0575		-0.7921	1.0658		-0.7921	1.0658	
14		(1-DEVD)*TELP	-0.6356	0.1271	***	-0.6356	0.1271	***	-0.6947	0.1241	***	-0.6947	0.1241	***
15		DEVD*TELP	-0.4384	0.1207	***	-0.4384	0.1207	***	-0.4818	0.1154	***	-0.4818	0.1154	***
16	Production	Intercept	0.0565	0.0561		0.0565	0.0561		-0.1465	0.0950		-0.1465	0.0950	
17		TTI	-0.0015	0.0029		-0.0015	0.0029		0.0193	0.0049	***	0.0193	0.0049	***
18		GA	0.0034	0.0017	**	0.0034	0.0017	**	-0.0083	0.0029	***	-0.0083	0.0029	***

Notes:

Model 1: Using mainlines, without fixed effects

Model 2: Using mainlines, with fixed effects

Model 3: Using mainlines plus cellular mobiles, without fixed effects

Model 4: Using mainlines and cellular mobiles, with fixed effects

* Significant at 10 per cent level

** Significant at 5 per cent level

*** Significant at 1 per cent level

Appendix E:
Measuring trade liberalization: A summary of methodology (Chapter 4)

Market Access (MA) Index:

In the area of market access (MA), I construct two sub-indices, MA/Trade and MA/Invest.

MA/Trade

MA/Trade measures the degree of openness to market access through trade in telecommunication services. It is constructed based on the following questions:

(1) Is domestic resale of voice services permitted for fixed-line?
(2) Is domestic resale of voice services permitted for mobile?
(3) Is international resale of voice services permitted for fixed-line?
(4) Is international resale of voice services permitted for mobile?

I assign score of one (1) if "Yes" and 0 otherwise for each of the four (4) questions. The total possible maximum score is four (4), and lowest score is zero (0).

MA/Invest

The second sub-index MA/Invest measures the extent of openness in market access through investment. It is constructed based on the following questions:

(5) How many fixed line operators in the market?
(6) How many mobile service operators in the market?
(7) What is the level of competition permitted in the services?
(8) Is the fixed line incumbent privatized, if yes, the percentage?
(9) What is the market share not covered by largest fixed line (domestic) operator?
(10) What is the market share not covered by largest fixed line (long distance) operator?

(11) What is the market share not covered by largest mobile service operator?

If the market for each fixed line and mobile has at least three operators, I assign score of three (3), two operators a score of two (2), and one (1) for the monopoly. The weight for this question is three (3), the total maximum for a member economy is thus nine (9), and the minimum is three (3).

The services include local services, domestic long distance, international long distance, mobile, data, leased lines and Internet services. The score for competitive is 1, partially competitive is 0.5, duopoly is 0.2 and monopoly is 0. The maximum score is six (6) if all the services are competitive, and zero (0) if all the services are monopoly. The weight for this question is two (2), thus the total maximum scores is fourteen (14).

I use the percentage of shares not owned by states or government to represent level of privatization of the incumbent. The weight for this question is one (1). I make use of the market shares of local access line not owned by the main operator and also market shares of long distance as well as mobile services not owned by the main operator. Total score is three (3) with weight one (1).

National Treatment (NT) Index:

For the National Treatment (NT) Index, I also have two sub-indices: NT/Trade and NT/FDI.

NT/Trade

The NT/Trade Index measures the degree of openness to foreign entrants through trade. It is constructed based on the following question:

(12) Is call-back services allowed? (1 if Yes and 0 otherwise)

NT/FDI

The second sub-index NT/FDI Index is a direct measure of openness to foreign ownership of domestic service providers. It is constructed based on the following question:

(13) What is the limit on foreign ownership? (0%-100%)

The maximum, minimum and weight in relation to the MA and NT sub-indices:

Index	Question	Maximum	Minimum	Weight	Total
MA/Trade	1	1	0		1
	2	1	0		1
	3	1	0		1
	4	1	0		1
		4	0	1	4
MA/Invest	5	3	1	3	9
	6	3	1	3	9
	7	7	0	2	14
	8	1	0	1	1
	9	1	0	1	1
	10	1	0	1	1
	11	1	0	1	1
					36
NT/Trade	12	1	0	1	1
NT/FDI	13	1	0	1	1

Regulatory principles Index:

The Regulatory Principle Index (RPI) is built on the regulatory principles outlined in the WTO Reference Paper. Accordingly, there are five sub-indices for each of the principles: competitive safeguard (CS), interconnections policy (IC), universal service Index (US), licensing (LS) and independent Regulator (IR).

