PATTERNS AND DETERMINANTS OF AUSTRALIA'S INTERNATIONAL TRADE IN PHARMACEUTICALS

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ABBREVIATIONS

ABS	Australian Bureau of Statistics
ADF	Augmented Dickey-Fuller
AECC	Australian Export Commodity Classification
AHECC	Australian Harmonised Export Commodity Classification
AICC	Australian Import Commodity Classification
ANZCERTA	Australia-New Zealand Closer Economic Relations Trading Agreement
APEC	Asia-Pacific Economic Cooperation
APMA	Australian Pharmaceutical Manufacturers Association
ARMA	Autoregressive Moving Average
ASEAN	Association of South East Asian Nations
ASIC	Australian Standard Industrial Classification
CRDW	Cointegrating Regression Durbin-Watson
DF	Dickey-Fuller
DFAT	Australian Department of Foreign Affairs and Trade
ECM	Error Correction Model
EEC	European Economic Community
EG	Engle-Granger
EPI	Export Propensity Index
ERA	Effective Rate of Assistance
ETMs	Elaborately Transformed Manufactures
FDI	Foreign Direct Investment
GATT	General Agreement on Tariffs and Trade
GDP	Gross Domestic Product
GNP	Gross National Product
IFT	Intra-Firm Trade
IIT	Intra-Industry Trade
MIIT	Marginal Intra-Industry Trade

ML	Maximum Likelihood
MNCs	Multinational Corporations
MP	Import Penetration
NRA	Nominal Rate of Assistance
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares
OTC	Over-the-Counter
PBPA	Pharmaceutical Benefits Pricing Authority
PBS	Pharmaceutical Benefits Scheme
R&D	Research and Development
RC	Revealed Competitiveness
RCA	Revealed Comparative Advantage
REA	Relative Export Advantage
RTA	Relative Trade Advantage
SITC	Standard International Trade Classification
STMs	Simply Transformed Manufactures
TSI	Trade Specialisation Index
UECM	Unrestricted Error Correction Model
VAR	Vector Autoregression
WTO	World Trade Organization

ABSTRACT

This thesis reports the results of a comprehensive analysis of the patterns and determinants of Australia's international trade in pharmaceuticals during the period 1975 to 1992. The thesis provides a thorough review of the theories, measurements and determinants of international trade. Thus, the thesis synthesises the theoretical framework and econometric methodology for analysing international trade patterns and their determinants. This synthesis will be beneficial to those wishing to undertake research in the area of international trade.

The pharmaceutical industry is classified as one of Australia's elaborately transformed manufacturing (ETM) industries whose exports and imports have increased rapidly during the past two decades, due to changes in industrial and trade policies. As Australia becomes increasingly integrated into the world economy, the achievement of successful trade performance in pharmaceuticals is of considerable importance to the Australian economy. In light of this, it is expected that this thesis provides a complete understanding of Australia's international trade in pharmaceuticals, which will be useful to the pharmaceutical industry and policy makers.

The calculated trade specialisation indexes for Australia's pharmaceutical trade are negative, indicating that Australia is a net-importer of pharmaceutical products. Australia's pharmaceutical industry has a low export propensity, but a high import penetration. Both the export propensity and import penetration have slightly declined, reflecting a substantial increase in the domestic consumption of

pharmaceuticals produced in Australia. In contrast, the international competitiveness of Australia's pharmaceuticals, measured in terms of export/import ratio, has significantly increased.

The results of the analysis of revealed comparative advantage show that, among industrial countries, Australia has a high degree of comparative disadvantage in pharmaceuticals. Revealed competitive advantage analysis indicates that Australia has a competitive disadvantage in pharmaceutical products, due to a small share of pharmaceutical exports relative to the total world exports.

To analyse the determinants of Australia's exports and imports of pharmaceuticals separately, the models of export supply, export demand, and import demand are developed and estimated using cointegration and error correction techniques. The results of the unrestricted error correction modelling and estimation indicate that Australia's pharmaceutical export supply is not very responsive to relative price (export price relative to domestic price). The Factor (f) scheme appears to have had a positive impact on pharmaceutical export supply, but its impact is not statistically significant. The findings also suggest that, in the long run, improvements in infrastructure and technology would result in an increase in Australia's export supply of pharmaceuticals. Foreign demand for Australia's pharmaceutical exports is highly responsive to relative price (Australia's export price relative to competitors' price), and to foreign income. Import demand for pharmaceuticals by Australia is highly elastic with respect to Australia's income. The demand for pharmaceutical imports by Australia is inelastic with respect to the relative price of imports (import price relative to domestic price). Although the acceleration of trade liberalisation during the late 1980s appears to have had a positive impact on the import demand for pharmaceuticals, its impact is not statistically significant.

The findings of the analysis of the extent and growth of Australia's intra-industry trade in pharmaceuticals indicate that among industrial countries, Australia has a relatively low extent of intra-industry trade in pharmaceuticals (Australia's exports and imports of differentiated products within the pharmaceutical industry). However, the growth of Australia's intra-industry trade in pharmaceutical products is due to the contributions of imports from pharmaceutical exporting countries to Australia and the contributions of exports from Australia to its neighbouring countries.

The results of the empirical analysis of the determinants of Australia's intra-industry trade in pharmaceuticals with the rest of the world lend support to the hypothesis that economies of scale, market structure and the degree of economic development have a positive impact on Australia's intra-industry trade, while trade barriers have a significantly negative impact. Although the capital-labour ratio and product differentiation show a negative influence on Australia's intra-industry trade in pharmaceuticals, they are not statistically significant.

The analysis of the determinants of bilateral intra-industry trade in pharmaceuticals between Australia and its trading partners shows that Australia seems to engage in intra-industry trade to a greater extent with the countries whose market size and language are similar to Australia's. National income, relative factor endowments (capital-labour ratio), and special trade arrangements do not have significant impacts on the extent of bilateral intra-industry trade in pharmaceuticals between Australia and its trading partners. However, because of its geographical distance from its trading partners, Australia appears to be disadvantaged when it comes to intra-industry trade.

DECLARATION

This thesis contains the original academic work of the author except where stated in the thesis. It contains no material which has been submitted for examination or award of any degree in any university.

Prasit Ch. Karn

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Looking back on the days when I started writing this thesis, I have to admit that I had little idea about which direction to proceed with my research. It took me quite a long time to come up with the first word to specify the research problem in relation to Australia's international trade in pharmaceuticals. However, I was very fortunate to receive assistance from a number of individuals and organisations in making this thesis possible. Among them, I owe a great intellectual debt to my supervisor, Dr. P.J. Gunawardana of the Department of Applied Economics at Victoria University of Technology, who has been very supportive at every stage of this research. I am very grateful for his valuable time and patience in reading, correcting and commenting on the drafts of the thesis and, more importantly, for his generosity and encouragement which I often needed to keep my research in progress. I also thank other members of the Department of Applied Economics, Victorai University, in particular Dr. Steve Bakalis, Dr. N. Kulendran, Mrs. Inka Harila, and Mr. Donald Feaver for their help and comments on some of the aspects covered in this thesis.

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CHAPTER 1

INTRODUCTION

1.1 The Research Problem

1.1.1 Australia's Pharmaceutical Industry

Pharmaceuticals play an increasingly important role in relation to health care in all nations. A nation's level of health care depends mainly upon the availability of pharmaceutical products and, therefore, pharmaceutical trade attracts a great deal of attention of policy makers. During the past two decades, both the total world consumption and the world output of pharmaceuticals have increased significantly (Ballance et al., 1992). As a result, world pharmaceutical trade has expanded substantially. However, pharmaceutical products appear to represent only a small proportion of international trade in manufactured goods. Pharmaceutical industry is a capital-intensive industry which depends upon a high level of technological capabilities in production. Pharmaceutical supply in the world market is dominated by a small number of industrial nations whose technology and product innovation are strong. These countries are: the U.S., Japan, and several countries in Western Europe. Multinational corporations (MNCs) and foreign direct investment (FDI) have become important parts of the world pharmaceutical industry and trade.

The pharmaceutical industry has been classified as one of Australia's elaborately transformed manufacturing (ETM) industries (Sheehan, Pappas and Cheng, 1994). Thus, the industry requires a high level of research and development input. It is expected that international trade in this industry involves intra-industry trade since it is characterised by a wide range of differentiated product lines and economies of scale. Australia's share in the world pharmaceutical market is only a small fraction, accounting for about 2 per cent of the value of the world ethical pharmaceutical sales (Parry and Creyke, 1991). According to the Australian Bureau of Statistics (1997, cat. no. 5422.0), in 1996-97, Australia's total exports of pharmaceutical products were A$939 million, while imports were A$1.93 billion. During the period 1988 to 1996, the value of Australia's imports of pharmaceuticals was more than twice the value of its exports. The major export destinations for Australian pharmaceutical products are: New Zealand, East Asian countries, the Association of South East Asian Nations (ASEAN) and European countries. The exports to these countries account for more than 50 per cent of total Australian pharmaceutical exports, and have showed an increasing trend in recent years. On the other hand, more than 50 per cent of Australia's pharmaceutical imports come from the major pharmaceutical manufacturing countries such as those in Western Europe and the U.S.

In 1950, the government of Australia introduced the Pharmaceutical Benefits Scheme (PBS) in order to provide an "equal opportunity" of pharmaceutical consumption. On the industry side, the Factor (f) scheme was introduced in 1988 to encourage pharmaceutical producers to increase their production activities, exports and technology development. Despite the low level of trade restrictions and government assistance to pharmaceutical industry, Australia implemented the trade policy in the form of export incentive assistance through the Factor (f) scheme. Thus, both the PBS and the Factor (f) scheme serve as a supportive framework for the Australian pharmaceutical industry.

1.1.2 Issues to be Investigated in the Thesis

In general, empirical studies have so far concentrated on the impact of industry policy towards the Australian pharmaceutical industry. Parry and Thwaites (1988) published the original *"Benchmark Study"* of Australia's pharmaceuticals. This report was later updated by Parry and Creyke (1991) in order to identify the recent changes in the industry policies and their impact on Australia's pharmaceutical industry. Johnston (1990), on the other hand, examined Australia's pharmaceutical industry in terms of the pricing strategy which has a significant impact on domestic consumption. An overview of Australia's pharmaceutical industry and the policies directed towards this industry is presented in the reports published by Australian Pharmaceutical Manufacturers Association (APMA; 1981; 1989), Bureau of Industry Economics (1991), and Standard & Poor's Industry Profile (1994). Recently, the APMA (1995) conducted a survey on industry perceptions of pharmaceutical manufacturing in Australia. The results highlight the major positive and negative influences, resulting from the changes in industry policy, on the business development of Australia's pharmaceutical industry. A recent report by the Industry Commission (1996) outlines the effect of current government policies, particularly the Factor (f) scheme on the structure and performance of Australia's pharmaceutical industry, together with a number of recommendations to provide future policy directions forwards the industry.

Thus, there has been no comprehensive study so far on Australia's international trade in pharmaceuticals. Moreover, econometric estimates in relation to the patterns and determinants of Australia's international trade in pharmaceuticals are virtually non-existent.[1] Therefore, the focus of this thesis is on the patterns and determinants of Australia's international trade in pharmaceuticals.

1.2 Objectives of the Study

The broad objective of this thesis is to analyse the patterns and determinants of Australia's international trade in pharmaceuticals over the past two decades (1975-1992).[2] The study is conducted within the conceptual framework of international trade theory in relation to inter-industry trade and intra-industry trade. The thesis attempts to accomplish four specific objectives. These are:

(i) to examine Australia's comparative advantage in pharmaceuticals, using the measures of trade specialisation, export propensity, import penetration, revealed comparative advantage, and revealed competitive advantage;

(ii) to develop and econometrically estimate models of Australia's export supply of pharmaceuticals, export demand for Australian pharmaceuticals by foreign countries, and import demand for pharmaceuticals by Australia, in order to identify the determinants of exports and imports and to estimate the relevant price and income elasticities;

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[1]An exception is a paper by Karn and Gunawardana (1996) in which they attempted a preliminary econometric estimation of Australia's pharmaceutical export supply and export demand functions.
[2]Although intra-firm trade, that is trade among subsidiaries belonging to the same multinational corporation, is an interesting area of study, it warrants a separate thesis. It is outside the scope of this thesis.

(iii) to examine the extent and growth of intra-industry trade in pharmaceuticals, using appropriate measurements; and

(iv) to develop and econometrically estimate models of Australia's intra-industry trade with the rest of the world, and Australia's bilateral intra-industry trade with its 14 major trading partners, in order to test the hypotheses in relation to the determinants of Australia's intra-industry trade in pharmaceuticals.

1.3 Significance of Research

The achievement of successful trade performance in manufactured products will contribute positively to the Australian economy in the years to come, as Australia becomes increasingly integrated into the global economy. Since the pharmaceutical industry is one of the significant sectors among Australia's elaborately transformed manufacturing industries, it is important to understand the patterns and determinants of international trade in this industry, in order to design and implement appropriate policies to expand trade, in particular to promote exports of pharmaceuticals.

In this regard, it is expected that this research will make three important contributions. First, it will provide a thorough understanding of Australia's international trade in pharmaceuticals in terms of both inter-industry trade and intra-industry trade. Secondly, the analysis of the patterns and determinants of Australian trade in pharmaceuticals will lead to a comprehensive understanding of the factors determining exports and imports of pharmaceuticals. Such knowledge will be useful for the firms and policy makers concerned with pharmaceutical trade. Finally, this research will synthesise the theoretical framework and elaborate the methodology for analysing international trade patterns and their determinants, which will be beneficial to those wishing to undertake research in international trade of manufactured products.

1.4 Outline of the Thesis

The thesis is organised into seven chapters. In order to set the scene for the analyses in Chapters 3 through to 6, Chapter 2 provides an overview of the world pharmaceutical industry, the pattern of world trade in pharmaceutical products, Australia's pharmaceutical industry, and Australia's international trade in pharmaceuticals.

In Chapter 3, a review of the principle of comparative advantage is undertaken first, in order to provide the theoretical framework for the analysis. Next, the degree of Australia's comparative advantage in pharmaceuticals is analysed using the concepts and measurements of trade specialisation, export propensity, import penetration, exports/imports ratio, revealed comparative advantage, and revealed competitive advantage.

In Chapter 4, export supply, export demand and import demand for pharmaceuticals are analysed. Separate models of export supply, export demand and import demand are developed and estimated econometrically, using cointegration and error correction techniques. The short run and long run relationships among the variables are identified, and price and income elasticities are estimated.

In Chapter 5, a review of the theory and measurements of intra-industry trade is presented first in order to provide the framework for the analysis of the extent and growth of the intra-industry trade in pharmaceuticals. Next, the focus of the chapter is on the measurement and analysis of the extent of and growth in Australia's intra-industry trade in pharmaceuticals with the rest of the world, as well as Australia's bilateral intra-industry trade in pharmaceuticals with its major trading partners.

In Chapter 6, a review of the theory and empirical studies in relation to the determinants of intra-industry trade is provided first. Next, the determinants of Australia's intra-industry trade in pharmaceuticals are analysed. Separate models are developed and estimated econometrically, for Australia's intra-industry trade in pharmaceuticals with the rest of the world, and Australia's bilateral intra-industry trade in pharmaceuticals with its major trading partners.

Finally, the major findings of the thesis and some suggestions for further research in relation to Australia's international trade in pharmaceuticals, are presented in Chapter 7.

CHAPTER 2

THE PHARMACEUTICAL INDUSTRY AND TRADE: AN OVERVIEW

2.1 Introduction

The world pharmaceutical industry has achieved technological advances similar to those in other high technology-intensive industries. New drugs are being introduced continuously to the market which help to maintain good health and extend human longevity. Since health care is a basic human need, pharmaceutical products have greater social relevance than the products of any other industry. Pharmaceuticals are chemical and biological substances that are used in the treatment and prevention of human disease. The industry has been defined by Reekie (1975:1) according to two viewpoints: as seen by the consumer, the industry is a group of firms manufacturing and distributing medicines in finished forms, and as seen by the producer, the industry consists of manufacturing and processing activities.

Pharmaceutical products are essential for health care in all countries. According to the Organization for Economic Co-operation and Development (OECD, 1985:9), pharmaceutical products account for 10-20 per cent of health care spending and 0.5-1.25 per cent of national income in most developed countries. In less developed countries, pharmaceutical products are even more important, as these products account for 20-30 per cent of national health care spending. As long as the exploration of treatment of diseases still exists, the pharmaceutical industry continues to expand and forms an important part of international trade.

The purpose of this chapter is to provide an overview of the structure of the world pharmaceutical industry, pattern of world trade in pharmaceutical products, Australia's pharmaceutical industry, and Australia's international trade in pharmaceuticals. This overview will provide the necessary background for the analyses to be conducted in Chapters 3 through to 6. Chapter 2 is organised as follows: Section 2.2 provides a brief account of the structure of the world pharmaceutical industry. Section 2.3 outlines the patterns of world trade in pharmaceutical products. An overview of Australia's pharmaceutical industry and Australia's international trade in pharmaceuticals is provided in Section 2.4. The chapter closes with concluding remarks in Section 2.5.

2.2 The Structure of the World Pharmaceutical Industry

Similar to other high technology-intensive industries which depend mostly upon product innovation and a high level of research and development (R&D) expenditure, the pharmaceutical industry has shown some unique characteristics. In general, the industry is characterised by two sets of factors: the large pharmaceutical firms and the government regulation. This section identifies the characteristics of pharmaceutical firms, the different segments of the pharmaceutical market, and the national legislation and government policies which directly impact upon the industry.

2.2.1 Characteristics of Pharmaceutical Firms

For several decades, multinational corporations (MNCs) have played an important role in the pharmaceutical industry in terms of foreign direct investment (FDI). The MNCs manufacture and carry out research in relation to a large number of drugs which dominate the world pharmaceutical industry. According to Gereffi (1983:169), there were more than 10,000 firms around the world in 1983 that were claimed to be pharmaceutical manufacturers. However, only about 100 of these firms had any significance in the international market, and supplied about 90 per cent of the total world consumption of pharmaceutical products for human use.

Table 2.1 shows the numbers of firms in the pharmaceutical industry in the seven OECD nations in which the largest number of pharmaceutical firms were operating in the year 1990. The largest number of pharmaceutical producers are concentrated in Japan, Europe and the U.S., where those countries have high-technology pharmaceutical industries.

Table 2.1 : Number of Pharmaceutical Companies Producing Pharmaceuticals for Human Use in the Major OECD Countries, 1990.

Country	Number of companies
Japan	1,315
Germany	1,000
U.S.	790
U.K.	352
Spain	351
France	350
Italy	303

Source: Scrip Yearbook, 1992: 54.

Unlike in other industries such as computers and automobiles, which have only four or five large manufacturers accounting for up to 90 per cent of the market, in the pharmaceutical industry the largest four companies share only 20-25 per cent of the market, while the fifty largest companies share up to 75 per cent of the total output sold in the market (Taggart, 1993: 30-31). Although the pharmaceutical industry is not obviously oligopolistic, it shows some signs of classical oligopoly such as high seller concentration, low cross-elasticity of demand between sub-markets, and a lack of price competition. The world's twenty-five largest pharmaceutical companies are listed in Table 2.2, ranked by total sales in 1994.

As shown in Table 2.2, the U.S. pharmaceutical companies have the largest market share of the world pharmaceutical sales. It is followed by German, Japanese, Swiss, the U.K. and French companies, respectively. These companies have attempted to maintain profit through increasing sales and the R&D process in order to introduce new products to the world market. Thus, a large proportion of expenditure on R&D is an important component of the overall cost structure of the industry.

Table 2.2: The World's Twenty-five Largest Pharmaceutical Companies, Ranked by Sales, 1994.

Ranking	Company	Nationality	Sales ($ m.)	Market share (%)
1	Glaxo Wellcome	U.K.	11,767	5.5
2	Merck Sharp & Dohme	U.S.	9,425	4.4
3	Hoechst Marion Roussel	Germany	9,399	4.4
4	American Home Products	U.S.	7,425	3.5
5	Bristol Mayers Squibb	U.S.	6,970	3.3
6	Roche (inc. Syntex)	Switzerland	6,375	3.0
7	Pfizer	U.S.	5,811	2.7
8	Smithkline Beecham	U.S.	5,707	2.7
9	Eli Lilly	U.S.	5,235	2.4
10	Johnson & Johnson	U.S.	5,158	2.4
11	Takeda	Japan	4,857	2.3
12	Sandoz	Switzerland	4,829	2.3
13	Ciba	Switzerland	4,469	2.1
14	Bayer	Germany	4,280	2.0
15	Sankyo	Japan	3,909	1.8
16	Schering-Plough	U.S.	3,714	1.7
17	Rhone-Poulenc Rorer	France	3,710	1.7
18	Astra	Sweden	3,570	1.7
19	Shionogi	Japan	3,395	1.6
20	Pharmacia	Scandinavia	3,055	1.4
21	Yamanouchi	Japan	3,050	1.4
22	Zeneca	France	3,000	1.4
23	Boehringer Ingelheim	Germany	2,768	1.3
24	Fujisawa	Japan	2,502	1.2
25	Schering	Germany	2,285	1.1

Source: Scrip, 1995b.