RP/Independence of Regulator (IR)

The sub-index, RP/IR, measures the degree of independence of regulators in telecommunications. It is constructed based on the following questions:

(14) Is the NRA separated from the ministry as well as telecommunication operations?
(15) What is the legal mandate of the NRA?
(16) Is the NRA autonomous in decision making?
(17) Is the NRA a collegial body?
(18) What is the percentage of budget not financed by the government?
(19) Does the NRA have single or multi-sector jurisdiction?
(20) Does the NRA report only to government/minister or legislative?
(21) Is the existence of the NRA is at least two years?

RP/Competitive Safeguards (CS)

The sub-index, RP/CS, aims to measure the competitiveness of the environment provided and committed by a country. It is constructed based on the following questions:

(22) Have your country adopted the WTO Reference Paper in full?
(23) Does the regulatory authority have the enforcement powers?
(24) Does a competition authority exist in your country?
(25) Are appeals to the decision of the regulatory authority allowed?
(26) Are public consultations mandatory before regulatory decisions are made?

RP/Interconnection (IC)

The degree of transparency and effectiveness of interconnections policy is measured by sub-index, RP/IC. It is constructed based on the following questions:

(27) Are interconnections agreements made public?
(28) Are interconnections prices made public?
(29) Are the operators required to publish Reference Interconnection Offer?
(30) Is unbundled access required?
(31) Is infrastructure sharing for mobile operators permitted?
(32) Are decisions on dispute resolution reported on the regulatory authority's website?
(33) Is pre-selection available?
(34) Is number portability available?

RP/Universal Service (US)

This sub-index, RP/US, measures the competitiveness of the universal service policy. It is constructed based on the following questions:

(35) Has your country defined universal access or services?
(36) Do you require any operators to provide the services?
(37) Do you require any operators to offer below cost prices to any subscribers?
(38) How the costs of universal service are funded?

RP/Licensing (LS)

The sub-index, RP/LA, measures the ease of market entry under various licensing regimes. It is constructed based on the following questions:

(39) What is the licensing/authorization regime for each of the services?
(40) Are licensing agreements publicly available?

Except the RP/LS, the four indices are coded as: 1 for yes and 0 otherwise. To be consistent with the indices constructed under Market Access, in RP/LS, I assign a score three (3) for Notification, two (2) for Registration, one (1) for Authorization, and zero (0) for license, for each of the 7 services discussed. Total possible scores for this index are twenty-two (22), and minimum score is zero (0).

The maximum, minimum and weight in relation to the Regulatory Principle sub-indices:

Index	Question	Maximum	Minimum	Weight	Total
CS	14	1	0		
	15	1	0		
	16	1	0		
	17	1	0		
	18	1	0		
		5	0	1	5
IC	19	1	0		
	20	1	0		
	21	1	0		
	22	1	0		
	23	1	0		
	24	1	0		
	25	1	0		
	26	1	0		
		8	0	1	8
US	27	1	0		
	28	1	0		
	29	1	0		
	30	1	0		
		4	0	1	4
LS	31	21	0	1	21
	32	1	0	1	1

					22
IR	33	1	0		
	34	1	0		
	35	1	0		
	36	1	0		
	37	1	0		
	38	1	0		
	39	1	0		
	40	1	0		
		8	0	1	8

Appendix F:
Treatment of fixed effects (Chapters 3 and 5)

One of the many advantages of using panel data is that it allows to control for unobservable heterogeneity or the systematic differences in the cross sectional data. As panel data has cross-sectional dimension of N and time dimension of T, it increases the degree of freedom while the dependence between the explanatory variables is also recognized.

The fixed effect (a_{0i}) estimators are obtained by using a separate intercept for each individual in the group in the regression. While in the model without individual fixed effect, the constant term in Equation (3.6) is fixed and common across individuals in the group as it is identified as (a_0).

I focus on two equations of interest, which are output and investment equations. The unrestricted model is the model that imposes a common intercept on all countries while unrestricted model does not have such restriction, that is, unrestricted model allows the intercept to vary for each country but still assume the slope coefficients are constant across countries. As shown below, there is evidence that the restricted models are invalid given the significant of the F-statistics in Hausman (1978) Test. I reject the null hypothesis that individual intercepts are common across countries.

It should be noted that the test is performed on an equation-by-equation basis. As the four structural equations are to be estimated simultaneously and to avoid correlation between fixed effects in the equations and also loss of degree of freedom, the fixed effect is thus only introduced in one of the equations at a time that is in the output equation in Chapter 3 and in the investment equation in Chapter 5.

The following test applies only to Chapter 5:

Equations	DF	RR	F-stats
Output Equation	F(6,130)		76.09 ***
Investment Equation	F(9,127)	MA	53.16 ***
	F(9,127)	NT	44.94 ***
	F(9,127)	RP1	40.07 ***
	F(9,127)	RP2	39.78 ***
	F(9,127)	RP3	39.51 ***
	F(9,127)	CI0	44.30 ***
	F(9,127)	CI1	43.79 ***
	F(9,127)	Ci2	43.39 ***
	F(9,127)	CI3	47.21 ***

Note:
*** Significant at 1 per cent level.

Appendix G:
Simultaneous equations: non-linear GMM using MA, NT and RP (22 years)(Chapter 5)

	Equations	Variables	MA		NT		RP1		RP2		RP3	
			Coeff	Std Error	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error
1	Output	Intercept	102.3989	11.2600 ***	115.5736	12.4771 ***	91.0751	10.1775 ***	91.3753	10.2363 ***	94.0705	10.4965 ***