The studies of Comanor (1965) and Grabowski (1968), which used data for the late 1950s, conclude that diseconomies of scale in R&D are experienced by companies with large size of annual prescription and hospital sales. But Angilley (1973) and Schwartzmann (1976) argue that there are economies of scale in expenditure on R&D in this industry. OECD (1985) supports the views of Angilley and Schwartzmann as follows:

> The general view within the (Pharma.) industry is that at this stage of the production process, economies of scale are of real importance. Chemical production requires a high level of skill and training than formulation and

packaging, and is best carried out in countries with a fully developed technical and economic infrastructure. (OECD, 1985:13)

Since the expenditures on product R&D and innovation are high, countries which have a strong complement of large diversified pharmaceutical companies are the homes of the world's leading multinational firms with distinct advantages to develop and market high-technology products.

2.2.2 Different Segments of the Pharmaceutical Market

In general, pharmaceutical products have been classified by the distribution channels and choice of use into two main groups: over-the-counter (OTC) and prescription (ethical) products.

The first group (OTC) consists of drugs which have small market shares, but their importance is growing. This product group is for self-treatment of minor ailments, and is safe to use without a physician's advice and supervision. Therefore, the drugs are sold in most countries directly to consumers without prescription, but with heavy advertising. The supplier is free to set its own price as price controls are lenient. Most of the OTCs are the existing drugs with newly established brands or reformulations. Low research intensities are needed since the rate of growth of sales is lower than that of other pharmaceutical groups. Johnson (1992) points out that in the U.S., the volume of OTC drugs used tends to exceed prescription drugs by a ratio of about 3:2. However, the total value of OTC drugs bought by consumers is approximately one-half or less than that of the drugs prescribed by physicians.

The second group (ethical) accounts for the bulk of medicines sold on prescription. In many countries, prescription drugs are available only through retail pharmacies or hospitals. Therefore, pharmacists and physicians are important parts of the distribution channel. Price competition is often more aggressive. In some developing countries, primary health care workers and sales representatives are important sources of local distribution. Government regulations enforcing distribution of this product group are more strict than of the OTC group.

Pharmaceutical products can also be classified in terms of product registration into two major groups: patent drugs and generic (out-of-patent) drugs. Patent drugs are sold on prescription. Products of this type show a spectacular growth within the pharmaceutical industry. They are the source of prosperity for innovative companies and for the generic sector as well. Patent protection is different from other types of policy because it has been a major international issue in the pharmaceutical industry for several decades. Only successful firms which have an innovative potential are able to compete in this channel. The investment required is high, and the return is large, as the firms have to spend a large amount of resources on the R&D process.

Generic drugs are out-of-patent products which may be produced by more than one company because their patents have already expired. These types of drugs are price-competitive since they contain the same active ingredient as the original brand. Generic drugs may be substituted for the prescribed brand name if they are cheaper.

2.2.3 Government Regulations

National legislation and government policies are factors which influence the pharmaceutical industry. The most widely shared concerns of governments are related to the safety and efficacy of products and their price. Governments in most countries direct their policies towards R&D and innovation, rather than foreign trade objectives. In OECD countries, government policy towards the pharmaceutical industry is mainly aimed at the approval of local pharmaceutical production. This varies from one country to another. Pharmaceutical firms are required to register their new products with the local administration. If these products are safe, effective and of "good" quality, then they are allowed to be sold on the local market. Once the approval of a new drug has been obtained, the other aspects of registration concerning the price and the government support are determined.

In many countries, governments try to cut back on their health care expenditure because of the rising costs of caring for an ageing population and because new drugs are expensive. To control pharmaceutical expenditure, only 5-15 per cent of which is directed to drugs, governments try to limit total spending, encouraging cheaper generic products rather than branded products. Reekie (1995:58) points out that the effectiveness of this solution is not clear since generic drugs are accepted only slowly in some countries such as Western Europe, where industry representatives and the medical profession have resisted the promotion of generic substitution. However, in some countries like the U.S., the acceptance of generic drugs has grown rapidly. These accounted for 29 per cent of the country's drug sales in 1988, and were expected to rise up to about one third by the early 1990s. One reason for this rapid growth of generic drugs is that legislation favours it, and most of the population in the U.S. depend on private health insurance (Ballance et al., 1992: 43-48).

Another objective of government policy which has a direct impact on the pharmaceutical industry is to assist the development of the domestic industry. This policy is aimed at increasing the national capacity for pharmaceutical production. In less developed countries, a number of incentives is offered to encourage foreign firms to build up local plants and set up research facilities. Several policies have strengthened the innovative capacity of their industries by offering concessions in terms of tax deduction and subsidies.

In summary, multinational firms and government policies have shaped the characteristics of the pharmaceutical industry for a long time. These characteristics have in turn influenced the trade pattern which is examined in the ensuring section.

2.3 The Pattern of World Pharmaceutical Trade

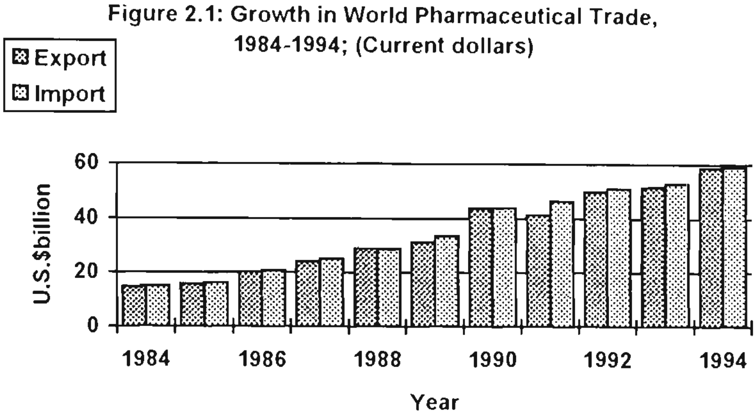
Over the past two decades, the consumption of world pharmaceuticals has shown an increasing trend. The U.S. remains the dominant producer and consumer, followed by the other developed market economies. Income has an obvious effect on consumption since consumers in developed countries spend more heavily on pharmaceutical products than those in less developed countries. However, there are other determinants of consumption as suggested in Ballance et al.(1992), such as price trends, the distribution system, the age structure of population and the national system of health care.

On the supply side, world production of pharmaceuticals has grown rapidly throughout most of the post-war period. However, the world leaders continue to be the countries where modern pharmaceutical production emerges. According to Ballance et al.(1992:22), world gross output of pharmaceuticals (in 1980 constant dollars) increased more than twofold between 1975 and 1990. Among the industrial countries, production in North America and Japan has expanded rapidly, while production has stagnated in Eastern Europe. Production growth in developing countries has generally been slow, although they account for around one fifth of the world production. China is the largest producer among pharmaceutical producers in developing countries, and has managed to establish a substantial pharmaceutical industry during the past two decades.

Scrip (1995c) reports that total world pharmaceutical sales have increased from $232 billion in 1992 to $247.9 billion in 1994, while the Industry Commission (1996) confirms that in 1994-95, the ethical market accounted for about 80 per cent, and the OTC market made up for the rest. The U.S. is by far the largest market with around 32 per cent of total world sales, followed by Japan, the second largest market in the world.[1]

From 1984 to 1994, the value of world pharmaceutical exports increased by 297 per cent from $14.8 billion to $58.7 billion; while that of pharmaceutical product imports increased by 291 per cent from $15.1 billion to $59.10 billion (Figure 2.1).

Figure 2.1: Growth in World Pharmaceutical Trade, 1984-1994; (Current dollars)



Source: United Nations, International Trade Statistics Yearbook (various years).
(Standard International Trade Classification, SITC 541: Medical and Pharmaceutical Products)

According to the United Nations data, in 1994 the major exporting countries were Germany, Switzerland, the U.S., the U.K. and France. Fifty-five per cent of total world exports of pharmaceuticals were from these OECD countries. On the other hand, 36.5 per cent of total world imports of pharmaceuticals were accounted for by Germany, the U.S., Japan, France and Italy (see Table 2.3).

The growth of total world imports of pharmaceuticals has marginally exceeded the growth of exports of the same commodity during the past decade. This trade pattern reflects the rapidly increasing world demand for pharmaceutical

[1] In 1989, the U.S. accounted for 29%, followed by Japan with 20%, of the world ethical pharmaceutical market (Scrip Yearbook, 1991: 35).

products. As reported by Howe (1992), the pharmaceutical market in less developed countries, especially in Southeast Asia, has tripled in size between 1989 and 1991, and expanded as a base for production as well as sales.[2] The supply of pharmaceutical products to these countries is dominated by the U.S. and European OECD countries.

Table 2.3: Major World Pharmaceutical Exporters and Importers in 1994, and Their Shares in Total World Imports and Exports

Rank (1994)	Exporters	Value of Exports ($m.) for 1994	% share of world total for 1994
1	Germany	8,722	14.8
2	Switzerland	6,194	10.5
3	U.S.	6,184	10.4
4	U.K.	6,009	10.2
5	France	5,415	9.2
	Rest of the world	26,252	44.9
	Total world export	58,776	100.0
Rank (1994)	**Importers**	**Value of Imports ($m.) for 1994**	**% share of world total for 1994**
1	Germany	5,253	8.9
2	U.S.	4,755	8.0
3	Japan	4,222	7.1
4	France	4,203	7.0
5	Italy	3,262	5.5
	Rest of the world	37,409	63.5
	Total World Import	59,104	100.0

Source : United Nations, International Trade Statistics Yearbook, 1994.
(SITC 541: Medicinal and Pharmaceutical Products).

However, the proportion of intra-firm trade (IFT)[3] among foreign subsidiaries in pharmaceutical trade remains strong as its trade values are lumped together with exports. IFT is an important part of pharmaceutical trade since it shows clear evidence of strong links between the parent company and its subsidiaries overseas. Data limitations do not allow an estimation of the importance of IFT in pharmaceutical trade. According to Ballance et al. (1992: 72), between 1970-88, the percentage share of IFT in U.S. pharmaceutical trade accounted for 70-71 per cent of

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[2]Scrip (1995d) confirms that in 1994, the growth of pharmaceutical sales in the Asian countries was valued at $18.1 billion or 13.6 percent, compared with the global growth of 7.6 percent. Sales in these countries grew faster than any other region worldwide.

[3]Intra-firm trade is defined by OECD (1993) as the international exchange of goods and services within a multinational corporation (MNC). More detailed studies on the main characteristics of IFT can be found in Lall (1980: 93-100) and Helleiner (1981).

its total exports. Although IFT is a large and interesting area which warrants a separate study, it is beyond the scope of the present thesis.

2.4 Australian Pharmaceutical Industry

During the past four decades, there were several changes in Australian industry policy. The Australian industry is influenced by the events in the world economy. Recent developments in the area of international trade has had a major impact upon the Australian domestic industries. The pharmaceutical industry has been classified as one of Australia's elaborately transformed manufacturing (ETM) industries. It includes the production and marketing of drugs for human use in several forms. The industry contributes only a small part (one per cent) to Australian manufacturing output. Most of the pharmaceutical products in Australia are developed overseas and then manufactured and supplied domestically. The major pharmaceutical businesses in Australia are the subsidiaries of multinational corporations (MNCs) from Europe and North America. The attractiveness of Australia as a host country for pharmaceutical investment lies in its various strengths. According to the survey of Australian Pharmaceutical Manufacturers Association (1995),[4] the four dominant factors which attract MNCs for pharmaceutical investment in Australia are as follows: the quality of Australian labour and management; Australia's location close to the growing Asia-Pacific market; Australia's expertise and infrastructure in R&D; and the importance of the Factor (f) scheme which compensates MNCs for low government-set prices.

As Australia is located in the southern hemisphere, high transport costs act as a natural barrier against foreign trade. MNCs establish subsidiaries in Australia in order to minimise transport and transaction costs. Given the importance of Australia's characteristics which include high-quality workforce, R&D infrastructure

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[4]The Australian Pharmaceutical Manufacturers Association conducted a survey of 38 leading pharmaceutical companies operating in Australia in 1995.

and English as a common language, Australia provides a relatively secure base for pharmaceutical operations.[5] Furthermore, Australia is regarded internationally as having substantial potential in the areas of basic research and clinical trials, particularly in biotechnology (Bureau of Industry Economics, 1991: 24-26). As long as pharmaceutical MNCs from Europe and America are more sophisticated and oriented towards R&D activities, Australia will become more attractive as a destination for high technology investment in pharmaceuticals.

As shown in Table 2.4, the MNCs from Europe and North America are the major suppliers of Australian domestic Pharmaceutical Benefit Scheme (PBS) market, while only a small proportion is supplied by domestic companies. This indicates that the performance of the pharmaceutical industry in Australia is heavily influenced by the operations of MNCs.

Table 2.4 : Major Companies of Pharmaceutical Products by PBS Sales[@], Australia, 1994-95 (A$ million)

Rank	Multinational Corporations	Nationality	PBS-Sales
1	Merck Sharp & Dohme	U.S.	223
2	Astra	Sweden	200
3	Glaxo	U.K.	195
4	Bristol-Mayer Aquibb	U.S.	98
5	SmithKline Beecham	U.K.	91
6	Ciba Geigy	Switzerland	88
7	ICI	U.K.	83
8	Roche	Switzerland	82
9	Eli Lilly	U.S.	74
10	Pfizer	U.S.	69
11	Wellcome	U.K.	54

Note: @ Pharmaceutical Benefit Scheme (PBS) Sales.
Source: Pharmaceutical Benefits Pricing Authority (PBPA), 1995.

Merck Sharp & Dohme is the largest pharmaceutical company in Australia, followed by Astra and Glaxo. However, the ranking of multinational corporations by the PBPA may alter due to the recent merger between Glaxo and Wellcome.

[5]Department of the Prime Minister and Cabinet (1991), Howe (1994), Sugimoto (1995), Bureau of Industry Economics (1995: 26-32) and Industry Commission (1996: 151-186) provide empirical evidence in support of this view.

According to Standard & Poor's Industry Profile (1994), the value of pharmaceutical exports by Merck Sharp & Dohme in 1993 were A$140 million, which contributed 25 per cent to total Australian exports in medicinal and pharmaceutical products ($564.4 million). In the same year, exports by Glaxo were A$63.2, or 11 per cent of total pharmaceutical exports. Thus, Merck Sharp & Dohme and Glaxo remain the two largest exporters of Australian pharmaceutical products.

Although the MNCs have dominated the pharmaceutical industry in Australia, there are eight Australian-owned companies with a combined pharmaceutical manufacturing turnover of around $200 million (Department of the Prime Minister and Cabinet, 1991:8). These companies are also involved in the manufacture and distribution of a wide range of pharmaceutical products (see Table 2.5). Among them, Faulding is the largest domestic manufacturer and distributor of pharmaceuticals. CSL specialises in manufacturing biological products such as insulin and plasma derivatives for local and international market. Blackmores is the Australian company which produces vitamin and mineral supplements for local OTC market. Other private companies, including Sigma, Soul Pattinson, Hamilton, Ego and Herron, produce their own branded products mostly for the OTC market. These include medical and pharmaceutical equipment, and veterinary and biotechnology related products.

Table 2.5: Australian Pharmaceutical Companies, Ranked by Business Sales*, 1991-92

Rank	Australian Company	Business Sales (A$ million)
1	Faulding	1,142
2	Sigma	536
3	CSL	165
4	Soul Pattinson	160
5	Blackmores	46
6	Ego Pharma.	4
7	Hamilton Pharma.	n/a
8	Herron Pharma.	n/a

*Note: *Including the distribution and marketing business.*
n/a = not available
Source: Standard & Poor's Industry Profile, 1994.

In terms of industry sales, Australian human use pharmaceutical sales were $3,760 million in 1993. Of this figure, about a half was considered as ethical products and the rest as OTC drugs (see Table 2.6). Total sales increased by 94.4 per cent during 1991-1993. In 1993, the prescription pharmaceuticals accounted for 75 per cent of the market, while the OTCs made up the rest. Of the total prescription sales, PBS products continue to be dominant, followed by hospital prescription and export prescription markets. The private prescription market is quite small in value. This reflects the influence of government policy in this area of health care.

Table 2.6: Pharmaceutical Industry Sales in Australia, Selected Years During 1987-1993, (Current dollars)

	1987 (A$ m.)	1990 (A$ m.)	1991 (A$ m.)	1993 (A$ m.)
PBS*	668.0	904.7	993.8	1,744.0
Hospital prescription	172.2	210.3	227.9	314.0
Private prescription	74.4	70.9	79.4	142.0
Export prescription	N/A	114.2	167.3	600.0
Total prescription	**914.6 (72%)**	**1,300.1 (75%)**	**1,468.4 (76%)**	**2,800.0 (75%)**
OTC	350.2	389.8	420.3	880.0
Export OTC	N/A	39.3	45.3	80.0
Total OTC	**350.2 (28%)**	**429.1 (25%)**	**465.6 (24%)**	**960.0 (25%)**
Total human use	**1,264.8 (100%)**	**1,729.2 (100%)**	**1,934.0 (100%)**	**3,760.0 (100%)**

**Note: PBS = Pharmaceutical Benefit Scheme.*
Prescription = Ethical products.
Source: Derived from Standard & Poor's Industry Profile (1994) and Industry Commission (1996).

The sales of OTC pharmaceuticals have grown more slowly than ethical products. The OTC market is regulated by the federal government through a number of Acts, but OTC products do not receive a government subsidy. They are sold through a highly competitive supermarket chain. Most of them are self-medication products, and in particular, the analgesic group and the vitamin supplements which account for 50 per cent and 20 per cent of OTC market sales, respectively (Standard & Poor's Industry Profiles, 1994). Ethical products account for about 76% of the total industry sales. They are classified into various therapeutic groups as shown in Table 2.7.

Table 2.7: Australian Ethical Pharmaceutical Therapeutic Groups, Classified by Number of Prescriptions: 1992-93.

Therapeutic groups	Number of prescriptions ('000)
Anti-asthmatics and bronchitics	10,207
Anti-hypertension	8,617
Penicillins	6,450
Sedatives and hypnotics	6,132
Non-steroidial anti-inflammatory	5,563
Anti-anginals	4,796
Non-narcotic analgesics	3,708
Anti-depressants	3,699
Drugs for gastric ulcers	3,616
Beta-blockers	3,575
Total all groups	105,953

Source: Derived from Standard & Poor's Industry Profile, 1994.

2.4.1 Government Regulatory Environment

Unlike other industries which can be operated mainly within a free market system, the pharmaceutical industry in Australia is mainly characterised by extensive government regulations and policies. In an attempt to increase domestic consumption and to develop the industry, the federal government has regulated the industry through two major policies: the Pharmaceutical Benefits Scheme (PBS) and the Factor (f) scheme. The objectives of these schemes mainly involve three aspects of industrial development: domestic consumption in pharmaceuticals, industrial policy and trade policy.

2.4.1.1 Domestic Consumption

In order to provide an "equitable" access to pharmaceutical products by all Australian consumers, the PBS was first introduced in 1950 by the federal government. This policy was designed to confer a large benefit towards both high- and low-income individuals. Subsidised pharmaceutical products are available at no cost to pensioners and their dependents, and at a co-payment for general users, with the wide range of listed prescription drugs.

Theoretical underpinnings of the PBS can be described as follows: in a free competitive market, there are marginal private or internal benefits of pharmaceutical consumption to those who pay for and use pharmaceutical products, and external benefits to others who enjoy benefits without paying, that is, the users positively affect the welfare of other individuals in the society. When this type of externality occurs without government intervention, the free market is unable to allocate resources efficiently. This results in a level of consumption which is lower than the socially desirable level, leading to inefficiency.

As the pharmaceutical products are subsidised by the PBS, the external benefit is added to the marginal private benefit of pharmaceutical consumption, resulting in the marginal social benefit which implies a greater demand and use of pharmaceuticals. With the increase in demand, a new equilibrium where the marginal cost is equal to the marginal social benefit generates the efficient quantity of pharmaceuticals after subsidy.

To ensure a reliable supply of PBS items at a reasonable price to consumers, the Pharmaceutical Benefits Pricing Authority (PBPA) was established by the government in 1988. The PBPA periodically reviews the prices of PBS items and negotiates with pharmaceutical manufacturers on proposed price changes. According to Bureau of Industry Economics (1991:56), the eight pricing factors the PBPA considers when pricing products listed on the PBS, are as follows:

Factor	Descriptors
a	the prices of alternative brands of drug;
b	comparative prices of drugs in the same therapeutic group;
c	cost information, when supplied by the manufacturer;
d	prescription volumes, economies of scale and the other manufacturing considerations;

e prices of the drug in reasonably comparable overseas countries;

f the level of activity being undertaken by the company in Australia including new investment, production and research and development;

g other relevant factors which the applicant company wishes to be considered; and

h other directions as advised by the Minister for health.

As described in the above criteria, the objective of Factors (b) and (c) is to ensure a reliable price of PBS items supplied to consumers, while Factor (f) serves as a principal guideline to promote an internationally competitive pharmaceutical manufacturing activity in Australia.

Due to subsidies, pharmaceuticals have been one of the rapidly growing areas of government expenditure over the years. Standard & Poor's Industry Profiles (1994:9) have shown that, in 1992-93, government expenditure on pharmaceuticals was 12 per cent of the total health care expenditure. However, according to Pharmaceutical Benefits Pricing Authority (1995:11), the total cost of pharmaceutical benefits increased from A$1.8 billion in 1992-93 to A$2.3 billion in 1994/95. This expenditure comprised total government payments of A$1.89 billion and total patient contributions of A$445 million. The concessional patients accounted for about A$1.4 billion of the total cost of pharmaceutical benefits. Pensioners were the largest beneficiaries of the PBS among the concessional groups.

Although the PBS contributes a large benefit towards Australian consumers, this policy also impacts upon the pharmaceutical industry and manufacturers as a whole. Parry and Thwaites (1988:18) state that:

> The funding of the PBS by government directly affects PBS prices and hence the returns to, and the development of, the industry in Australia. Thus, any changes in policy concerning access to pharmaceutical benefits do have implications for industry development considerations.

2.4.1.2. Industry Policy

One of the issues in the pharmaceutical industry which is relevant to the industry policy is technological spillovers, or the inability of pharmaceutical firms to appropriate all the benefits they generate from their knowledge and innovations. In a competitive environment, if one pharmaceutical firm generates research and development (R&D) outcomes that can be utilised by other pharmaceutical firms without costs, the innovating firm tends to under-invest in R&D. Such externalities represent a potential market failure in the pharmaceutical industry. In this context, the relevant questions are: should the government subsidise the R&D in this industry, and to what extent is the subsidy justified? These questions are at the heart of arguments concerning industry policy where technological spillovers occur.[6]

In Australia, the pharmaceutical industry policy was designed in 1988 by the PBPA to encourage pharmaceutical manufacturers, which is known as "the Factor (f) scheme". Under this scheme, eligible pharmaceutical companies receive a compensation from the government when they commit themselves to increase their activities which enhance local manufacture, R&D, exports, and product and technology development in Australia.

According to the Department of Industry, Technology and Commerce (1993), the export value added of Australian Pharmaceuticals was $416 million and R&D expenditure was $152 million, for the year 1993-94. On the other hand, it cost the government $109.2 million in total assistance to the pharmaceutical manufacturing industry under this program in the same year.[7] The scheme has been extended to the end of June 1999, and at present there are 11 local and multinational pharmaceutical

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[6]See Krugman and Obstefeld, 1994: 282-284.

[7]Standard & Poor's Industry Profiles (1994) estimate that the government expenditure on Factor (f) assistance will be $820 million over the period 1992-93 to 1998-99.

companies participating in the program.[8]

The Factor (f) scheme serves as a catalyst for the changes in the Australian pharmaceutical industry in two respects. Firstly, it helps the MNCs with a higher capacity of product development to increase their R&D expenditure and the value added in Australian pharmaceutical production. Secondly, the scheme encourages local companies to transform themselves into large scale manufacturers by entering into an alliance with the MNCs which creates positive externalities.[9] This internalisation is accomplished before any technological spillovers occur.

However, under the PBS and Factor (f) schemes, multinational companies in Australia argue that the Australian government policy pushes the prescription pharmaceutical average prices, below the prices in comparable overseas countries. By 1990, Australian ethical pharmaceutical prices were, on average, 50 per cent of the world price (Parry and Creyke, 1991; Johnston, 1990). The Bureau of Industry Economics (1991) states that most pharmaceutical MNCs considered Australia as an unattractive place in which to do business because of the lower level of prices and the complex regulatory environment.

2.4.1.3 Trade Policy

The relaxing of Australia's trade restrictions since the early 1980s has allowed the value of manufacturing trade to rise. Manufacturing exports have increased rapidly since 1989-90. Assistance to manufacturing continues to decline in line with the government program of reductions in assistance by the year 2000-01.

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[8]Astra, BM Pharmaceuticals, Pisons, Pfizer, Wellcome, Glaxo, AMRAD. CSL, Merck Sharp & Dohms, Upjohn (Delta West) and Faulding.

[9]An example of IDT and Pfizer which helps create a higher capacity of manufacturing.

Two alternative measures of assistance commonly used are the nominal rate of assistance (NRA) and effective rate of assistance (ERA). According to the Industry Commission (1993), the NRA is based on two different approaches: The NRA on materials is the percentage increase in the cost of intermediate inputs due to government intervention, relative to the hypothetical situation of no assistance. On the other hand, the NRA on outputs is defined as the percentage by which government assistance allows the average gross returns per unit of output to increase, relative to the hypothetical situation of no assistance. The ERA is defined as the percentage increase in returns to value added per unit of output in an industry with government assistance, relative to the hypothetical situation in which no assistance is provided. These measures cover the government assistance which includes tariffs, quantitative import restrictions and export incentives.

Table 2.8 shows the NRAs and ERAs for pharmaceutical and veterinary products for the period 1989-90 to 1994-95. The NRAs on outputs remain unchanged while the NRAs on materials slightly decrease. The ERAs to Australia's pharmaceutical industry are either zero or negative. The negative rates of assistance

Table 2.8: Average Nominal Rates of Assistance (NRAs) and Average Effective Rates of Assistance (ERAs) for Pharmaceutical and Veterinary Products (Australian Standard Industrial Classification, ASIC 2763), Australia, 1989-90 to 1994-95.

Year	NRAs on outputs (%)	NRAs on materials (%)	ERAs (per cent)
1989-90	1	3	-1
1990-91	1	3	-1
1991-92	1	3	-1
1992-93	1	3	-1
1993-94	1	2	0
1994-95	1	2	0

Note : - Based on 1989-90 series.

- Estimations for 1992-93 to 1994-95 reflect 1991-92 prices.

Source: Industry Commission (1993), Annual Report 1992-93.

result from the price-related protection for imported inputs and/or price controls on final products in pharmaceuticals (General Agreement on Tariffs and Trade, GATT, 1994a: 147). In any case, it is evident that Australia has a very low level of effective assistance to the pharmaceutical industry as the rates of assistance continue to decline over recent years.

According to the Department of Foreign Affairs and Trade (1994a:49), as an outcome of the Uruguay Round of GATT tariff negotiations, tariffs will be eliminated in the pharmaceutical sector in most OECD countries such as the U.S., the E.C. and Japan, over a four year period, commencing on January 1, 1995. Tariffs in the world pharmaceutical market are expected to be reduced by an average of 68 per cent, with a final average tariff of 2.6 per cent in all export destinations. Australia's tariff commitments in pharmaceuticals fall within the current tariff reduction program, with tariff bound at an average of 0.3% in 1993-94.

Thus, tariffs will be of little consequence to the pharmaceutical trade in the future as the tariff rates are being reduced under the GATT (World Trade Organization, WTO) commitments. Therefore, there are potential benefits for Australia through a more open trading system, particularly in the expansion of export opportunities.

Australia redefined its trade policies in 1988 to encourage the pharmaceutical exports in the form of export incentive assistance through the Factor (f) scheme. Under this scheme, participating firms can gain increased prices for selected pharmaceutical products listed on the PBS on the condition that they achieve a minimum export to import ratio of 0.5, and increase their domestic value added up to 50 per cent over a three to five year period. According to the Industry Commission (1993:340), the payments to participating firms increased from $26 million to $52 million from 1991-92 to 1992-93. These payments are expected to increase substantially over the coming years.[10]

2.4.2 Australian Pharmaceuticals in the World Market

Australia's pharmaceutical trade has become considerably export oriented in recent years although its share is only a small fraction of the world market. The industry was recognised as one of the significant contributions to exports in the late eighties and the early nineties after the government policy started to change through the Factor (f) scheme. Major new investment was undertaken in new plants, facilities and R&D in order to enhance the local manufacturing activities in Australia. The change in the development of the industry has strengthened the growth in exports of pharmaceutical products over the recent years.

2.4.2.1. General Trade Pattern

During the decades of the 1950s and 1960s, Australia became less involved in international trade. According to Athukorala (1995:2) and Krause (1984:276), Australia's trade (export and import) share of GDP declined from 40 per cent in the early 1950s to less than 30 per cent by the late 1960s and the early 1970s. This was in contrast to other industrial countries whose levels of trade orientation doubled during the same years. As a result, Australia's economy became considerably less open than those of other industrial countries. Australia contributed about 3 per cent of world trade during the early post war period, but this share continued to decline to 1.27 per cent from 1975 to 1977.[11]

In the 1980s, there was a considerable expansion of Australia's trade due to several changes in Australia's industrial and trade policies. Over the past two

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[10]However, the prices granted under the Factor (f) scheme have remained below the average for comparable OECD countries (GATT, 1994a: 72).

[11] See discussions in McColl and Nicol (1980:145-157).

decades, important structural improvements in Australia's trade have taken place. Both exports and imports of Australia's merchandise have grown rapidly, especially during 1993-94. In 1993, Australia generated 1.1 per cent of the world's merchandise exports, and became the world's 20th largest exporting country. Meanwhile, Australian imports comprised 1.2 per cent of the world's total imports, and Australia was ranked the 21st largest importing country in the world (GATT, 1994b:8).

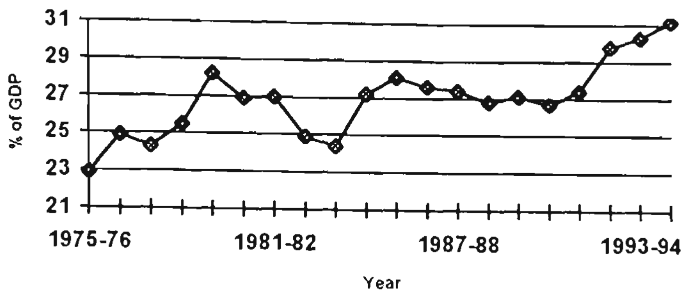
Table 2.9 provides information on Australia's exports and imports of merchandise, measured at current prices. It is clear from Table 2.9 and Figure 2.2 that the export and import values of Australia's merchandise trade between 1993-94 and 1994-95 are about 15 per cent of GDP, which are higher than they were in the late 1970s and the 1980s. Thus, there is a significant increase in Australia's trade orientation during the 1990s. The trade orientation [(exports + imports) /GDP*100] rises from 22.9 in 1975-76 to 31.2 per cent in 1994-95, reflecting the marked increase in Australia's economic interdependence with the rest of the world.

Table 2.9: Australia's Merchandise Exports and Imports, Selected Years During 1975-76 to 1994-95 (Current prices).

Item (A$ million)	**1975-76**	**1980-81**	**1985-86**	**1990-91**	**1993-94**	**1994-95**
Exports	9,399	18,949	32,795	52,398	64,578	67,063
Imports	8,153	18,790	34,691	48,912	64,470	74,634
Trade balance	1,246	159	-1,896	3,486	108	-7,571
Share of GDP (%)						
Exports	12.3	13.5	13.7	13.8	15.2	14.8
Imports	10.6	13.4	14.5	12.9	15.1	16.4
Exports *plus* imports	22.9	26.9	28.1	26.7	30.3	31.2

Sources: Export and import values from ABS, Cat. no. 5436.0 and 5437.0, GDP from The World Bank, World Tables 1995.

Figure 2.2 : Trade Orientation for Australia's Merchandise Trade, from 1975-76 to 1994-95 (current values).



Source: Estimates compiled using export and import values from ABS, cat.no. 5436.0 and 5437.0, GDP from the World Bank, World Tables 1995.

It is evident from Table 2.10 that primary products are the main contributors to the growth in Australia's merchandise exports, despite the declining trend in their share in total exports during 1989-90 to 1995-96. The exports and imports of manufactured commodities continued to rise over the same period, resulting in changes in the composition of Australia's trade. According to the Department of Foreign Affairs and Trade (1996:3), Australia's manufactured exports have increased by 14 per cent per year from 1992-93 to 1995-96.

Table 2.10: Australia's Merchandise Trade by Broad Category, from 1989-90 to 1995-96.

Exports	**1989-90**	**1990-91**	**1991-92**	**1992-93**	**1993-94**	**1994-95**	**1995-96**
Primary products (%)	65.3	64.2	62.7	61.5	58.0	57.2	56.7
Manufactures (%)	25.5	26.5	27.6	29.3	31.2	33.4	33.7
Other (%)	9.2	9.3	9.7	9.2	10.8	9.5	9.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Imports							
Primary products (%)	12.6	13.8	12.9	13.8	12.7	12.1	12.3
Manufactures (%)	85.3	84.0	84.6	84.2	85.5	86.5	86.5
Other (%)	2.1	2.2	2.4	2.0	1.8	1.4	1.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Department of Foreign Affairs and Trade (various years), Composition of Trade, Australia.

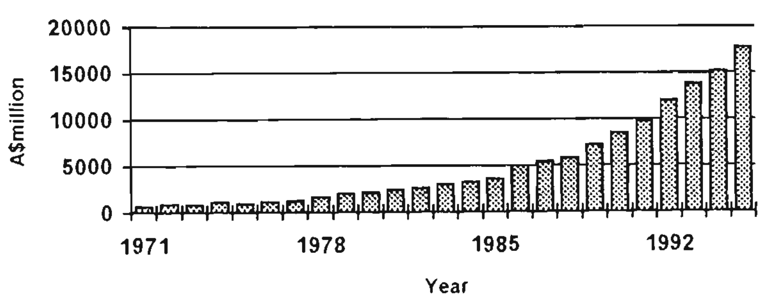
As shown in Table 2.11, manufactured exports are classified into two categories: simply transformed manufactures (STMs), the share of which in the total manufactured exports gradually declined during 1979-80 to 1995-96, and elaborately transformed manufactures (ETMs), which have a high value-added content, and continued to grow rapidly over the same period (see Figure 2.3).

Table 2.11: Composition of Australia's Manufactured Exports, Selected Years During 1979-80 to 1995-96.

Manufactured Exports	1979-80	1983-84	1987-88	1991-92	1992-93	1993-94	1994-95	1995-96
ETMs (%)	51.8	59.5	56.9	63.9	67.2	68.5	67.5	69.4
STMs (%)	48.2	40.5	43.1	36.1	32.8	31.5	32.5	30.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Department of Foreign Affairs and Trade (various years), Composition of Trade, Australia.

Figure 2.3 : Australia's Elaborately Transformed Manufacture Exports, 1971 to 1995, current values.



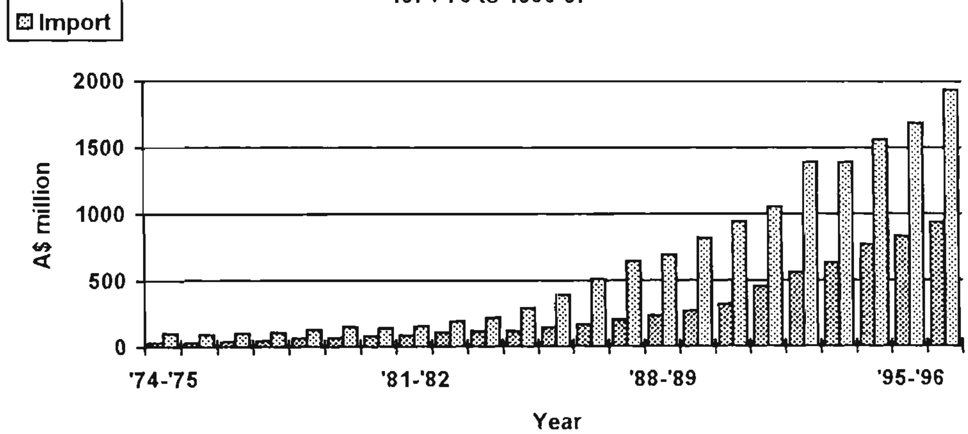
Source : Department of Foreign Affairs and Trade (various years).

ETMs consist of about two-thirds of total manufactured exports, and increased by 15 per cent annually during 1991-92 to 1995-96. Much of the rapid growth in ETMs has been in the areas of chemical manufactures and related products (SITC 5), manufactured goods classified by material (SITC 6), machinery and transport equipment (SITC 7), and miscellaneous manufactured articles (SITC 8).

2.4.2.2. Pharmaceutical Trade Flows

Pharmaceutical sales in Australia accounted for about 2 per cent of the value of the world ethical pharmaceutical sales in 1989. The growth in Australian pharmaceutical exports in 1996-97 has been faster than the domestic sales. The total exports of pharmaceutical products reached A$939.0 million, while imports were A$1.94 billion in 1996-97 (see Figure 2.4).

Figure 2.4 : Growth in Australian Pharmaceutical Trade, 1974-75 to 1996-97



Source: ABS, cat.no. 5424.0, 5426.0 and 5422.0
SITC 54: Medical and Pharma. Products.

Australia's imports of pharmaceuticals have exceeded its exports of the same commodity during the past three decades. Parry and Creyke (1991: 53-54) state that the trade deficit of Australian pharmaceuticals is due to the low return on pharmaceutical operations in Australia. The government performs as a monopsony and keeps the prices of pharmaceuticals about 50 per cent less than the world average. Therefore, the MNCs "pulled out of R&D in Australia, and confined their operations to formulation and packaging only. As a result, drug exports fell while imports rose, and Australia began to run a trade deficit in pharmaceuticals" (Capling and Galligan, 1992:136-137).

As shown in Table 2.12, Australian pharmaceutical exports show a significant increase during the period 1988 to 1996, reflecting the impact of the Factor (f) scheme on exports. During this period, exports have expanded at a more rapid rate than the imports of pharmaceuticals.

Table 2.12: Composition of Australian Pharmaceutical Trade, Selected Years During 1979 to 1996 (Current Australian dollars)

						Average Annual per cent Change (%)			
	1979 ($m.)	1983 ($m.)	1988 ($m.)	1993 ($m.)	1996 ($m.)	1979-83	1984-88	1989-93	1994-96
Exports	70.2	118.7	232.9	637.0	939.0	12.9	14.7	25.1	13.9
Imports	152.4	221.3	693.8	1,393.0	1,936.0	11.6	26.1	19.3	11.6
Trade Balance	-82.2	-102.6	-460.9	-756.0	-997.0	-11.6	-36.6	-13.1	-12.42

Source: ABS, Cat. no. 5424.0, 5426.0 and 5422.0.

Thus, the trade pattern of Australian pharmaceuticals has changed significantly since the mid 1980s, reflecting the changes in trade policy and the pharmaceutical industry policies. Parry and Creyke (1991:33) carried out a survey of twenty-two pharmaceutical companies, and estimated that some 90 per cent of these companies' exports in 1989-90 were accounted for by the growing exports of the companies participating in the Factor (f) scheme.

As shown in Table 2.13, the most important destinations for Australian pharmaceutical exports are New Zealand, East Asian countries, ASEAN and European countries. The exports to these countries accounted for 78.7 per cent of total exports in 1992-93. New Zealand appears to be the largest importer of Australian pharmaceuticals, followed by East Asian countries such as Hong Kong, Taiwan, Korea and Japan. Most of the pharmaceutical exports are in the form of finished goods which are locally manufactured and supplied overseas by the MNCs. On the import side, the pharmaceutical imports from European countries which consist of world leading pharmaceutical manufacturers are the most dominant, accounting for 57 per cent of Australian pharmaceutical imports. This is followed by the countries in North America, mainly the U.S.