2		KA	0.8504	0.0325 ***	0.8338	0.0358 ***	0.8303	0.0301 ***	0.8282	0.0302 ***	0.8277	0.0308 ***
3		HK	0.2149	0.0755 ***	0.1535	0.0823 *	0.2988	0.0697 ***	0.2943	0.0701 ***	0.2711	0.0717 ***
4		TLF	0.2065	0.0346 ***	0.2306	0.0382 ***	0.2143	0.0318 ***	0.2165	0.0320 ***	0.2183	0.0327 ***
5		PEN	0.1433	0.0348 ***	0.1687	0.0385 ***	0.1370	0.0316 ***	0.1380	0.0318 ***	0.1415	0.0326 ***
6		t	-0.0514	0.0055 ***	-0.0579	0.0061 ***	-0.0456	0.0049 ***	-0.0457	0.0050 ***	-0.0471	0.0051 ***
7	Demand	Intercept	-6.4021	0.3081 ***	-6.3503	0.3073 ***	-6.3279	0.3109 ***	-6.3180	0.3111 ***	-6.3337	0.3109 ***
8		GDPPC	1.3645	0.0224 ***	1.3575	0.0225 ***	1.3638	0.0225 ***	1.3606	0.0225 ***	1.3562	0.0225 ***
9		TELP	-1.1288	0.0519 ***	-1.1276	0.0517 ***	-1.1393	0.0523 ***	-1.1366	0.0524 ***	-1.1284	0.0524 ***
10	Investment	GA	0.0994	0.2108	-0.0853	0.1610	0.2874	0.0624 ***	0.2853	0.0624 ***	0.2869	0.0695 ***
11		GD	-0.0051	0.0025 **	-0.0113	0.0039 ***	0.0004	0.0021	0.0003	0.0020	0.0008	0.0022
12		(1-DEVD)*WLPC	-41.4941	12.3600 ***	-55.3840	14.9372 ***	-23.5097	5.2955 ***	-25.3404	5.2158 ***	-32.5360	6.0415 ***
13		(1-DEVD)*TELP	3.4110	0.6250 ***	3.7958	0.4700 ***	2.7375	0.2176 ***	2.7062	0.2105 ***	2.7093	0.2256 ***
14		DEVD*TELP	2.2552	3.8825	4.7354	1.0810 ***	3.5766	0.2883 ***	3.5702	0.2582 ***	3.7466	0.2627 ***
15		STR	3.6895	0.5895 ***	2.9909	0.7077 ***	4.0298	0.3841 ***	3.7220	0.3931 ***	2.9696	0.4484 ***
16		(1-DEVD)*RR	-0.3775	0.9709	2.9741	1.9743 #	0.2732	1.1256	1.3144	1.1724	3.0343	1.3452 **
17		DEVD*RR	3.8242	30.4156	-12.5965	6.5718 *	-12.4003	3.2710 ***	-11.8063	2.7017 ***	-12.9754	2.4876 ***
18	Production	Intercept	-0.3105	0.0806 ***	-0.3106	0.0806 ***	-0.3031	0.0808 ***	-0.3043	0.0808 ***	-0.3123	0.0807 ***
19		(1-DEVD)*TTI	0.0316	0.0044 ***	0.0314	0.0044 ***	0.0307	0.0044 ***	0.0307	0.0044 ***	0.0312	0.0044 ***
20		DEVD*TTI	0.0266	0.0041 ***	0.0264	0.0041 ***	0.0257	0.0041 ***	0.0257	0.0041 ***	0.0261	0.0041 ***
21		GA	-0.0126	0.0026 ***	-0.0123	0.0026 ***	-0.0117	0.0026 ***	-0.0117	0.0026 ***	-0.0118	0.0026 ***