Table 2.13: Australian Pharmaceutical Exports and Imports by Country/ Regional Group, 1992-93 (Current Australian dollars)

Country/Regional Group	Exports ($'000)	Imports ($'000)
New Zealand	162,426 (28.8%)	18,022 (1.3%)
East Asian countries	112,392 (19.9%)	55,858 (4.0%)
ASEAN	86,909 (15.4%)	14,236 (1.0%)
European countries	84,917 (15.0%)	792,562 (56.9%)
North America	35,453 (6.3%)	213,312 (15.3%)
Others	82,269 (14.6%)	298,706 (21.4%)
Total	564,366 (100.0%)	1,392,696 (100.0%)

Source: ABS, Cat. no. 5410.0

Table 2.14 provides recent data on Australia's pharmaceutical exports by country of destination in 1994-95. New Zealand remains the largest export destination for Australia's pharmaceuticals, followed by the U.K., the U.S. and the countries in East Asia. The proportion of Australia's pharmaceutical exports to these countries accounted for more than 50 per cent of total exports in 1994-95. According to the Industry Commission (1996: 25), Australia's pharmaceutical exports to the U.K. and China have substantially increased during 1992-93 to 1994-95.

Table 2.14: Australian Pharmaceutical Exports by Country of Destination, 1994-95

Country	% of total exports
New Zealand	30
U.K.	11
U.S.	5
Taiwan	4
Singapore	4
China	2
Japan	2
Other countries	42
Total	100

Source: ABS, Cat. no. 5422.0

The value of Australian pharmaceutical imports by country and regional group reflects Australia's dependence on overseas as a source of R&D and technology for pharmaceutical manufacturing. Most of the pharmaceutical products in the form of active ingredients and finished goods are imported from the countries with a high-technological intensity, particularly Europe and North America. On the other hand, Australian pharmaceutical exports are in the form of finished goods which are locally manufactured and supplied by the MNCs to the neighbouring countries, mainly New Zealand and Asian countries.

2.5 Conclusion

It is apparent from the review in this chapter that the world pharmaceutical industry has been shaped by two principal characteristics: pharmaceutical MNCs and government regulations. The pharmaceutical industry depends strongly upon advanced technology and innovations, and therefore, the industry is concentrated in a small number of nations where high-technology and R&D are strong. The production of pharmaceuticals in each country is dominated by a relatively few companies which are multinational in their operations. Government policies toward the pharmaceutical industry are mainly concerned with product safety and local demand for pharmaceuticals. These two characteristics have exerted a major influence on the world trade in pharmaceuticals for several decades. The recent expansion of world pharmaceutical trade is indicative of a substantial growth in demand for pharmaceutical products. Although the OECD countries are both the major exporting and importing countries for pharmaceutical products, there is evidence that a rapid growth of pharmaceutical demand also exists in less developed countries, particularly in East and Southeast Asia.

As Australia is strongly endowed with natural resources, primary products such as agricultural and mineral products are dominant exports, while high-tech manufactured goods such as pharmaceuticals form a significant part of the country's imports. However, Australia's pharmaceutical trade has changed recently in both its pattern and direction due to changes in government intervention. Various policies in the form of industry assistance have been implemented to enhance local manufacturing activities and exports. The volume of pharmaceutical exports by Australia has rapidly expanded during recent years reflecting the impact of these policies upon the trade pattern.

However, there has been no previous research which provides a comprehensive study of Australia's international trade in pharmaceuticals. Therefore, research is undertaken in Chapters 3 to 6 of this thesis to analyse the trade pattern and its determinants in relation to the Australian pharmaceutical industry.

CHAPTER 3

AUSTRALIA'S COMPARATIVE ADVANTAGE IN PHARMACEUTICALS

3.1 Introduction

Historically, Australia has been a net-exporter of agricultural and mineral products, and a net-importer of manufactures. As Australia is a country which is endowed with a rich natural resource base, it is no surprise that primary products have become the dominant merchandise export on which Australia has relied heavily for several decades. However, as explained in Chapter 2, a surge in manufactured exports has occurred during recent years as a result of changes in Australian trade and industry policies. As a consequence, the commodity composition of Australian trade has also changed. Pharmaceutical products are one of Australia's elaborately transformed manufactured commodities whose values of exports and imports have rapidly grown in recent years.

The purpose of this chapter is to examine the trade performance of Australia's pharmaceuticals and to analyse the degree of Australia's comparative advantage in pharmaceuticals, relative to other pharmaceutical exporting countries. To achieve this purpose, a trade specialisation index, export propensity, import penetration and the export/import ratio are used as one set of indicators of Australia's comparative advantage in pharmaceuticals. Next, Balassa's index is used to analyse Australia's revealed comparative advantage in pharmaceuticals. In analysing the extent to which Australia's pharmaceutical industry has been competitive in the world market, Vollrath's revealed competitive advantage indexes are used.[1] The structure of this

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[1] Sheehan et al (1994) examined revealed comparative advantage in Australia's elaborately transformed manufactures, using Balassa's revealed comparative advantage index and Vollrath's revealed competitive advantage indexes. Son and Wilson (1995), on the other hand, analysed revealed comparative advantage in commodity trade for Australia and Korea, using Balassa's revealed comparative advantage index.

chapter is as follows: To provide the theoretical background for the analysis of comparative advantage, Section 3.2 presents a review of the theory of comparative advantage. Section 3.3 discusses Australia's comparative advantage in general. Australia's comparative advantage in pharmaceutical industry, compared with other pharmaceutical exporting countries, is analysed in Section 3.4. Conclusions are included in a final section.

3.2 Theory of Comparative Advantage

3.2.1 Adam Smith's Theory of Absolute Advantage

The early international trade theory as an organised body of knowledge was established in 1776 by Adam Smith in *The Wealth of Nations* (Smith, 1937). Smith explained the pattern of trade in terms of absolute advantage in production. According to the theory of absolute advantage, in a world of two commodities and two nations with homogeneous labour, trade between two nations occurs when one nation is more efficient than (or has an absolute advantage over) another nation in the production of one commodity, but is less efficient in (or has an absolute disadvantage with respect to) the other nation in the production of a second commodity. A basis for mutually beneficial international trade between two nations exists as each nation exports the commodity in which it has an absolute advantage and imports the commodity in which it has an absolute disadvantage.

Chacholiades (1990:14-15), Dunn and Ingram (1996:14-17) explain the theory of absolute advantage by using numerical examples. By assuming that the world consists of nation A and nation B, produce the commodities i and j, X is the number of units of commodity output which requires one unit of labour, for instance X_{ia} is the units of commodity i which requires one unit of labour to produce in nation A, and so on. To show that both nations gain from trade, suppose nation A is more efficient in the production of commodity i, rather than commodity j. Thus, $X_{ia} > X_{ja}$. Nation A is said to have an absolute advantage in commodity i over nation B, when

$$X_{ia} > X_{ib} \tag{3.1}$$

On the other hand, nation B is more efficient in the production of commodity j, rather than commodity i. Thus, $X_{jb} > X_{ib}$. Nation B is said to have an absolute advantage in commodity j over nation A, when

$$X_{jb} > X_{ja} \tag{3.2}$$

According to Adam Smith's view, in this example, nation A will specialise in the production of commodity i, while nation B will specialise in the production of commodity j. Then, by exporting commodity i to nation B and importing commodity j from nation B, nation A can benefit. At the same time, nation B also benefits by exporting commodity j to nation A and importing commodity i from nation A. Therefore, a nation does not produce all the commodities it needs. Rather, it produces only those commodities which it can produce most efficiently, and then exchanges a part of their output for other commodities to maximise total world output and each nation's consumption. This results in the maximum aggregate welfare for the nations engaged in trade.

The theory of absolute advantage rules out substantial trading relationships. It can explain only a small part of world trade in which one nation has as absolute advantage and the other nation has as absolute disadvantage, such as trade in primary products in exchange for manufactures between less developed and developed nations. It fails to explain the trade pattern in which one of the two nations has an absolute advantage in both goods. However, the theory of absolute advantage has provided a basis for other economists to develop new economic theories of international trade.

3.2.2 The Ricardian Model of Comparative Advantage

In 1817, David Ricardo presented the theory of comparative advantage in his *Principles of Political Economy and Taxation* (Ricardo, 1973). The theory of comparative advantage shows that, in a world of two nations and two commodities, there is still a basis for mutually beneficial trade even if one nation is more efficient than the other in the production of both goods. The nation which is comparatively more efficient would specialise in the production and export of the commodity in which it has a comparative advantage and import the commodity in which it has a comparative disadvantage.

Suppose nation A is more efficient than nation B in the production of both commodities, i and j. Thus, $X_{ia} > X_{ib}$ and $X_{ja} > X_{jb}$.

If nation A has a comparative advantage in commodity i, that is:

$$\frac{X_{ia}}{X_{ib}} > \frac{X_{ja}}{X_{jb}} \quad , \qquad (3.3)$$

then, nation A will specialise in the production of commodity i and exchange part of its output for commodity j from nation B. On the other hand, if nation A has a comparative advantage in commodity j, that is:

$$\frac{X_{ia}}{X_{ib}} < \frac{X_{ja}}{X_{jb}} \quad , \qquad (3.4)$$

then, nation A will specialise in the production of commodity j and export some of its output for commodity i in which nation B has a comparative advantage.

According to the theory of comparative advantage, each nation can gain from specialisation in production of the commodity in which it has a comparative advantage. No mutually beneficial trade takes place if nation A and nation B have a comparative advantage in neither commodity, that is:

$$\frac{X_{ia}}{X_{ib}} = \frac{X_{ja}}{X_{jb}} \tag{3.5}$$

Although Ricardo's theory of comparative advantage is accepted as one of the most fundamental and important laws in economics, the model is built upon the labour theory of value which assumes that labour in production is homogeneous and is used in fixed proportion in the production of all commodities. These assumptions are unnecessary, and the labour theory of value can be rejected as an explanation of the basis of the law of comparative advantage.

Haberler (1936) explains the law of comparative advantage in terms of comparative cost, or opportunity cost theory. Under this theory, the law of comparative advantage is acceptable since it is based on the assumption which implies that the cost of producing a commodity is the amount of a second commodity that must be given up. Therefore, the nation with the lower opportunity cost in the production of a commodity has a comparative advantage, and specialises in the production of that commodity. This nation will export some of its output in exchange for the other commodities which have higher opportunity costs.

The law of comparative advantage is based on the assumption that each producer is too small relative to the market size to control the price of each commodity it produces. This causes the price of each commodity to be equal to its marginal cost of production. The output increases in the same proportion as the increase in all inputs used in production, that is, constant returns to scale. Therefore, the theory of comparative advantage is built upon the differences in relative commodity prices between two nations, under constant returns to scale and perfect competition.

3.2.3 The Heckscher-Ohlin Explanation of Comparative Advantage

The principle of the Heckscher-Ohlin explanation of comparative advantage was first published in 1919 by Eli F. Heckscher and was later refined in 1933 by Bertil Ohlin, in his *Interregional and International Trade*. The principle explains that the differences in domestic relative commodity prices on which international trade is based arise from the different relative factor endowments of the trading nations. A nation exports the commodity whose production requires the intensive use of the nation's relatively abundant factor and imports the commodity whose production requires the intensive use of the nation's relatively scarce factor. In addition to the basic assumptions used in the theories reviewed in previous sections, the Heckscher-Ohlin model assumes that one commodity is labour intensive in both nations, the other commodity is capital intensive in both nations, and tastes and technology are the same in both nations. The nations differ in factor abundance, that is labour and capital. There are constant returns to scale in production, but no transportation costs between the two nations.

In this sense, a nation which is labour abundant will produce and export the commodity whose production requires the intensive use of labour and import the commodity whose production requires the intensive use of capital. The basis of trade is the differences in relative factor endowments which lead to different relative commodity prices between the two nations.

Heckscher-Ohlin principle of comparative advantage has failed to explain the trade patterns in some circumstances. Leontief (1956) conducted an empirical test of the Heckscher-Ohlin theory by using United States data for 1947 and found that U.S.

import substitutes were about 30 per cent more capital intensive than U.S. exports. This result was opposite to what the Heckscher-Ohlin model predicts on the basis of relative factor endowments, because the U.S. is the most capital-abundant nation. This is the well-known "Leontief paradox". Some studies, including Kravis (1956), Kenen (1965), Keesing (1966) and Baldwin (1971) attempt to explain the Leontief paradox in terms of human capital which was completely ignored in Leontief's measure. However, recent empirical studies such as Leamer (1980), Stern and Maskus (1981) and Bowen, Leamer and Sveikauskas (1987) present conflicting results.

The finding of factor intensity reversal by Minhas (1962) has cast doubt on the accepted conclusion of the Heckscher-Ohlin international trade model. Factor intensity reversal occurs when there is a large difference in the elasticity of substitution between the factors used in the production of the two commodities. It is empirically possible for factor intensities to reverse themselves. For example, one commodity is forced to be labour intensive in the labour abundant nation and capital intensive in the capital abundant nation. In this situation, the Hechscher-Ohlin model fails to explain the pattern of trade as the two nations cannot possibly export the same commodity to each other. But Leontief (1964) and Ball (1966) argue that factor intensity reversals seem to be rare in the real world, and the Heckscher-Ohlin model is based on the assumption of two commodities, one of which is labour intensive and the other is capital intensive in both nations, which implies the absence of factor reversals.

3.3 Australia's Comparative Advantage in General

According to the theory of comparative advantage reviewed in the preceding sections, the pattern of specialisation in production and trade of a country is determined by its relative factor endowments. As Australia has an abundance of natural resources, its specialisation in production and exports have been overwhelmingly in primary products and minerals. To illustrate this point, percentage shares of different categories of merchandise exports and imports for the period 1965 to 1993 are shown in Table 3.1.

Table 3.1: Structure of Merchandise Exports and Imports, Australia, Selected Years During 1965-1993.

Percentage share of merchandise exports

Year	Fuels, minerals, metals	Other primary commodities	Machinery &Transport equipment	Other manufactured products	Textile& clothings	Total
1965	13	73	5	8	1	100
1970	28	53	5	13	1	100
1985	44	35	5	15	1	100
1986	40	38	5	16	1	100
1987	37	38	7	17	1	100
1988	37	38	7	17	1	100
1989	32	35	5	27	1	100
1990	34	29	6	30	1	100
1991	36	29	6	28	1	100
1992	36	29	6	28	1	100
1993	36	29	6	28	1	100

Percentage share of merchandise imports

Year	Foods	Fuels	Other primary commodities	Machinery & Transport equipment	Other manufactured products	Total
1965	5	8	10	36	41	100
1970	5	5	7	41	42	100
1985	5	7	4	42	42	100
1986	5	5	4	42	44	100
1987	5	5	4	39	47	100
1988	5	5	4	39	47	100
1989	5	5	4	45	41	100
1990	5	5	4	42	44	100
1991	5	6	3	40	46	100
1992	5	6	3	40	46	100
1993	5	6	3	43	43	100

Source: World Bank (various years), World Development Report.

It is not surprising that Australia's exports are primarily natural resource intensive commodities such as fuels, minerals, metals and other primary products, while its imports are largely human capital intensive and technology intensive commodities such as machinery and transport equipment and other manufactured products.

A more precise indication of Australia's comparative advantage can be obtained by comparing trade specialisation indexes of Australia's merchandise trade in separate sectors: primary and manufactured products. This indicator is expressed in terms of the ratio of net sectoral trade over the sum of sectoral exports and imports. Formally, the trade specialisation index (TSI) is as follows:

$$TSI_{ij} = (X_{ij} - M_{ij}) / (X_{ij} + M_{ij}) \tag{3.6}$$

where, X_{ij} = exports of commodity i by country j,

M_{ij} = imports of commodity i by country j.

The trade specialisation index takes a value between minus one and plus one. A positive value of TSI indicates that a country specialises in the production of commodity i, and is a net-exporter of that commodity. Thus, the country seems to have comparative advantage in the trade of commodity i. In contrast, if the value of TSI is negative, the country appears to have a comparative disadvantage in the trade of commodity i, and is a net-importer of commodity i.

Table 3.2 shows that the trade specialisation indexes for Australia's primary products are positive, suggesting that there have been a higher volume of exports relative to imports, and a trade surplus in this sector. On the other hand, the trade specialisation indexes for manufactures are negative, indicating that Australia has experienced a trade deficit in manufactures. This suggests that Australia has a strong comparative advantage in primary products and a comparative disadvantage in most manufactured products which are capital- and knowledge-intensive.[2]

Table 3.2: Index of Trade Specialisation, Australia, Selected Years During 1980-1994.

Year	Primary products	Manufactures
1980	0.54	-0.59
1982	0.55	-0.57
1985	0.68	-0.64
1988	0.66	-0.57
1990	0.66	-0.49
1992	0.64	-0.48
1994	0.62	-0.48

Source: Estimates compiled using data from Department of Foreign Affairs and Trade (1994a, 1994b).

3.4 Australia's Comparative Advantage in Pharmaceuticals

3.4.1 Trade Specialisation Index for Pharmaceuticals

The trade specialisation index in equation (3.6) is used to measure Australia's comparative advantage in pharmaceuticals. It is clear from Table 3.3 that the TSI for Australia's pharmaceuticals is negative, indicating Australia is a net-importer of pharmaceutical products. Despite the imbalance between exports and imports of Australia's pharmaceuticals, the negative value of TSI has increased in absolute magnitude for 1980 to 1987, but subsequently decreased since 1988, perhaps reflecting the impact of the Factor (f) scheme on pharmaceutical exports, and Australia becoming more involved in intra-industry trade in pharmaceuticals.

[2] Detailed discussions on Australia's comparative advantage can be found in Krause (1984:275-287), Anderson (1995:33-36) and Anderson and Findlay (1995:74-90).

Table 3.3: Index of Trade Specialisation for Australia's Pharmaceuticals, 1979-1996

Year	Exports (A$million)	Imports (A$million)	Trade Specialisation Index (TSI)
1979	70.19	152.37	-0.37
1980	81.73	141.04	-0.27
1981	88.45	155.30	-0.27
1982	108.42	193.36	-0.28
1983	118.67	221.26	-0.30
1984	122.27	293.81	-0.41
1985	147.48	393.04	-0.45
1986	166.31	507.94	-0.51
1987	204.99	646.74	-0.52
1988	232.89	693.84	-0.50
1989	270.47	819.90	-0.50
1990	320.62	942.41	-0.49
1991	456.33	1,052.63	-0.39
1992	564.37	1,392.69	-0.42
1993	637.00	1,393.00	-0.37
1994	770.00	1,560.00	-0.34
1995	835.00	1,689.00	-0.34
1996	939.00	1,936.00	-0.35

Source: Estimates compiled using data from ABS, cat. no. 5422.0, 5424.0 and 5426.0.

3.4.2 Export Propensity

The export propensity index (EPI_p) for Australia's pharmaceutical industry is defined as the percentage ratio of the exports of Australia's pharmaceuticals, divided by domestic production of pharmaceuticals, that is:

$$EPI_p = (X_p / D_p) * 100 \qquad (3.7)$$

where, X_p = exports of Australia's pharmaceuticals,

D_p = total domestic output of pharmaceuticals in Australia.

Since individual pharmaceutical firms or the industry as a whole do not publish or disclose domestic sales and production of pharmaceuticals, total domestic sales of Australia's pharmaceuticals are estimated here from human-use pharmaceutical sales (see Table 2.6, Chapter 2). The total domestic production is calculated as follows

$$D_p = DS_p + (X_p - M_p) \quad (3.8)$$

where, DS_p = total domestic sales of pharmaceuticals,

M_p = imports of pharmaceuticals by Australia.

As shown in Table 3.4, export propensity of the Australia's pharmaceutical industry continued to rise during 1987-1990, but declined in 1993. This is due to a rapid increase in domestic pharmaceutical production in Australia. Between 1990 and 1993, pharmaceutical production in Australia has increased by more than 100 per cent both in the prescription and OTC markets, resulting in a substantial growth in domestic sales of pharmaceuticals produced in Australia.

Table 3.4: Export Propensity of Australia's Pharmaceutical Industry, Selected Years During 1987-1993.

Year	X_p (A$ million)	D_p (A$ million)	Export propensity (EPI)
1987	204.99	823.05	24.91
1990	320.62	1,107.41	28.95
1993	637.00	3,004.00	21.20

Source : Estimates compiled from ABS data, cat. no.5422.0, 5424.0, 5426.0 and data presented in Table 2.6, all values are current prices.