Function Value	543.44	515.83	592.18	588.68	570.03

Note:

*** significant at 1 per cent level
** significant at 5 per cent level
* significant at 10 per cent level
# significant at 15 per cent level
significant at 20 per cent level

1 RP1: Equal weight of 0.20 for each of the 5 principles; including weight for US is 0.20.
2 RP2: Equal weight of 0.225 for each of the 4 principles; weight for US=0.1.
3 RP3: Equal weight of 0.25 for each of the 4 principles; weight for US is 0.

Appendix H:
Simultaneous equations: non-linear GMM using MA, NT and RP (10 years)(Chapter 5)

	Equations	Variables	MA		NT		RP1		RP2		RP3	
			Coeff	Std Error	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error
1	Output	Intercept	172.9943	45.3639 ***	231.5962	50.1832 ***	167.0250	43.9923 ***	176.9119	46.2375 ***	189.6345	49.6615 ***
2		KA	0.8561	0.0500 ***	0.8260	0.0548 ***	0.8602	0.0506 ***	0.8520	0.0532 ***	0.8408	0.0572 ***
3		HK	0.2641	0.1245 **	0.1438	0.1230	0.2725	0.1061 **	0.2721	0.1108 **	0.2639	0.1182 **
4		TLF	0.1677	0.0532 ***	0.2215	0.0571 ***	0.1669	0.0501 ***	0.1782	0.0529 ***	0.1933	0.0572 ***
5		PEN	0.1036	0.0649 *	0.1693	0.0683 **	0.0979	0.0601 *	0.1088	0.0632 *	0.1237	0.0681 *
6		t	-0.0865	0.0224 ***	-0.1157	0.0248 ***	-0.0836	0.0217 ***	-0.0885	0.0228 ***	-0.0948	0.0245 ***
7	Demand	Intercept	-5.0793	0.3524 ***	-5.1010	0.3535 ***	-5.0658	0.3544 ***	-5.0723	0.3548 ***	-5.0731	0.3552 ***
8		GDPPC	1.4027	0.0332 ***	1.4011	0.0332 ***	1.4023	0.0333 ***	1.4027	0.0333 ***	1.4028	0.0334 ***
9		TELP	-1.3575	0.0775 ***	-1.3519	0.0775 ***	-1.3592	0.0776 ***	-1.3586	0.0776 ***	-1.3587	0.0776 ***
10	Investment	GA	0.6789	0.2102 ***	0.4195	0.0966 ***	0.3948	0.0985 ***	0.3783	0.0933 ***	0.3678	0.0883 ***
11		GD	0.0033	0.0025 ##	0.0021	0.0021	0.0032	0.0025 ##	0.0026	0.0023	0.0020	0.0021
12		(1-DEVD)*WLPC	-21.0552	13.7840 #	-15.1746	7.4101 **	-30.3379	8.7659 ***	-24.8712	7.8895 ***	-19.4574	7.2905 ***
13		(1-DEVD)*TELP	1.7603	0.6650 ***	2.4217	0.2742 ***	2.7414	0.3465 ***	2.7124	0.3259 ***	2.6596	0.3025 ***
14		DEVD*TELP	10.4611	5.2374 **	1.6078	0.5030 ***	2.5635	0.4724 ***	2.5106	0.3946 ***	2.4744	0.3346 ***
15		STR	5.3525	1.0554 ***	4.7135	0.7560 ***	4.6960	0.8208 ***	4.6674	0.7762 ***	4.6431	0.7436 ***
16		(1-DEVD)*RR	-1.1637	1.4698	-3.3617	1.6918 **	-5.0307	2.0312 **	-4.6796	1.9989 **	-4.1532	1.9372 **
17		DEVD*RR	-63.0245	39.8453 #	3.7419	3.0146	-4.3615	5.0818	-3.4233	3.9657	-2.8163	3.0683
18	Production	Intercept	-2.0309	1.1605 *	-2.5748	1.1496 **	-2.2579	1.1679 *	-2.3359	1.1704 **	-2.3886	1.1708 **
19		(1-DEVD)*TTI	0.1523	0.0628 **	0.1790	0.0621 ***	0.1649	0.0632 ***	0.1681	0.0633 ***	0.1695	0.0633 ***
20		DEVD*TTI	0.1585	0.0604 ***	0.1855	0.0597 ***	0.1704	0.0608 ***	0.1737	0.0609 ***	0.1753	0.0609 ***
21		GA	-0.0988	0.0351 ***	-0.1015	0.0346 ***	-0.1017	0.0351 ***	-0.1010	0.0351 ***	-0.0996	0.0350 ***

Function Value	233.42	236.28	235.13	234.68	234.52

Note:

*** significant at 1 per cent level
** significant at 5 per cent level
* significant at 10 per cent level
# significant at 15 per cent level
significant at 20 per cent level

1 RP1: Equal weight of 0.20 for each of the 5 principles; including weight for US is 0.20.
2 RP2: Equal weight of 0.225 for each of the 4 principles; weight for US=0.1.
3 RP3: Equal weight of 0.25 for each of the 4 principles; weight for US is 0.

Appendix I:
Simultaneous equations: non-linear GMM using CI (22 years)(Chapter 5)