3.4.3 Import Penetration

The import penetration ratio is an indicator of international competition faced by domestic industry. The import penetration index (MP_p) for Australia's pharmaceutical industry is defined as the percentage ratio of pharmaceutical imports, divided by apparent consumption (total domestic sales) of Australia's pharmaceuticals, that is

$$MP_p = (M_p \ / \ DS_p) * 100 \qquad (3.9)$$

The results presented in Table 3.5 show that the import penetration ratio of pharmaceuticals has slightly increased for the period 1987 to 1990, but fell sharply to 37.0 per cent in 1993. The decline of the ratio in 1993 is due mainly to a rapid growth of total domestic consumption of pharmaceuticals in Australia during the period 1990-1993.

Table 3.5: Import Penetration of Australia's Pharmaceuticals, Selected Years During 1987-1993

Year	M_p (A$ million)	DS_p (A$ million)	Import penetration (MP)
1987	646.74	1.264.80	51.10
1990	942.41	1,729.20	54.50
1993	1,393.00	3,760.00	37.00

Source : Estimates compiled from ABS data, cat. no.5422.0, 5424.0, 5426.0 and data given in Table 2.6, all values are current prices.

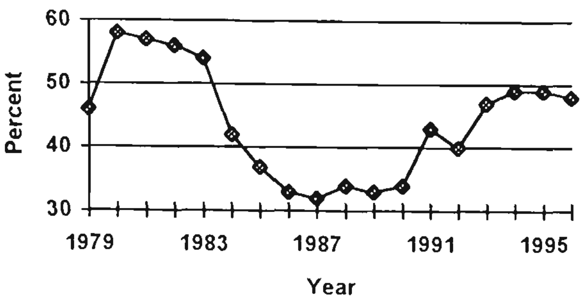
3.4.4 Export/Import Ratio

To identify the competitiveness of Australia's pharmaceutical trade, a ratio of exports to imports is calculated.[3] Figure 3.1 and Table 3.6 reveal that Australia's pharmaceutical export/import ratio declines steadily from 58 per cent in 1980 to 33 per cent in 1989. This may be due to the policy reform, at the beginning of the 1970s, towards a reduction in Australia's protection (Sheehan et al, 1994:6-7; Pomfret, 1995:1-6). However, between 1990 and 1996 the ratio rebounds to almost 50 per cent, indicating a remarkable increase in Australia's competitiveness in pharmaceuticals from 1990 onwards. The acceleration of Australia's competitiveness

[3]The export/import ratio was first employed in the work of Verdoorn (1960) to examine changing trade pattern within the Benelux union.

in pharmaceuticals during the 1990s seems to reflect the influence of industry policy, particularly the Factor (f) scheme, on Australia's pharmaceutical exports.

Figure 3.1: Export/Import Ratio for Australia's Pharmaceuticals, 1979-1996.



Source: Data compiled from ABS, cat.no. 5422.0, 5424.0 and 5426.0.

Table 3.6: Export/Import Ratio for Australia's Pharmaceuticals, 1979-1996.

Year	Export/Import ratio (%)
1979	46
1980	58
1981	57
1982	56
1983	54
1984	42
1985	37
1986	33
1987	32
1988	34
1989	33
1990	34
1991	43
1992	40
1993	47
1994	49
1995	49
1996	48

Source: Data compiled from ABS, cat. no. 5422.0, 5424.0 and 5426.0

3.4.5 Revealed Comparative Advantage

3.4.5.1 Balassa's Index of Revealed Comparative Advantage

In theory, comparative advantage is based on pre-trade relative prices, while post-trade relative prices are observed in the real world. To measure the extent of comparative advantage in the real world, Balassa (1965) developed the index of revealed comparative advantage (RCA) which refers to the ratio of export share held by a country over the world export share, for a particular commodity. That is:

$$RCA_{ij} = (X_{ij} / X_j) / (X_{iw} / X_w) \qquad (3.10)$$

where, RCA_{ij} = Balassa's revealed comparative advantage index

X_{ij} = exports of commodity i by country j

X_j = exports of all commodities by country j

X_{iw} = exports of commodity i by all countries in the world

X_w = exports of all commodities by all countries in the world.

The value of the index which is less than one occurs when the commodity's share in a country's exports is less than its share in world trade. This indicates that the country has a revealed comparative disadvantage in the trade of that commodity. On the other hand, if the ratio is greater than one, the country has a revealed comparative advantage in the trade of that commodity. Balassa's index of revealed comparative advantage has been employed in the work of Yamazawa (1970; 1971), Kojima (1970), Roemer (1977), Hillman (1980), Yeats (1985), and Son and Wilson (1995). However, the limitations of this index have been pointed out by some authors. Bowen (1983) argues that this index takes into account exports only, whereas the main concept of comparative advantage should be properly based upon both exports and imports. Yeats (1985), on the other hand, criticises Balassa's index of revealed comparative advantage for failing to serve as either a reliable cardinal or ordinal measure of a country's revealed comparative advantage. This view is strongly supported by Ballance et al. (1987) who confirm that there is a high inconsistency of using revealed comparative advantage indexes as a cardinal or ordinal measure.

3.4.5.2 Revealed Comparative Advantage in Pharmaceuticals

Medical and pharmaceutical products are classified as SITC 541, by the United Nations.[4] Trade data from ten pharmaceutical exporting countries including Australia, Belgium, France, Germany, Italy, Japan, the Netherlands, Switzerland, the U.K. and the U.S. are used in the analysis in this section, for SITC 541. Balassa's revealed comparative advantage index is used as an empirical measure to examine the degree of revealed comparative advantage in pharmaceuticals for each of these countries.

At the time of the analysis, a complete series of data for all the countries was available only for the period 1975 to 1992. Therefore, the ensuing analysis is confined to the selected years in this period. The data series used in the analysis are given in Appendix 3.1.

The results presented in Table 3.7 indicate that the countries with a relatively high degree of revealed comparative advantage in pharmaceuticals are Belgium, France, Germany, Italy, the Netherlands, Switzerland, the U.K. and the U.S. The RCA index for these countries is greater than one. On the other hand, the pharmaceutical importing countries such as Australia and Japan have the RCA indexes less than one. Specifically, Table 3.7 shows that Switzerland has the highest revealed comparative advantage indexes. This result implies that Switzerland has a high export share which exceeds its share in the total world exports. A similar

[4] Medical and pharmaceutical products (SITC 541) is equivalent to SITC 54 classification used by the Australian Department of Foreign Affairs and Trade (DFAT).

explanation can be applied to other exporting countries such as Germany, France, the U.K. and the U.S. On the other hand, Australia has a RCA index which is less than one, reflecting the lower export share of pharmaceuticals than the total world exports. This confirms that Australia has a revealed comparative disadvantage in pharmaceuticals.

Table 3.7: Revealed Comparative Advantage Indexes of Australia and Major Exporting Countries, Selected Years During 1977-1992. SITC 541: Medical and Pharmaceutical Products

Country	1977	1982	1987	1992
Australia	0.51	0.51	0.40	0.49
Belgium	1.49	1.49	1.34	1.52
France	1.62	1.87	1.65	1.53
Germany	1.58	1.51	1.42	1.27
Italy	1.44	1.19	1.05	1.02
Japan	0.31	0.27	0.26	0.29
Netherlands	1.35	1.08	1.16	0.96
Switzerland	8.05	7.59	6.81	6.81
U.K.	2.40	2.23	2.09	2.03
U.S.	1.27	1.43	1.37	1.89

Source: Estimates compiled using data from United Nations (various years), International Trade Statistics Yearbook.

3.4.6 Vollrath's Indexes of Revealed Competitive Advantage: An Application for Australia's Pharmaceuticals

In this section, United Nations data are used to investigate revealed competitive advantage in pharmaceuticals (SITC 541) for Australia and other exporting countries. At the time of the analysis, a complete series of data for pharmaceutical exports and imports were available for the period 1975-1992. Thus, the ensuing analysis is confined to the selected years in this period. The measures used in this analysis are based on Vollrath (1991), which expresses revealed competitive advantage in terms of three measurements, namely, relative trade advantage (RTA), relative export advantage (REA) and revealed competitiveness (RC). Following Vollrath, the three measurements are written as follows:

$$RTA_{ia} = (X_{ia} / X_{in}) / (X_{ra} / X_{rn}) - (M_{ia} / M_{in}) / (M_{ra} / M_{rn}) \quad (3.11)$$

$$REA_{ia} = \ln (X_{ia} / X_{in}) / (X_{ra} / X_{rn}) \quad (3.12)$$

$$RC_{ia} = \ln (X_{ia} / X_{in}) / (X_{ra} / X_{rn}) - \ln (M_{ia} / M_{in}) / (M_{ra} / M_{rn}) \quad (3.13)$$

where, RTA_{ia} = relative trade advantage of country i in commodity a,

REA_{ia} = relative export advantage of country i in commodity a,

RC_{ia} = revealed competitiveness of country i in commodity a,

X_{ia} = exports of commodity a, by country i,

M_{ia} = imports of commodity a, by country i,

X_{in} = exports of all commodities excluding commodity a, by country i,

M_{in} = imports of all commodities excluding commodity a, by country i,

X_{ra} = exports of commodity a, by all countries in the world excluding country i,

M_{ra} = imports of commodity a, by all countries in the world excluding country i,

X_{rn} = exports of all commodities excluding commodity a, by all countries in the world excluding country i,

M_{rn} = imports of all commodities excluding commodity a, by all countries in the world excluding country i,

r = the world minus country i,

n = all traded commodities minus commodity a.

All three indexes of revealed competitive advantage given above eliminate country and commodity double counting in world trade as they embody a country's pharmaceutical export (or import) share over all traded commodities other than pharmaceutical products. Furthermore, RTA and RC also encompass both export and import sides which are more consistent with the real world trade. A positive value of RTA, REA or RC indicates a competitive advantage, while a negative value indicates a competitive disadvantage.

Results presented in Table 3.8 indicate that Australia and Japan have negative values for all three indexes; that is, RTA, REA and RC. Thus, Australia and Japan have a competitive disadvantage in medical and pharmaceutical products. The negative values of RTA and RC indexes for Australia and Japan also show that they experience trade deficits in these products. On the export side, both Australia and Japan also have negative values of REA, reflecting a small export share of pharmaceutical products over the total world exports.

Based on the estimates of Balassa's revealed comparative advantage index and Vollrath's revealed competitive advantage indexes, it is concluded that Australia has a high degree of comparative disadvantage in pharmaceutical products.

Table 3.8: Vollrath's Revealed Competitive Advantage Indexes for Medical and Pharmaceutical Products (SITC 541): Selected Years During 1978-1990.

Country	RTA_{ia}			
	1978	1982	1986	1990
Australia	-0.70	-0.46	-0.80	-1.03
Belgium	0.09	0.34	0.25	0.06
France	0.77	1.21	0.88	0.48
Germany	0.53	0.64	0.45	0.86
Italy	0.05	0.21	-0.35	-0.64
Japan	-1.06	-0.97	-1.25	-0.78
Netherlands	0.23	0.94	-0.08	-0.12
Switzerland	6.98	6.61	5.48	4.59
U.K.	1.90	1.56	1.52	1.05
U.S.	0.94	1.08	1.07	0.45

Country	REA_{ia}			
	1978	1982	1986	1990
Australia	-0.59	-0.67	-0.82	-0.83
Belgium	0.36	0.41	0.32	0.09
France	0.45	0.67	0.57	0.34
Germany	0.42	0.46	0.40	0.96
Italy	0.17	0.19	0.11	-0.37
Japan	-1.30	-1.34	-1.44	-1.49
Netherlands	0.23	0.08	0.08	-0.20
Switzerland	2.15	2.13	1.99	1.77
U.K.	0.92	0.87	0.85	0.58
U.S.	0.33	0.41	0.47	-0.20

Country	RC_{ia}			
	1978	1982	1986	1990
Australia	-0.81	-0.64	-1.04	-1.21
Belgium	0.06	0.25	0.02	0.05
France	0.67	0.96	0.69	0.42
Germany	0.42	0.51	0.36	0.39
Italy	0.04	0.19	-0.27	0.65
Japan	-1.59	-1.55	-1.84	-1.49
Netherlands	0.20	0.09	-0.07	0.14
Switzerland	1.67	1.54	1.36	1.53
U.K.	1.43	1.06	1.04	0.89
U.S.	1.12	1.26	1.10	0.81

Source: Estimates compiled using data from United Nations (various years).

3.5 Conclusion

This chapter has been concerned with an analysis of Australia's comparative advantage in pharmaceuticals. The measures of the trade specialisation index, export propensity, import penetration and export/import ratio were used as indicators of Australia's comparative advantage in pharmaceuticals. Balassa's revealed comparative advantage index and Vollrath's revealed competitive advantage indexes were calculated in order to examine the revealed comparative advantage in pharmaceuticals.

The results based on the trade specialisation index, export propensity, import penetration, and export/import ratio indicate that Australia is a net-importer of pharmaceutical products. The propensity to export and import penetration of the Australian pharmaceutical industry have slightly declined between 1990 and 1993, resulting from a substantial growth in domestic consumption of pharmaceuticals produced in Australia during the period 1990 to 1993. In terms of competitiveness, the export/import ratio of Australia's pharmaceuticals has increased since the 1990s, indicating the impact of policy reform, particularly the Factor (f) scheme on Australia's pharmaceutical exports.

The analyses based on both Balassa's revealed comparative advantage index and Vollrath's revealed competitive advantage indexes suggest that, among the pharmaceutical exporting countries, Australia has a high degree of revealed comparative disadvantage in pharmaceutical products.

Australia mainly exports primary products in which it has a comparative advantage, in exchange for high value-added manufactures in which it has a comparative disadvantage. However, as explained in Chapter 2, in recent years, the changing pattern of world trade in pharmaceuticals and Australia's trade and industrial policies have encouraged Australia to export increasing volumes of some pharmaceutical products, while importing some other types of pharmaceutical products at the same time. This means that there is two-way trade (intra-industry trade) in pharmaceuticals.

It is clear that Australia's two-way trade in pharmaceuticals (simultaneous exports and imports) cannot be explained by the principle of comparative advantage. The two-way trade, or intra-industry trade, is based on economies of scale, product differentiation and imperfect competition. The extent and determinants of Australia's intra-industry trade in pharmaceuticals are analysed in Chapter 5 and 6. Before analysing intra-industry trade, however, separate analyses of export supply, export demand and import demand for pharmaceuticals in Australia are presented in Chapter 4.

CHAPTER 4

EXPORT SUPPLY, EXPORT DEMAND, AND IMPORT DEMAND FOR PHRAMACEUTICALS

4.1 Introduction

As explained in Chapter 2, Australia's trade in pharmaceuticals has grown rapidly during the last two decades, resulting mainly from the changes in world demand and Australia's trade and industry policies. However, there have been no systematic empirical studies undertaken so far to investigate the determinants of export supply of and export demand for Australian pharmaceuticals, and import demand for pharmaceuticals by Australia. Houthakker and Magee (1969) point out that the direction of the trade balance for a particular country over time depends upon the country's income and price elasticities of demand for imports and exports. Thus, it is important to analyse the effects of, and estimate elasticities with respect to, relative prices, income and other variables for Australia's pharmaceutical exports and imports. Therefore, the purpose of this chapter is to develop and estimate separate models of export supply of and export demand for Australian pharmaceuticals, and import demand for pharmaceuticals by Australia.

The chapter begins with a review of empirical studies on the determinants of export supply, export demand and import demand in Section 4.2. Models to be used for the econometric estimation of export supply, export demand and import demand for pharmaceuticals are developed in Section 4.3. In Section 4.4, the variables used in the econometric analysis, data, and sources of data are described. Econometric methodology, with emphasis on the analysis of time series properties of data, particularly in relation to stationarity and cointegration, is discussed in Section 4.5. Results of the analysis are presented and discussed in Section 4.6. Major findings are summarised in the concluding section.

4.2 Review of Literature on the Determinants of Exports and Imports

In empirical work, the determinants of exports and imports have been analysed separately, through the use of econometric estimation. Empirical studies of exports have concentrated on the formulation and estimation of demand relationships for exports. Thus, in the work of Goldstein and Khan (1978; 1985), Arize (1987), Koshal et al. (1992), Bullock et al. (1993) and Warr and Wollmer (1996), the quantity of exports of a particular commodity is regarded as a function of relative prices and foreign income, that is:

$$X_{ij} = f(PX_{ij}/PXW_i,\ YW) \qquad (4.1)$$

where, X_{ij} = quantity of country j's exports of commodity i,

PX_{ij} = price of country j's exports of commodity i,

PXW_i = price of exports of commodity i in the rest of the world,

YW = total income of country j's trading partners.

In fact, this is a model of demand for country j's exports by foreign countries. However, according to Bullock et al. (1993), exports depend not only on relative prices and the world income, but also on other factors such as the exchange rate, domestic demand, and trade protection. Thus, Bullock et al. (1993) included variables that affect both export demand and export supply together in one equation. Grimes (1993), however, argues that the models of export supply and export demand should be estimated separately, in order to correctly obtain separate structural estimates of export supply and export demand.

A number of previous empirical studies has concentrated on the impact of relative prices on the quantity of export supply. The quantity of a country's export supply for a particular commodity is modelled as a function of relative prices and production capacity in the long run, that is:

$$X_{ij} = f(\, PX_{ij}/PD_{ij},\ \ TIME) \qquad (4.2)$$

where, X_{ij} = quantity of country j's exports of commodity i,

PX_{ij} = price of country j's exports of commodity i,

PD_{ij} = domestic price of commodity i,

TIME = time trend variable representing the production capacity in the long run.

This model has been employed in the studies of Arize and Afifi (1987), Koshal et al. (1992) and Gunawardana et al. (1995).

On the import side, the volume of a country's imports is usually modelled as a function of the price of imports relative to domestic prices, and the level of national income. Thus, a model of a country's imports is specified in equation (4.3) below:

$$M_{ij} = f(PM_{ij}/PD_{ij},\ Y_j) \tag{4.3}$$

where, M_{ij} = quantity of country j's imports of commodity i,

PM_{ij} = price of country j's imports of commodity i,

PD_{ij} = domestic price of commodity i,

Y_j = national income of country j.

A number of empirical studies on international trade flows has focused on the impact of prices on import volume (Haynes and Stone, 1983; Thursby and Thursby, 1984; Arize and Afifi, 1987; and Thursby, 1988). Haynes and Stone (1983) and Warner and Kreinin (1983) use the relative price based on domestic wholesale price index as a proxy. However, Menon (1995) argues that this index suffers from several deficiencies as it includes some non-tradeable goods and refers to list prices rather than transaction prices. To overcome these problems, the studies of Athukorala and Menon (1995) and Menon (1995) employ the relative price which is derived by dividing the tariff- augmented import price by the price of the domestic competing commodity.

A recent study by Dwyer et al. (1994) examines the "pass-through effect" of changes in the exchange rate upon the domestic price of exported and imported goods. The study confirms that exchange rate changes pass-through to import prices more rapidly than to export prices. Although literature on the pass-through effect is not extensive, research has generated several findings. Menon (1992) reports that the pass-through effect is incomplete[1] for most of Australian manufactured products, and that there are differences in the degree of exchange rate pass-through across products. Athukorala and Menon (1993) investigate the exchange rate pass-through effect for Japanese trade flows, and find evidence of incomplete pass-through to Japanese exports.

Wilkinson (1992) estimates the demand for Australia's imports as a function of the relative prices of importables, exportables and non-traded goods, real income and production capacity in the Australian economy. The study differs from most earlier studies of import demand as it separately estimates short-run and long-run elasticities of price and income. The results show that both domestic activity in terms of national expenditures and the relative price of imports are the major contributors to variations in imports. However, the contribution of relative price is found to be more important than that of domestic activity.

Although economic theories of international trade provide no guidance as to the appropriate functional form in the estimation of export supply, export demand and import demand functions, there are several studies addressing the issue of functional form for estimation in terms of either linear or log-log formulations (Krenin, 1967; Houthakker and Magee, 1969; Leamer and Stern, 1970). The choice between these two forms has been suggested by Khan and Ross (1975) that a linear relationship is convenient in a forecasting study, while a log-log form is preferable in

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[1]Incomplete pass-through refers to a non-responsiveness of prices of traded goods to exchange rate changes. Such rigidity could lead to insensitive trade flows, although demand is highly elastic (Menon, 1992: 2).

a study which allows the dependent variable to respond to a rise or fall in the explanatory variables over time.

4.3 The Models

In this thesis, Australia's exports and imports of pharmaceuticals and their determinants are analysed through the estimation of three separate functions: an export supply function, an export demand function, and an import demand function.

4.3.1 Australia's Export Supply Function for Pharmaceuticals

Following the previous studies on export supply (Arize and Afifi, 1987; Koshal et al., 1992; and Gunawardana et al., 1995), Australia's pharmaceutical export supply (EXPT) is hypothesised to depend primarily upon relative prices of exports (AREEXP) and production capacity (TIME). In addition, a dummy variable, D, is included to account for the impact of the Factor (f) scheme on pharmaceutical exports since 1988, the year in which the scheme was introduced. This scheme is expected to enhance Australia's export activities by providing assistance to pharmaceutical exporters in the form of export incentives (see Chapter 2). Thus, the model of export supply can be specified as:

$$EXPT_t = f(\, AREEXP_t, TIME, D\,) \qquad (4.4)$$

where, $EXPT_t$ is the real exports of pharmaceuticals which are derived by deflating Australia's pharmaceutical exports in current dollars by the gross domestic product (GDP) deflator, TIME is the time trend variable included as a proxy for long run changes in production capacity, and D is the dummy variable for the Factor (f) scheme; D is zero for 1975-87 and is one for 1988-92.

Due to the absence of data for price indexes of Australia's pharmaceuticals, the price indexes of "chemical and related products" (Australian Export Commodity Classification, AECC, section 5) are used to construct the relative price indexes for Australia's pharmaceutical exports. The relative price of Australia's pharmaceutical exports ($AREEXP_t$) is calculated as the percentage ratio of export price index to domestic price index of Australia's chemical and other chemical products (ASIC 275-276). That is:

$$AREEXPt = (APX_t / PD_t) * 100 \qquad (4.5)$$

Here, APX_t is an adjusted export price index of Australia's chemical and related products, and PD_t is a domestic price index of Australia's chemical and other chemical products.

As suggested in Gunawardana et al. (1995: 249), the export price should be adjusted if the commodities are subject to export subsidies and taxes. Thus, to take account of the effects of government assistance, the adjusted export price index (APX_t) is derived using the following formula:

$$APX_t = PX_t * (1 + ERA_t) \qquad (4.6)$$

where PX_t is the export price index of Australia's chemical and related products (AECC, section 5) and ERA_t is the average effective rate of assistance to Australia's chemical, petroleum and coal products (ASIC 27). The empirical equation for the estimation of model (4.4) is specified in log-log form, as follows:

$$LEXPT_t = L\alpha_0 + \alpha_1 LAREEXP_t + \alpha_2 TIME + \alpha_3 D + \varepsilon_t \qquad (4.7)$$

The prefix "L" indicates logarithm of the variables, α_o is the intercept, α_1 and α_2 are the slope coefficients, α_3 is an intercept shifter, and ε_t is an error term. α_1 is expected to be positive because an increase in export price relative to domestic price will induce Australian manufacturers to supply pharmaceuticals overseas instead of supplying to the domestic market. α_2 and α_3 are also expected to be positive, as an expansion of the long run production capacity (through improvements in technology, infrastructure development and R&D), and the Factor (f) schem will increase exports of Australia's pharmaceuticals.

4.3.2 Foreign Demand Function for Australia's Pharmaceutical Exports

From the foreign countries' point of view, their demand function for Australia's pharmaceutical exports is specified as:

$$EXPT_t = f(AREX_t, GDPW_t) \qquad (4.8)$$

where, $AREX_t$ = Price of Australia's pharmaceutical exports relative to competitors' export price.

$GDPW_t$ = Total real GDP of major countries importing pharmaceuticals from Australia (New Zealand, the U.K., the U.S., France, Japan, Korea, Indonesia, Malaysia, the Philippines and Thailand).

The relative price of pharmaceutical exports ($AREX_t$) is calculated as the percentage ratio of Australia's adjusted export price index (APX_t) to the weighted average price index of manufactured exports of Australia's competing countries (PXW_t), as shown in the following formula:

$$AREX_t = (APX_t / PXW_t) * 100 \tag{4.9}$$

Here, PXW_t is calculated as follows:

$$PXW_t = \frac{\sum_{i=1}^{n} (Q_i * U_i)}{\sum_{i=1}^{n} Q_i} \tag{4.10}$$

where Q_i = volume index of manufactured exports of competing country i.

U_i = unit value index of manufactured exports of competing country i.

i = 1, 2, 3,............., 8 (Australia's competing countries consist of eight major pharmaceutical exporting countries; Belgium, France, Germany, Italy, the Netherlands, Switzerland, the U.K. and the U.S.).

The following log-log form is specified to estimate the foreign demand function for Australia's pharmaceutical exports:

$$LEXPT_t = L\beta_o + \beta_1 LAREX_t + \beta_2 LGDPW_t + u_t \qquad (4.11)$$

where β_o is the intercept term, β_1 and β_2 are the slope coefficients of relative price of exports and income variables, respectively, and u_t is an error term. β_1 is expected to be negative, as Australia's export price relative to competing countries' export price increases, foreign countries will substitute competing countries' pharmaceuticals for Australian pharmaceuticals. β_2 is expected to be positive, as an increase in income of countries that import from Australia will increase the demand for Australia's pharmaceuticals.

4.3.3 Australia's Import Demand Function for Pharmaceuticals

Australia's import demand for pharmaceuticals is hypothesised to depend on three explanatory variables: price of imports relative to domestic price, Australia's national income (Australia's GDP), and the extent of trade liberalisation. Thus, the model of Australia's import demand for pharmaceuticals is specified as:

$$IMPT_t = f\,(RIMP_t,\ GDPA_t, DTL) \qquad (4.12)$$

where, $IMPT_t$ is the real imports of pharmaceuticals which are derived by deflating Australia's pharmaceutical imports in current prices by the import price index (IMP_t) of Australia's chemical and related products (Australian Import

Commodity Classification, AICC, section 5), $RIMP_t$ is the relative price of imports, $GDPA_t$ is Australia's real GDP, and DTL is the dummy variable for trade liberalisation of Australia's chemical and related products. Due to a substantial increase in the extent of trade liberalisation for Australia's chemical and related products since 1989, DTL is specified as zero for 1975-88 and as one for 1989-92. As the data for import price index of Australia's pharmaceuticals are not available, $RIMP_t$ is calculated as the ratio of import price index (IMP_t) of Australia's chemical and related products (AICC, section 5) to domestic price index (PD_t) of Australia's chemical and other chemical products (ASIC 275-276). All Australian import duties are excluded from the import price index according to the ABS. Therefore, the relative price of imports ($RIMP_t$) is derived using the following formula:

$$RIMP_t = (IMP_t / PD_t) * 100 \qquad (4.13)$$

Australia's import demand function for pharmaceuticals with the dummy variable for trade liberalisation is specified in log-log form as:

$$LIMPT_t = L\gamma_o + \gamma_1 LRIMP_t + \gamma_2 LGDPA_t + \gamma_3 DTL + \mu_t \qquad (4.14)$$

where, γ_0 is the intercept, γ_1 and γ_2 are the slope coefficients, γ_3 is an intercept shifter, and μ_t is the error term. It is expected that the relative price of imports ($LRIMP_t$) has an inverse relationship with Australia's pharmaceutical imports ($LIMPT_t$), as an increase in import price relative to domestic price will result in a decline of pharmaceutical imports. On the other hand, when Australia's national income ($LGDPA_t$) and the extent of trade liberalisation (DTL) increase, pharmaceutical imports by Australia will increase. Therefore, γ_1 is expected to be negative, γ_2 and γ_3 are expected to be positive.

4.4 Data and Sources

Data to be used in the estimation of export supply, export demand and import demand functions were collected from various sources, mainly the Australian Bureau of Statistics (ABS). The export and import data are reported in current values by the ABS. In the third version of the United Nations' Standard International Trade Classification (SITC, Revision 3), internationally traded manufactured commodities are classified by one-digit number from 0 to 9 as follows:

Section	Description
0	Food and live animals
1	Beverages and tobacco
2	Crude materials, except fuels
3	Mineral fuels, lubricants and related materials
4	Animal and vegetable oils, fats and waxes
5	Chemical and related products
6	Manufactured goods classified by material
7	Machinery and transport equipment
8	Miscellaneous manufactured articles
9	Commodities and transactions not classified elsewhere.

Each of these categories is disaggregated into a two-, three-, four-, or five-digit codes. Medical and pharmaceutical products are categorised as SITC 54, within the chemical and related products in SITC, section 5.

At the time of the analysis, a complete series of data for pharmaceutical exports and imports was available from the ABS (Foreign Trade, Australia, Merchandise Exports/Imports), only for the period from 1975 to 1992. Thus, export and import data used in this study are confined to this period.

To calculate the real values of exports and imports, the two-digit ABS trade data in current prices are converted into real values. The nominal exports for pharmaceuticals are deflated by using the gross domestic product (GDP) deflator, while the nominal imports for pharmaceuticals are converted into real imports by using the import price index of chemical and related products (AICC, section 5) as a deflator. The GDP for Australia and its trading partners and the GDP deflator were obtained from the World Bank, World Tables. Data for the import price index were collected from the ABS.

In the absence of data for price indexes of Australia's pharmaceuticals, we construct the relative prices of Australia's pharmaceutical exports and imports by using the export and import price indexes of chemical and related products (AECC, and AICC, section 5) and the domestic price index of chemical and other chemical products (ASIC 275-276), published by the ABS. Medical and pharmaceutical products are a sub-category of chemical and related products in all the above classifications. According to the ABS, the 1975-1989 trade data for export price index of chemical and related products are categorised in section 5 of AECC, while the 1990-1992 series are categorised under chemical and allied products in section 5 of Australian Harmonised Export Commodity Classification, AHECC. The ABS trade data for import price index date back to 1981 only.

The 1975-1980 series of import price index were obtained from the Statistical Bulletin of the Reserve Bank of Australia. The import price index of chemical and related products for 1981-1989 are categorised in section 5 of Australian Import Commodity Classification (AICC), while the 1990-1992 series are categorised in section 5 of SITC. All price indexes were adjusted to the common base year of 1980.

The weighted average export prices for Australia's competing countries were calculated by using the volume and unit price indexes of manufactured exports which are reported in the Yearbook of International Trade Statistics published by the United Nations.

The data series used in the estimation are given in Appendix 4.1. A description of data and their sources is provided in Appendix 4.2. Summary statistics of the data used in the estimation are presented in Appendix 4.3.

4.5 Econometric Methodology

4.5.1 Nonstationary Time Series

A time series is a collection of sequential numerical data in which each item of the variable is associated with a particular instant in time. Time series can be classified as stationary when the mean, variance and covariance between any two values of the data series are constant over time. However, it is apparent that most economic time series data are nonstationary because they steadily grow over time. The use of nonstationary data can lead to misleading regressions which are known as "spurious regressions". Granger and Newbold (1974) describe spurious regressions as misleading least squares regressions of time series data which have high R^2 values and significant t-statistics, but the relationships are biased and not real.

The theoretical rationale for stationary time series is closely related to the characteristics of models with unit roots. Therefore, to test for stationarity of time series is to examine the presence of unit roots. For instance, consider the time series Y_t which is generated as the following trend stationary process:

$$Y_t = \gamma + \beta T + \varepsilon_t \tag{4.15}$$

where, γ is a constant, β is a coefficient of time trend (T) and ε_t is white noise error term. The subscript "t" indicates the time difference of the series (t = 1, 2,...., n). Alternatively, if the series is in difference form, Y_t is generated by the following process:

$$Y_t = \alpha Y_{t-1} + \varepsilon_t \tag{4.16}$$

where, α is the autoregression coefficient.

There is a large number of statistical procedures available in the literature for testing unit roots in time series data, including the Dickey-Pantula (1988) and Phillips-Perron (1988) tests.[2] However, one of the most commonly used is the test proposed by Dickey and Fuller (1979). In this thesis, three alternative tests, the

[2] A review of these tests can be found in Dolado et al. (1990).

Dickey-Fuller (DF), Augmented Dickey-Fuller (ADF) and Johansen tests are applied to test for the presence of unit roots in each series of data used in the econometric estimation.

The regression model of DF is based on testing the hypothesis in both trend stationary process and difference stationary process, which can be expressed as follows:

$$Y_t = \beta_0 + \beta_1 T + \beta_2 Y_{t-1} + u_t \tag{4.17}$$

where β_0, β_1 and β_2 are parameters. When β_1 equals zero and β_2 equals one, the regression model will revert to the difference stationary process in (4.16). If β_2 is equal to zero, the model is generated in a form of trend stationary process as in (4.15). The time series Y_t is said to have a unit root, or to be integrated at order one, I(1), if β_2 equals one. Under this condition, the usual t- and F-distribution tests are not appropriate for testing the null hypothesis. Therefore, Dickey and Fuller (1979) constructed the corrected tables of critical values for the asymptotic distributions of the *t*- and *F*-statistics.

The ADF test is based on the DF test, but is different in some respects, since it includes as many terms in the lagged dependent variable as are necessary to achieve residual whiteness. The ADF regression can be written as:

$$\Delta Y = \beta_0 + \beta_1 T + \beta_2 Y_{t-1} + \sum_{i=1}^{k} \beta_i \Delta Y_{t-i} + u_t \qquad (4.18)$$

where $\Delta Y_t = Y_t - Y_{t-1}$ and $\sum_{i=1}^{k} \beta_i \Delta Y_{t-i}$ represent the lagged terms, with the length of the lag structure k. The main purpose in adding these terms to the model is to allow for Autoregresssive Moving Average (ARMA) error processes, and to remove the effects of serial correlation in the residuals of the equation. The statistics of DF and ADF tests have asymptotically the same distribution, and therefore, the same significance tables can be used (Maddala, 1992:583-584).

In order to convert a nonstationary time series to the stationary form, the process of differencing by obtaining the change from one period to the next is applied to the model. If a nonstationary series is differenced d times before it becomes stationary, it is said to be integrated at order d, and is written as I(d). The integrated variable is derived from the presence of unit roots, that is I(d), or d unit roots. This approach has strong support from Box and Jenkins (1970), and Granger and Newbold (1974).

4.5.2 Cointegration

Granger (1981) introduced the theory of cointegration when two or more nonstationary time series data have the property that their linear combination is stationary over time. Suppose that each variable, Y_t and X_t, is integrated at order 1, or I(1), so that we can write the regression equation as follows:

$$Y_t = \beta X_t + u_t \qquad (4.19)$$

The variables Y_t and X_t are said to be cointegrated if the two series are integrated at the same order, and the cointegrating parameter (β) must exist such that $Y_t - \beta X_t = u_t = \mathrm{I}(0)$, or $(1, -\beta)$ as written in terms of the cointegrating vector. This approach suggests that, in the long-run, there is an equilibrium relationship between these two cointegrated series as they move closely and do not drift far apart from each other (Engle and Granger, 1987:253).

To test for the cointegration of time series, is to examine whether two or more variables have the property of linear combination over time, and are able to form a valid cointegrating vector; in other words, they are I(1). In this study, two different but most widely used methods are employed to test for cointegration, that is the Engle-Granger two-step procedure (EG) and Johansen maximum likelihood procedure.

4.5.2.1 Engle-Granger (EG) Two-Step Procedure

Engle and Granger (1987) proposed a two-step procedure for the testing of cointegration. First, the long-run relationship is estimated by regressing the variables in levels form. To explain this process, consider that equation (4.19) is estimated by the ordinary least squares (OLS) method.[3] The regression of Y_t on X_t is called the

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[3] In general, an intercept should be included in the estimation (Perman, 1991:14).

"cointegrating regression".[4] Second, the fitted residuals from this regression are used to test for cointegration.

Suppose that E is the term for fitted residuals from the cointegrating regression. To test for cointegration of variables Y_t and X_t , the residual terms can be generated using the following model:

$$E_t = \alpha_0 E_{t-1} + \varepsilon_t \tag{4.20}$$

The two variables Y_t and X_t are cointegrated if $|\alpha_0|$ is less than 1; in other words, E_t is stationary and integrated at order zero I(0). However, Y_t and X_t are not cointegrated if $|\alpha_0|$ is equal to 1, E_t will then be integrated at order one I(1) in the stationary differenced form. Therefore, to find the cointegration of these variables is to test whether E_t in equation (4.20) is close to I(0).

For the process of examining the cointegrating residuals of the regression, we apply the DF and ADF tests on the residuals, as suggested in Engle and Granger (1987). Furthermore, the Cointegrating Regression Durbin-Watson statistic (CRDW) is computed as a suggestive complement to the DF and ADF tests. The CRDW test was first introduced in the work of Sargan and Bhargava (1983) in order to test the CRDW statistic against a value of zero. If CRDW is close to zero, the lack of cointegration is suspected. On the other hand, if CRDW test is significantly positive, the two series are said to be cointegrated.

[4] The testing for cointegration by using regression is used, for example, in Phillips and Durlauf (1986), Stock (1987) and Gunawardana et al. (1995).

Although the EG two-step procedure is relatively simple and intuitive, the test suffers from some limitations. When more than two variables are included in the model, the EG procedure is not capable of demonstrating the uniqueness of the cointegrating vector. Furthermore, in a small-sample size, the OLS cointegrating regression is likely to lead to substantial bias.[5] However, Hatanaka (1996:200) suggests that the EG procedure is applicable only when the cointegration rank is at most 1, and the coefficient of the dependent variable (Y_t) is not zero. Thus, it can be normalised to 1. However, this test will show some defects when it is applied to the model with cointegrated vector autoregression.

4.5.2.2 Johansen Maximum Likelihood (ML) Procedure

The general idea of ML starts from calculating the probability of observed data by using a probability distribution, and then choosing the parameter estimates which maximise the probability of the observed data. Therefore, these parameter estimates are the maximum likelihood estimates of the unknown true parameter values. By applying this procedure to the model, all the variables are captured within the complete distribution of observations (Davidson and MacKinnon, 1993: 243-7; Griffiths et al., 1993: 93-4).

Johansen (1988) introduces a method based on the maximum likelihood approach to estimate all the distinct cointegrating relationships which may exist within a set of variables, and to construct a range of statistical tests. This procedure

[5] The shortcomings of the EG test are discussed in Banerjee et al. (1986), Stock (1987), Johansen (1988), Persaran and Persaran (1991: 166) and Menon (1995: 51).

parameterises an unrestricted vector autoregression (VAR) into the form of error correction representation which consists of a set of lagged differenced terms.

Suppose V_t is a vector autoregression in the levels of N variables. That is,

$$V_t = \Pi_1 V_{t-1} + \dots\dots\dots + \Pi_k V_{t-k} + e_t \qquad (4.21)$$

where Π_1 is a matrix of parameters (N x N). Equation (4.21) can be changed into an error correction model as,

$$\Delta V_t = \Gamma_1 \Delta V_{t-1} + \Gamma_2 \Delta V_{t-2} + \dots\dots\dots + \Gamma_k V_{t-k} + e_t \qquad (4.22)$$

where $\Gamma_i = -I + \Pi_1 + \dots\dots\dots + \Pi_i$, $i = 1, 2, 3, \dots\dots\dots, k$.

If k is the length of the lagged variable in the VAR, the matrix of VAR will have (N x k-1) different terms. Johansen uses the cannonical correlation method to estimate all the distinct combinations of the levels of V_t which are the cointegrating vectors, and estimates all of the distinct cointegrating vectors by using the ML method. Then, the eigenvalues are applied to construct a test of the number of cointegrating vectors in the model. This method provides the consistent distribution as it does not vary with the estimating model or other variable factors. Thus, it can overcome the drawbacks of the EG two-step test, particularly in the case of the DF tests for cointegration.

Hatanaka (1996) reviews a large number of empirical studies in the areas of economics and finance which use the method of Johansen ML, and concludes that "the major difficulties that one faces in applying the Johansen method are due to structural changes, not just in the deterministic trends but more seriously in the variance" (Hatanaka, 1996: 245-246). A comprehensive exposition of this test can be found in Harvey (1990), Cuthbertson et al. (1992) and Hatanaka (1996).

4.5.2.3 Error Correction Model

When a pair of variables are cointegrated, there is a *long-run* relationship between them, and the *short-run* dynamics can be described by the *error correction model* (ECM). This approach is known as the *Granger Representation Theorem*. The error correction model is very closely related to the concept of cointegration as it expresses a proportion of the disequilibrium in one period is corrected in the next period. The error correction model was first adopted by Sargan (1964) in a study of the relationship between wages and prices in the United Kingdom. Contributions in this area can also be found in the work of Davidson et al. (1978), Hendry (1984) and Sargan (1984).