	Equations	Variables	CI0		CI1		CI2		CI3	
			Coeff	Std Error	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error
1	Output	Intercept	105.8585	11.5590 ***	99.7801	10.9718 ***	99.8684	10.9822 ***	100.1232	11.0071 ***
2		KA	0.8434	0.0333 ***	0.8381	0.0320 ***	0.8369	0.0321 ***	0.8356	0.0321 ***
3		HK	0.2089	0.0770 ***	0.2485	0.0742 ***	0.2484	0.0742 ***	0.2470	0.0744 ***
4		TLF	0.2158	0.0355 ***	0.2156	0.0340 ***	0.2167	0.0340 ***	0.2180	0.0341 ***
5		PEN	0.1511	0.0357 ***	0.1450	0.0339 ***	0.1455	0.0340 ***	0.1463	0.0341 ***
6		t	-0.0531	0.0056 ***	-0.0500	0.0053 ***	-0.0501	0.0053 ***	-0.0502	0.0053 ***
7	Demand	Intercept	-6.3889	0.3076 ***	-6.3506	0.3089 ***	-6.3442	0.3089 ***	-6.3373	0.3090 ***
8		GDPPC	1.3648	0.0224 ***	1.3653	0.0224 ***	1.3644	0.0224 ***	1.3631	0.0224 ***
9		TELP	-1.1312	0.0518 ***	-1.1378	0.0520 ***	-1.1375	0.0520 ***	-1.1370	0.0520 ***
10	Investment	GA	0.0970	0.0944	0.1566	0.0683 **	0.1594	0.0682 **	0.1610	0.0687 **
11		GD	-0.0066	0.0028 **	-0.0047	0.0018 ***	-0.0046	0.0018 **	-0.0045	0.0018 **
12		(1-DEVD)*WLPC	-38.1957	8.8700 ***	-31.0312	6.3608 ***	-31.1531	6.3350 ***	-31.7449	6.3917 ***
13		(1-DEVD)*TELP	3.3115	0.2916 ***	3.1023	0.2298 ***	3.0816	0.2280 ***	3.0657	0.2281 ***
14		DEVD*TELP	3.9157	1.3872 ***	4.3880	0.9643 ***	4.3244	0.8469 ***	4.3326	0.7604 ***
15		STR	3.9206	0.5027 ***	4.1554	0.4426 ***	4.0713	0.4414 ***	3.9538	0.4447 ***
16		(1-DEVD)*RR	0.2590	1.1829	0.1399	1.1310	0.4129	1.1417	0.7530	1.1637
17		DEVD*RR	-8.5631	9.6366	-14.4891	7.9119 *	-13.8661	6.8756 **	-13.8148	6.0999 **
18	Production	Intercept	-0.3056	0.0806 ***	-0.3043	0.0807 ***	-0.3043	0.0807 ***	-0.3046	0.0807 ***
19		(1-DEVD)*TTI	0.0312	0.0044 ***	0.0310	0.0044 ***	0.0309	0.0044 ***	0.0309	0.0044 ***
20		DEVD*TTI	0.0262	0.0041 ***	0.0260	0.0041 ***	0.0259	0.0041 ***	0.0259	0.0041 ***
21		GA	-0.0123	0.0026 ***	-0.0121	0.0026 ***	-0.0121	0.0026 ***	-0.0120	0.0026 ***

Function Value	542.72	563.01	562..97	561.74

Note:

*** significant at 1 per cent level

** significant at 5 per cent level

* significant at 10 per cent level

1 CI0: Equal weight for MA and NT; RP is excluded.

2 CI1: Equal weight for MA, NT and RP1.

3 CI2: Equal weight for MA, NT and RP2.

4 CI3: Equal weight for MA, NT and RP3.

Appendix J:
Quantifying the impact of trade liberalization (Chapter 5)

From equation (5.2),

$$\frac{\delta \log GDP_{it}}{\delta PEN_{it}} = a_4 \Rightarrow \delta \log GDP_{it} = a_4 * \delta PEN_{it} \qquad \text{(A)}$$

From equation (5.4), and given DEVD=1,

$$\frac{\delta \log TTI_{it}}{\delta RR_{it}} = c_8 \Rightarrow \delta \log TTI_{it} = c_8 * \delta RR_{it} \qquad \text{(B)}$$

From equation (5.5),

$$\frac{\delta \log PEN_{it}}{\delta \log TTI_{it}} = d_2 \Rightarrow \delta \log PEN_{it} = d_2 * \delta \log TTI_{it} \qquad \text{(C)}$$

Putting (B) into (C),

$$\Rightarrow \delta \log PEN_{it} = d_2 * \delta \log TTI_{it}$$

$$\Rightarrow \delta \log PEN_{it} = d_2 * a_8 * \delta RR_{it} \qquad \text{(D)}$$

Now, putting (D) into (A),

$$\Rightarrow \delta \log GDP_{it} = a_4 * \delta PEN_{it}$$

$$\Rightarrow \delta \log GDP_{it} = a_4 * d_2 * c_8 * \delta RR_{it} \qquad \text{(E)}$$