The error correction model with lagged adjustment can be written in the following form:

$$\Delta Y_t = \beta_1 \Delta X_t + \beta_2 (X_{t-1} - Y_{t-1}) + u_t \qquad (4.23)$$

Δ denotes the change in a variable from period t-1 to t. β_1 and β_2 are the magnitudes of the dynamic adjustment coefficients. The term $(X_{t-1} - Y_{t-1})$ represents the short-run disequilibrium adjustment. Thus, equation (4.23) captures the short-run adjustment; on the other hand, it is guided by long-run theory. As described in Stock (1987), when two variables are cointegrated, the estimates of the long-run equilibrium parameter are considered "superconsistent" and "highly efficient". However, the process of adding lagged variables to overcome the problems of spurious regression should be undertaken with sufficient care. For example, Cuthbertson et al. (1992:133) point out that:

> "The danger with dynamic estimation is the very richness of the dynamic structure may make the residual process appear to be white noise in a small sample when in fact the levels terms do not cointegrate and the true process is nonstationary."

Furthermore, the process of eliminating trends in the model by adding lags to the variables will throw away potential valuable information in the long-run if the model is entirely in terms of differenced forms (Gilbert, 1986).

4.5.3. Estimation Procedure Used in this Analysis

The estimation procedure used in this analysis starts with testing the time series properties of the data by using the Dickey-Fuller, ADF and Johansen tests to gauge whether or not the variables in the models are stationary. If time series data are nonstationary, or have unit roots, the conventional regression procedure leads to the 'spurious regression problem', with biased coefficients and test statistics (Granger and Newbold, 1974; Phillips, 1986). If all the variables in a model are integrated in the same order, that is if all the variables are stationary either in level form [I(0)] or in first difference form [I(1)], then it is possible for the variables to be cointegrated. That is , a long run relationship, which is consistent over time, exists among variables in the model. To test for cointegration between two variables integrated in the same order, the Engle-Granger procedure may be used. When there are more than two variables integrated in the same order, the Johansen Maximum Likelihood cointegration procedure may be used.

When the cointegration between nonstationary data series exists, error correction models are estimated with data in differenced form. Following Engle and Granger (1987), the general form of the short run dynamic error correction model is specified as follows:

$$\Delta Y_t = \beta_0 + \sum_{i=0}^{n} (\beta_1 \Delta X_{t-1} + \beta_2 \Delta Y_{t-1}) + \beta_3 \mu_{t-1} + \varepsilon_t \tag{4.24}$$

where, μ_{t-1} is the error correction variable estimated by the residuals from the cointegration regression in (4.19) and ε_t is an error term. The existence of cointegration will be confirmed when the coefficient β_3 is significant.

In the absence of cointegration between nonstationary series, or when the cointegrating relationships cannot be identified, the alternative technique of the unrestricted error correction model (UECM) is employed to estimate the relationship between the independent and dependent variables in each model. The UECM is based on the LSE approach[6] which is known as the general-to-specific, or top-down methodology. This procedure to model building starts with a general dynamic model which is overparameterised, or in other words, has more lags than necessary. Then, the model is progressively simplified with respect to a series of diagnostic and statistical tests. These tests are: serial correlation test (Godfrey, 1978a; 1978b), Ramsey's RESET test for functional form (Ramsey, 1969), normality test (Jarque and Bera, 1980; Bera and Jarque, 1981), and heteroscedasticity test (White, 1980; 1982).

The general form of the UECM can be written as follows:

$$\Delta Y_t = \beta_0 + \sum_{i=0}^{n}(\beta_1 \Delta X_{t-i} + \beta_2 \Delta Y_{t-i}) + \sum_{i=0}^{n}(\beta_3 X_{t-1-i} + \beta_4 Y_{t-1-i}) + \varepsilon_t \qquad (4.25)$$

where, "Δ" indicates the difference operator and the subscript i refers to the length of the lag.

The UECM is estimated with different lag lengths for the right hand side variables ΔX, ΔY, X and Y. The preferred model is then chosen for each function according to the corresponding diagnostic tests. Long run elasticity of Y with respect to X is calculated as $-\beta_3 / \beta_4$. The variables ΔX, ΔY and X, Y represent the short run and long run relationships, respectively. This approach has been considered to be superior for small samples as it provides a unique insight to the short run dynamics

[6]This approach has been developed largely by members of the London School of Economics (LSE). See Cuthbertson et al. (1992: 98-106) and Maddala (1992: 494-496) for details.

and long run responses in the same model (Cuthbertson et al, 1992: 98-106). The UECM has been employed in the studies, for example, of Muscatelli and Hurn (1992), Menon (1992), Bullock et al. (1993), Athukorala and Menon (1994), and Gunawardana et al. (1995).

4.6 Results and Findings

4.6.1 Results of Tests for Unit Roots

The results of DF, ADF and Johansen tests for each of the variables are summarised in Appendix 4.4. From the Johansen test it is evident that, the variables LEXPT, LGDPW, LRIMP, and LGDPA are nonstationary in levels but become stationary after differencing once, at the 5 per cent significance level. On the other hand, the Johansen test confirms that the variables LAREEXP, LAREX and LIMPT are stationary in the levels form. The results of the DF and ADF tests are rather mixed and inconsistent.

As Johansen tests show, most of the variables are nonstationary. Thus, the modelling in levels form of data can lead to the problems of spurious regression as discussed in the previous section. Therefore, further investigation of cointegrating relationships between the variables is undertaken in the ensuing section.

4.6.2 Results of Tests for Cointegration

Having discovered that the variables LAREEXP and LAREX are integrated at order zero, and the other variables are integrated at order one, it is evident that the cointegrating relationships among the variables in the export supply and export demand functions do not exist.

In the import demand function, the variable LIMPT is integrated at order zero, and the other variables are integrated at order one. Thus, it is not possible for the variables to be cointegrated.

Therefore, it is concluded that there are no cointegrating relationships among the variables in the export supply, export demand and import demand functions.

4.6.3 Estimation Results of the Unrestricted Error Correction Models

The unrestricted error correction modelling (UECM) procedure is used in this section to obtain short run and long run relationships among variables in the models for Australia's exports and imports of pharmaceuticals. The estimates of Australia's export supply function, demand function for Australia's exports and Australia's import demand function are reported, together with the diagnostic statistics, in Table 4.1 to 4.5. In terms of serial correlation, functional form mis-specification, non-normality and heteroscedasticity, all functions show no evidence of these problems. Thus, the estimated models are statistically well-performed.

4.6.3.1 Australia's Export Supply Function for Pharmaceuticals[7]

The parsimonious estimates of the UECM of Australia's export supply function for pharmaceuticals, with Factor (f) dummy, are reported in Table 4.1.

[7]A preliminary version of the results for export supply and export demand functions were presented in Karn and Gunawardana (1996).

All the estimated coefficients, with the exception of that of the dummy variable, are significant at or above the 10 per cent level. Although the Factor (f) scheme appears to have a positive impact on export supply, it is statistically non-significant. Thus, in order to obtain an appropriate model for Australia's export supply function, the dummy variable is deleted from the estimation. The results of the variable deletion test show no statistical significance. The estimates of the preferred UECM of Australia's export supply function, without the Factor (f) dummy variable, are reported in Table 4.2.

In the estimated equation (4.27), the coefficient associated with the relative price variable in the difference form, $\Delta LAREEXP_{(t-2)}$, is significant at the 10 percent level. This indicates that, in the short run, there is a significant positive relationship between the relative price and Australia's pharmaceutical exports. If the relative price of exports increases, manufacturers would find the foreign markets more attractive and prefer to export pharmaceuticals instead of supplying to the domestic market, and therefore increase the quantity of export supplied. On the other hand, if the price of exports declines relative to the price in the domestic market, manufacturers may find it more profitable to supply pharmaceuticals to the domestic market instead of exporting, and thus reduce the quantity of export supplied.

The long run price elasticity of export supply is 0.95, indicating that, even in the long run, export supply of pharmaceuticals is not very responsive to the changes in relative price. This may be a result of a slow movement of information flow to Australian exporters regarding the changes in export price relative to the price in the

Table 4.1: Estimated UECM of Australia's Export Supply Function for Pharmaceuticals: with Factor (f) Dummy.

$$\Delta LEXPT_t = \underset{(-0.185)}{-0.146} + \underset{(1.967)^{*}}{0.239}\, \Delta LAREEXP_{(t-2)} + \underset{(3.296)^{**}}{0.546}\, LAREEXP_{(t-3)}$$

$$- \underset{(-2.308)^{**}}{0.664}\, LEXPT_{(t-1)} + \underset{(2.782)^{**}}{0.063}\, TIME + \underset{(1.119)}{0.088}\, D \qquad (4.26)$$

(Figures in parentheses are t-ratios: ***Significant at the 1 per cent level; **Significant at the 5 per cent level; *Significant at the 10 per cent level).

Long run price elasticity = 0.82 (t-ratio = 3.351)

R^2 = 0.657; Adjusted R^2 = 0.467; $F_{(5,9)}$ = 3.450; DW = 2.027

Lagrange multiplier test of serial correlation : $\chi^2(1)$: 1.384 (prob: 0.239)

Ramsey's Specification Error : RESET(1) : $F_{(1,8)}$: 0.032 (prob: 0.863)

Normality : $\chi^2(2)$: 0.536 (prob: 0.765)

Heteroscedasticity: $\chi^2(1)$: 0.115 (prob: 0.734)

Table 4.2: The Preferred UECM of Australia's Export Supply Function for Pharmaceuticals: without Factor (f) Dummy.

$$\Delta LEXPT_t = \underset{(-0.729)}{-0.527} + \underset{(1.968)^{*}}{0.242}\ \Delta LAREEXP_{(t-2)} + \underset{(3.136)^{***}}{0.521}\ LAREEXP_{(t-3)}$$

$$- \underset{(-2.017)^{*}}{0.548}\ LEXPT_{(t-1)} + \underset{(2.711)^{**}}{0.062}\ TIME \qquad (4.27)$$

(Figures in parentheses are t-ratios: ***Significant at the 1 per cent level; **Significant at the 5 per cent level; *Significant at the 10 per cent level).

Long run price elasticity = 0.95 (t-ratio = 2.938)

$R^2 = 0.609$; Adjusted $R^2 = 0.453$; $F_{(4,10)} = 3.901$; DW = 1.852

Lagrange multiplier test of serial correlation : $\chi^2(1)$: 1.015 (prob: 0.314)

Ramsey's Specification Error : RESET(1) : $F_{(1,9)}$: 0.109 (prob: 0.749)

Normality : $\chi^2(2)$: 3.236 (prob: 0.198)

Heteroscedasticity: $\chi^2(1)$: 0.384 (prob: 0.535)

Joint Test of Zero Restrictions on the Coefficient of Deleted Variable:

Langrange multiplier statistic	$\chi^2(1) = 1.831$ (prob: 0.176)
Likelihood ratio statistic	$\chi^2(1) = 1.953$ (prob: 0.162)
F-statistic	$F_{(1,9)} = 1.251$ (prob: 0.292)

domestic market, and the rigidity in domestic factor markets serving export activities, such as transport and labour. The coefficient for the TIME variable shows a positive and significant relationship, indicating that an increase in long run production capacity in terms of infrastructure and technological change will result in a rise of exports.

4.6.3.2 Foreign Demand Function for Australia's Pharmaceutical Exports

The preferred UECM estimates of the demand function for Australia's exports of pharmaceuticals are presented in Table 4.3. The short run coefficients for the difference forms of both relative price of exports, $\Delta LAREX_{(t-2)}$, is significant, while that for foreign income, $\Delta LGDPW_{(t-3)}$, is not significant. Thus, it appears that in the short run, export demand is responsive to changes in relative price, but not responsive to changes in foreign income.

However, in the long run, the coefficient for the relative price of exports is significant at the 1 per cent level. The coefficient for foreign income also shows a significant positive relationship with the exports of pharmaceuticals, at the 1 per cent level. The long run price elasticity of demand of -1.06 indicates that a 1 per cent increase in Australia's export price relative to competitors' export price, *ceteris paribus*, will result in a 1.06 decline in the exports of Australia's pharmaceuticals. The less than infinite price elasticity may indicate that Australia has some market power in relation to the exports of its differentiated pharmaceutical products.

Table 4.3: The Preferred UECM of Foreign Demand Function for Australia's Pharmaceutical Exports

$$\Delta LEXPT_t = \underset{(-5.656)^{***}}{-5.209} + \underset{(2.971)^{**}}{0.105}\ \Delta LAREX_{(t-2)} - \underset{(-1.595)}{0.383}\ \Delta LGDPW_{(t-3)}$$

$$- \underset{(-7.521)^{***}}{0.460}\ LAREX_{(t-5)} + \underset{(6.252)^{***}}{1.111}\ LGDPW_{(t-1)} - \underset{(-4.164)^{***}}{0.434}\ LEXPT_{(t-1)} \qquad (4.28)$$

(Figures in parentheses are t-ratios: ***Significant at the 1 per cent level; **Significant at the 5 per cent level).

Long run price elasticity = -1.06 (t-ratio = 5.381)

Long run income elasticity = 2.56 (t-ratio = 10.421)

R^2 = 0.949; Adjusted R^2 = 0.913; $F_{(5,7)}$ = 26.233; DW = 1.473

Lagrange multiplier test of serial correlation : $\chi^2(1)$: 0.605 (prob: 0.437)

Ramsey's Specification Error : RESET(1) : $F_{(1,6)}$: 1.3693 (prob: 0.286)

Normality : $\chi^2(2)$: 0.558 (prob: 0.754)

Heteroscedasticity: $\chi^2(1)$: 0.069 (prob: 0.793)

The long run income elasticity of foreign demand for Australia's pharmaceutical exports is 2.56. That is, a 1 per cent rise in foreign countries' real income, *ceteris paribus*, will result in 2.56 per cent increase in the demand for Australia's pharmaceutical exports. Therefore, it appears that foreign demand for Australia's pharmaceutical exports is highly responsive to income growth in Australia's trading partners. Recent evidence suggests that strong economic growth in Southeast Asian countries has provided Australia with some gain in market share of pharmaceutical exports in this region. According to Australian Pharmaceutical Manufacturers Association (1995), Australia's pharmaceutical exports to ASEAN rose to 22.2 per cent of total exports in 1993/94. This is second only to the traditional market of New Zealand.

In comparison with the supply factors, demand factors appear to be more important in explaining Australia's pharmaceutical exports during the period of study (1974-1992).

4.6.3.3 Australia's Import Demand Function for Pharmaceuticals

The parsimonious estimates of the UCEM for Australia's pharmaceutical import demand function, with trade liberalisation dummy, are reported in Table 4.4.

The coefficient associated with the dummy variable for trade liberalisation (DTL) has the expected positive sign, but it is statistically not significant even at the 10 per cent level. Therefore, the dummy variable, DTL is deleted from the estimation to obtain an appropriate model of import demand. The import price (IMP_t) should then be adjusted to include the effects of tariffs and other border taxes. Thus, the adjusted relative price of imports ($ARIMP_t$) is calculated as the following:

$$ARIMP_t = (AIMP_t / PD_t) * 100 \qquad (4.29)$$

Here, the adjusted import price index ($AIMP_t$) is derived by:

$$AIMP_t = IMP_t * (1 + NRA_t) \qquad (4.30)$$

where, NRA_t is the nominal rate of assistance to Australia's chemical, petroleum and coal products (ASIC 27). The data for $ARIMP_t$ is in Appendix 4.1. The result of the unit root test for $ARIMP_t$ is in Appendix 4.4.

Australia's import demand function for pharmaceuticals without the dummy variable (DTL) is then given in the log-log form:

$$LIMPT_t = L\gamma_o + \gamma_1 LARIMP_t + \gamma_2 LGDPA_t + \mu_t \qquad (4.31)$$

The variable deletion test for DTL shows no statistical significance. Thus, the preferred UECM estimates of Australia's import demand function for pharmaceuticals are presented in Table 4.5.

Table 4.4: Estimated UECM of Australia's Import Demand Function for Pharmaceuticals: with Trade Liberalisation Dummy

$$\Delta LIMPT_t = \underset{(-1.944)^{*}}{-3.310} - \underset{(-0.091)}{0.014}\, \Delta LRIMP_{(t-3)} + \underset{(3.935)^{***}}{1.561}\, \Delta LGDPA_{(t-3)} - \underset{(-3.155)^{***}}{0.366}\, LRIMP_{(t-4)}$$

$$+ \underset{(6.506)^{***}}{2.603}\, LGDPA_{(t-5)} - \underset{(-7.917)^{***}}{0.536}\, LIMPT_{(t-1)} + \underset{(0.211)}{0.013}\, DTL \qquad (4.32)$$

(Figures in parentheses are t-ratios: ***Significant at the 1 per cent level; **Signigicant at the 5 per cent level; *Significant at the 10% level).

Long run price elasticity = -0.68 (t-ratio = -2.925)

Long run income elasticity = 4.85 (t-ratio = 10.487)

$R^2 = 0.962$; Adjusted $R^2 = 0.923$; $F_{(6,6)} = 25.139$; DW = 2.685

Lagrange multiplier test of serial correlation : $\chi^2(1)$: 1.197 (prob: 0.240)

Ramsey's Specification Error : RESET(1) : $F_{(1,5)}$: 0.026 (prob: 0.879)

Normality : $\chi^2(2)$: 1.166 (prob: 0.558)

Heteroscedasticity: $\chi^2(1)$: 0.128 (prob: 0.770)

Table 4.5: The Preferred UECM of Australia's Import Demand Function for Pharmaceuticals: without Trade Liberalisation Dummy.

$$\Delta LIMPT_t = \underset{(-6.167)^{***}}{-2.967} - \underset{(-0.326)}{0.034}\ \Delta LARIMP_{(t-3)} + \underset{(4.578)^{***}}{1.589}\ \Delta LGDPA_{(t-3)} - \underset{(-7.965)^{***}}{0.338}\ LARIMP_{(t-4)}$$

$$+ \underset{(9.710)^{***}}{2.543}\ LGDPA_{(t-5)} - \underset{(-8.582)^{***}}{0.533}\ LIMPT_{(t-1)} \qquad (4.33)$$

(Figures in parentheses are t-ratios: ***Significant at the 1 per cent level).

Long run price elasticity = -0.73 (t-ratio = -6.909)

Long run income elasticity = 4.76 (t-ratio = 35.364)

$R^2 = 0.963$; Adjusted $R^2 = 0.937$; $F_{(5,7)} = 37.287$; DW = 2.539

Lagrange multiplier test of serial correlation : $\chi^2(1)$: 2.684 (prob: 0.110)

Ramsey's Specification Error : RESET(1) : $F_{(1,6)}$: 1.561 (prob: 0.258)

Normality : $\chi^2(2)$: 0.978 (prob: 0.613)

Heteroscedasticity: $\chi^2(1)$: 0.275 (prob: 0.970)

Joint Test of Zero Restrictions on the Coefficient of Deleted Variable:

Langrange multiplier statistic	$\chi^2(1) = 0.095$ (prob: 0.757)
Likelihood ratio statistic	$\chi^2(1) = 0.096$ (prob: 0.756)
F-statistic	$F_{(1,6)} = 0.044$ (prob: 0.840)

In the estimated equation (4.33), the coefficients associated with the differenced form of the relative price of pharmaceutical imports ($\Delta LARIMP_{(t-3)}$) is statistically not significant, while the coefficient for Australia's income ($\Delta LGDPA_{(t-3)}$) is significant and positive at the 1 per cent level. This indicates that, in the short run, imports are responsive to income, but not to the relative price.

However, the long run price elasticity of demand of -0.73 indicates that the quantity of import demanded of pharmaceuticals by Australia is not very responsive to changes in the relative price. The result shows that a 1 per cent rise in the relative price (import price relative to domestic price) of pharmaceutical imports, *ceteris paribus*, will result in a 0.73 per cent decline in the demand for pharmaceutical imports. Therefore, it is concluded that in the long run import demand for pharmaceuticals by Australia is inelastic with respect to the relative price, indicating that pharmaceutical products as a group are an essential commodity with no substitutes.

The coefficient for Australia's income variable, $LGDPA_{(t-5)}$, is significant and positive at the 1 per cent level. The estimate of the long run income elasticity of import demand (4.76) suggests that the import demand for pharmaceuticals is highly elastic with respect to Australia's income. This result is consistent with that reported by Menon (1995:53). Ballance et al.(1992: 32-35) point out that income is one of the key determinants that has a positive effect on pharmaceutical consumption, and hence imports, of developed countries in particular.

One should not expect the long run price and income elasticities estimated in this chapter to stay the same over long periods of time because of the effects of changing business cycles and other economic factors.

4.7 Conclusion

Models of export supply and export demand for Australia's pharmaceuticals, and a model of import demand for pharmaceuticals by Australia, were developed and estimated in this chapter, using cointegration and error correction techniques. The results indicate that there are no cointegrating relationships among the variables in the export supply, export demand and import demand functions, as these variables are integrated at different orders. In the absence of cointegration, the alternative technique of unrestricted error correction model was employed to estimate the models of export supply, export demand and import demand.

The results suggest that the relative price of exports (Australia's export price relative to domestic price) and the long run production capacity have a positive relationship with the supply of exports. The estimate of long run price elasticity of export supply is less than 1, indicating that, even in the long run, Australia's pharmaceutical exports are not very responsive to changes in export price. A 1 per cent increase in relative price of exports, in the long run, results in only 0.95 per cent increase in the supply of exports. Although the Factor (f) scheme appears to have a positive influence on pharmaceutical export supply, it is statistically not significant.

On the other hand, foreign demand for Australia's pharmaceutical exports exhibits a high response to changes in the relative price of exports (Australia's export price relative to competitors' export price) and to changes in foreign income. The long run price elasticity of export demand is -1.06, indicating that a 1 per cent increase in export price relative to competitors' export price, *ceteris paribus*, will reduce Australia's pharmaceutical exports by 1.06 per cent. The long run income elasticity of export demand is 2.56, suggesting that a 1 per cent increase in foreign income, *ceteris paribus*, will increase Australia's pharmaceutical exports by 2.56 per cent. Therefore, the quantity of exports demanded will increase as a result of rises in foreign income and declines with the increases in Australia's export price relative to competitors' export price. Thus, it appears that Australia's pharmaceutical exports during the period 1975-1992 have been more responsive to foreign income than to relative price of exports. Since Australia obviously cannot influence foreign income, future increases in exports have to rely on domestic supply shifts which may be achieved by the implementation of appropriate domestic industry policies such as R&D subsidies and input subsidies.

The demand for pharmaceutical imports by Australia is inelastic with respect to the relative price of imports (price of imports relative to domestic price), but highly elastic to Australia's income. The long run price elasticity of import demand is -0.73, indicating that a 1 per cent increase in import price relative to domestic price, *ceteris paribus*, will result in a 0.73 decline in pharmaceutical imports by Australia. The long run income elasticity of import demand is high (4.76). Although the acceleration of trade liberalisation during the late 1980s was found to have a positive impact on the import demand for pharmaceuticals, it was statistically not significant in explaining changes in import demand.

In conclusion, the findings of this chapter provide explanations of the relationship between exports of pharmaceuticals and their determinants, and imports of pharmaceuticals and their determinants, separately. However, there also exists an intra-industry trade where Australia both exports and imports pharmaceutical products. The two-way trade within the same industry, or intra-industry trade, is based on economies of scale and product differentiation under imperfect competition. This type of trade creates another trade pattern which implies that countries can gain from trade by exchanging differentiated products of the same industry. Therefore, Chapters 5 and 6 of this thesis are devoted to an analysis of Australia's intra-industry trade in pharmaceutical products.

CHAPTER 5

INTRA-INDUSTRY TRADE IN PHARMACEUTICALS: EXTENT AND GROWTH

5.1 Introduction

Traditionally, the major part of Australia's international trade has been inter-industry trade rather than intra-industry trade. Thus, most of Australia's exports have been in natural resource-based commodities, while the imports have been mainly in manufactures. However, the existence of international trade in products within the same industry (intra-industry trade) in Australia has been observed in several empirical studies (Grubel and Lloyd, 1975; Lowe, 1990; Siriwardana, 1990; Hamilton and Kniest, 1991; Ratnayake and Athukolara, 1992; Matthews, 1995). Compared with other OECD countries, the extent of intra-industry trade in Australia's manufactures was low before the 1980s, mainly due to the high levels of protection and the lack of specialisation in domestic production (Siriwardana, 1990: 168-169). The high rates of protection led domestic manufacturers to become less competitive in the world market, while the lack of specialisation in production prevented domestic manufacturers to gain advantages from economies of scale and product differentiation.

According to Industry Commission (1993), Australia's intra-industry trade accounted for 29 per cent of total merchandise trade and 31 per cent of total manufacturing trade in 1992-93, measured at the 4-digit Australian Standard Industrial Classification (ASIC) level. Matthews (1995) reports that, despite its low proportion, Australia's intra-industry trade has grown from 6 per cent in the late

1970s to about 15 per cent of total trade in 1993, measured at the 1-digit Standard International Trade Classification (SITC) level. This increase in Australia's intra-industry trade may be due to the recent changes in trade policy in terms of the reduction of trade barriers.

The most noticeable increase in Australia's intra-industry trade is in the manufacturing sectors (SITC 5-8), of which medical and pharmaceutical products are sub-categories. According to the Industry Commission (1993), pharmaceutical products are ranked as the fourth major industry, following electronic equipment, motor vehicles and industrial machinery, contributing most to the increase in the extent of intra-industry trade in Australia between 1981-82 and 1992-93. However, Australia's intra-industry trade in pharmaceuticals has not been a subject of an empirical study so far. Therefore, the purpose of Chapters 5 and 6 is to provide an empirical analysis of Australia's intra-industry trade in pharmaceuticals.

The focus of this chapter (Chapter 5) is on two main aspects of intra-industry trade. First, the extent of Australia's intra-industry trade in pharmaceuticals with the rest of the world, and bilateral intra-industry trade in pharmaceuticals between Australia and its trading partners, is analysed. Second, the growth of bilateral intra-industry trade between Australia and its trading partners is examined to explain the changes in intra-industry trade in pharmaceuticals over time.

The remainder of Chapter 5 is organised as follows: Section 5.2 reviews the theory of intra-industry trade, based on the concepts of economies of scale, product differentiation and imperfect competition. Section 5.3 focuses on the measurements of the extent of intra-industry trade. In Section 5.4, the extent and growth of Australia's intra-industry trade in pharmaceuticals are analysed. Major findings of the analysis are summarised in the concluding section.

5.2 Theory of Intra-Industry Trade

The term "industry" has been defined in the standard Heckscher-Ohlin model as an agglomeration of firms which produce a perfectly homogeneous commodity with constant returns to scale. Firms supply homogeneous goods to consumers in perfectly competitive markets. Each nation either exports or imports, according to whether it has a comparative advantage or disadvantage in production. The concept is adequate to explain inter-industry trade, but rules out the simultaneous export and import of goods from the same industry (Grubel and Lloyd, 1975:3). While the Heckscher-Ohlin model is retained in the theory of international trade, other explanations are required to complement the Heckscher-Ohlin model. Under some conditions, mutually beneficial trade can occur even when two nations produce the same commodities. This type of trade, which is known as intra-industry trade, is not explained by the Heckscher-Ohlin model.

Intra-industry trade arises from efficiencies of large scale production, product differentiation and imperfect competition. The rapid growth of world intra-industry trade seems to have several causes. The changing pattern of world trade in response to changes in consumers' preferences is a crucial factor leading to intra-industry trade. Intra-industry trade also reflects increasing demand for new products, the globalisation of business, increasing product differentiation and the pursuit of the benefits of economies of scale (Sheehan, Pappas and Cheng, 1994).

Lancaster (1966) developed a new approach to consumer choice by assuming that a commodity will possess more than one characteristic, and goods in combination may possess characteristics different from those pertaining to the goods separately. According to this view, there is no perfect substitutes for any two goods with respect to all characteristics. In contrast to the standard Heckscher-Ohlin model, product differentiation has relaxed the assumption of product homogeneity under perfect competition. Under perfect competition, each producer is a price taker, that is, it fails to raise the price above market level because the product is homogeneous. With differentiated products under imperfect competition, each producer is able to set its own price by differentiating products which may involve branding, styling, labelling, packaging, thus segmenting the market according to consumers' income and preferences. As the number of other similar products are available in the market, differentiated products enable each producer to monopolise in its particular product and to ignore the impact of the competitors' prices.

When a nation experiences economies of scale[1] and product differentiation under imperfect competition, it is not able to produce a wide range of products by itself. A large amount of a limited number of differentiated product varieties and styles are produced in order to satisfy the majority of domestic consumer tastes and

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[1] Economies of scale are defined as decreasing cost per unit of production as output increases. Krugman and Obstfeld (1994: 115-116) define internal economies of scale as "the cost per unit (which) depends on the size of an individual firm but not necessarily on that of the industry", and external economies of scale as "the cost per unit (which) depends on the size of the industry, but not necessarily on the size of any firm".

preferences. Some of the products are exchanged across nations for other varieties and styles. Differentiated products in the same commodity class are also imported to satisfy the minority taste of that nation at the same time. Such trade allows each nation to import and export the differentiated products to each other according to consumers' preferences. This type of trade not only increases the choice for domestic consumers, but also creates a new trade pattern which implies that two nations gain from trade by exchanging differentiated products of the same industry.

Intra-industry trade is based on two different types of product differentiation: horizontal and vertical. The horizontal differentiation refers to the differences in product characteristics related to style and consumers' preferences, while the vertical differentiation refers to the differences related to quality. These two characteristics of products are sufficient to encourage intra-industry trade when they are combined with economies of scale.

The studies of Linder (1961) and Falvey (1981) confirm that a high capital-labour ratio in an industry results in a high-quality of products. This causes the capital-abundant country to export relatively high-quality products, while the labour-abundant country to export relatively low-quality products. In this sense, the commodity is vertically differentiated by quality which is determined by the ratio of capital relative to labour used in the production. Thus, each country exports the qualities which use their relatively abundant factors intensively, and imports the qualities which use their relatively scarce factors intensively. As long as the demand for both high-quality and low-quality products exists, the exchange in products within the same industry will continue. This model is consistent with the Hechscher-Ohlin theory, but differs in some respects. The Falvey model assumes that there are only two factors of production, capital and labour, and one of these is fixed and cannot move between industries. Furthermore, the model allows at least one sector to produce a vertically differentiated commodity, that is differentiated by quality.[2]

In contrast to the Falvey model, Dixit and Stiglitz (1977), Krugman (1979; 1980) and Krugman and Obstfeld (1994: 119-124) attempt to explain intra-industry trade based on monopolistic competition. These models are independent of relative factor endowments and assume that commodities are horizontally differentiated instead of vertically differentiated. According to this view, the alternative varieties of a particular commodity differ in their actual or perceived characteristics. Consumers select the alternative varieties of goods by their preferences and perceptions with no unique characteristics of purchasing patterns. Firms produce differentiated products in order to diversify production to match the diversity in consumers' preferences. Krugman (1979) demonstrates two crucial aspects of intra-industry trade. First, decreasing unit costs in production and horizontal product differentiation provide a basis for trade in products within the same industry. Second, the increasing product variety and the scale of production will result in gains from trade.

In monopolistic competition, no country is able to produce a wide range of products by itself due to economies of scale. Each individual country specialises in a production of a large amount of fewer product varieties in which its production can

[2] Greenaway and Milner 1986, pp. 10-11, have argued that there are some high-quality products which are not necessary to be produced in a high capital-abundant country, such as hand-made clothing, and custom-built motor cars.

achieve internal scale economies. In such nations, domestic firms produce goods to satisfy only the majority tastes of their own country, but ignore the minority consumers with tastes for different types of the same products produced in other countries. Thus, some of the differentiated products are imported from foreign countries to increase the variety of the basic goods available for domestic consumption. In the short run, domestic firms may earn profits or losses depending on domestic demand for differentiated products of foreign countries. This leads to a competitive adjustment between domestic firms and foreign firms in the world market. As a result, the demand in the world market for differentiated products becomes even more elastic. Therefore, national gains from trade increases as there are more varieties of the basic goods available to domestic consumers through imports (Krugman and Obstfled, 1994:124-125; and Lindert and Pugel, 1996:100-104).

Krugman (1980) suggests that the introduction of transport costs will reduce the volume of intra-industry trade, since such trade between two countries will be negatively correlated with the distance between them. Balassa (1986), reviewing Krugman (1980), points out that, when the distance between two countries increases, it causes the availability of information on the characteristics of differentiated products to decrease. Thus, transport costs will rise. As suggested by Grubel and Lloyd (1975:73-75), in some countries sharing common borders, intra-industry trade may occur in the form of border trade to reduce transport costs. Products are exchanged across the border by each country because of the greater proximity of consumers to the foreign producer rather than the domestic producer. In addition, some products which have seasonal characteristics in nature, such as some fruits and vegetables which grow in different hemispheres, also cause intra-industry trade to occur.

Many recent studies have attempted to explore the causes for the existence and growth of intra-industry trade. Some studies (Linder, 1961; Helpman, 1981; Flam and Helpman, 1987) suggest that intra-industry trade does occur as the income per capita of nations increases. When the income per capita of a nation increases, the degree of quality characteristics of a product demanded by residents of that nation will become higher. Consequently, these products tend to be differentiated and cause intra-industry trade to become increasingly important in trade among the nations with high income per capita. Greenaway and Milner (1986:1) suggests that "it would be wrong to suggest that intra-industry trade occurs exclusively in manufactures, and moreover in trade between industrial countries". In fact, intra-industry trade has been observed to occur not only among developed countries, but also among less developed countries. For example, a study by Hellvin (1994) finds that, in a group of less developed countries in Asia, a large part of intra-industry trade is in non-manufactured goods. Kalirajan and Shand (1996) report that, there is evidence of significantly increasing intra-industry trade in manufactures between Australia and developing countries in the Indian Ocean region (Indian Ocean Grouping countries). Thus, intra-industry trade continues to be an increasingly significant part of world trade.

In summary, the review so far indicates that intra-industry trade occurs as a consequence of diversity in consumer preferences and economies of scale under monopolistic or imperfect competition, and that gains from trade result from the ability of the countries engaged in trade to benefit from the exploitation of scale economies and greater product diversity.

5.3 Measurements of the Extent of Intra-Industry Trade

5.3.1 Intra-Industry Trade Indexes to Explain the Pattern of Trade

Verdoorn (1960) used the ratio of exports to imports of the same commodity group to measure the extent of intra-industry trade:

$$V_i = \frac{X_i}{M_i} \tag{5.1}$$

where, V_i = Verdoorn's index of intra-industry trade,

X_i = exports of commodity group i,

M_i = imports of commodity group i.

However, Verdoorn's index does not provide a measure of the extent of intra-industry specialisation (Grubel and Lloyd, 1975: 24-25). Balassa (1966) proposed a trade specialisation index in order to examine the predominance of intra-industry as against inter-industry specialisation in the trade in manufactured goods among industrial countries. Using the ratio of the absolute difference between exports and imports (net trade) over the total gross trade, he defined the index as:

$$B_i = \frac{\left|X_i - M_i\right|}{\left(X_i + M_i\right)} \tag{5.2}$$

where, B_i = extent of trade, inversely related to intra-industry trade,

X_i = exports of commodity i,

M_i = imports of commodity i.

Balassa's index has specific weighting characteristics. Greenaway and Milner (1986: 60-61) suggest that, Balassa's index can take on a specific value for markedly different absolute values of imports and exports. In addition, if the signs on the trade imbalances at the sub-group level are all the same, this index will give a weighted average of any sub-group indexes. However, if there are opposite signs on sub-group trade balances, this weighting property is lost. Therefore, when there is no opposite sign effect, the index must be adjusted as:

$$B_o = \frac{\sum_{j=1}^{n}\left|X_{ij} - M_{ij}\right|}{\left(X_i + M_i\right)} \tag{5.3}$$

where, X_{ij} = export of sub-group j in commodity i.

M_{ij} = import of sub-group j in commodity i.

j = number of sub-group (1, 2, 3,........., n).

$B_o = B_i$ when there is no opposite sign effect. Meanwhile, when there is an opposite sign effect, the index must be adjusted as follows:

$$B_o = \sum_{j=1}^{n} w_j B_{ij} \tag{5.4}$$

where, B_{ij} = the index of sub-group j in commodity i, and

$$w_j = \frac{X_{ij} + M_{ij}}{X_i + M_i}$$

This type of adjustment can be performed as a weighted average (B_w) of all the B_{ij} indexes, that is

$$B_w = \frac{\sum_{i=1}^{n} \left| X_i - M_i \right|}{\sum_{i=1}^{n} \left(X_i + M_i \right)} = \sum_{i=1}^{n} w_i B_i \tag{5.5}$$

Here, B_i = the index from equation (5.2), and

$$w_i = \frac{X_i + M_i}{\sum X_i + \sum M_i} .$$

Balassa (1966) used the unweighted average of these indexes to define his measure of intra-industry trade as:

$$\beta_i = \frac{1}{n} \sum_{i=1}^{n} B_i$$

$$\beta_i = \frac{1}{n}\sum_{i=1}^{n}\left[\frac{\left|X_i - M_i\right|}{\left(X_i + M_i\right)}\right] \tag{5.6}$$

Grubel and Lloyd (1975: 26) argue that this unweighted average of the ratios really measures inter-industry trade, and not intra-industry trade. Further, this unweighted average has some undesirable properties for summary measures of trade, because it gives equal weight to all industries regardless of whether their shares in total trade are large or small. On the other hand, this index does not resolve the issue of aggregate trade imbalance and their implications on the measurement of intra-industry trade.

In contrast to Balassa's index, Michaely (1962) proposed an index to measure the extent to which exports in each commodity grouping as a proportion of total exports offset imports of each industry as a proportion of total imports, that is:

$$M_i = 1 - \frac{1}{2}\sum_{i=1}^{n}\left|\frac{X_i}{\Sigma X_i} - \frac{M_i}{\Sigma M_i}\right| \tag{5.7}$$

This index shows the similarity in the commodity composition of a nation's trade, and reflects fluctuations in the commodity terms of trade. Higher values indicate greater similarity in the commodity composition of imports and exports. The drawback of this index is that it does not measure the actual proportion of overall intra-industry trade since the value of unity is not dependent on the overall trade balance ($\Sigma X_i = \Sigma M_i$). Therefore, it is not suitable for measuring intra-industry trade at the individual industry level.[3]

The most commonly used measure of intra-industry trade is the standard index of Grubel and Lloyd (1975). In this measure, inter-industry trade is defined as the ratio of the absolute value of exports and imports, $|X_i - M_i|$, over the total trade, ($X_i + M_i$), of the industry. On the other hand, intra-industry trade is defined as the ratio of the total trade remaining after subtraction of net trade over the total trade of the industry. In its condensed form, the Grubel-Lloyd index defines intra-industry trade as the difference between inter-industry trade and unity. It also shares the same weighting characteristics as the Balassa index. Most of the time, the index is expressed as a percentage of each industry's combined exports and imports as follows:

$$GL_i = \left(\frac{(X_i + M_i) - |X_i - M_i|}{(X_i + M_i)} \right) 100 \text{ , or}$$

$$GL_i = \left(1 - \frac{|X_i - M_i|}{(X_i + M_i)} \right) 100 \qquad (5.8)$$

If all trade is intra-industry trade, the index (GL_i) equals 100. This means that the country's imports and exports of the same industry are equal. On the other

[3] As Grubel and Lloyd (1975: 27-28), and Greenaway and Milner (1986: 62) point out, the similarity of actual imports and exports by industry groups can be measured by a correlation coefficient. This measure is applied by Linneman (1966) to compare the commodity composition of different countries' trade.

hand, the index is zero if there is no intra-industry trade in a particular industry, that is, all trade in that industry is inter-industry trade.

Grubel and Lloyd also proposed a weighted average of the values of intra-industry trade, at a given level of aggregation in each industry's share of a country's total trade:

$$GL_W = \left(\frac{\sum_{i=1}^{n} GL_i \left(X_i + M_i \right)}{\sum_{i=1}^{n} \left(X_i + M_i \right)} \right) 100$$

$$= \left(\frac{\sum_{i=1}^{n} (X_i + M_i) - \sum_{i=1}^{n} \left| X_i - M_i \right|}{\sum_{i=1}^{n} (X_i + M_i)} \right) 100$$

$$= \left(1 - \frac{\sum_{i=1}^{n} \left| X_i - M_i \right|}{\sum_{i=1}^{n} (X_i + M_i)} \right) 100 \qquad (5.9)$$

where, GL_W measures average intra-industry trade as a percentage of the export and import trade. In other words, it is equal to the sum of the intra-industry trade for the industries as a percentage of the total trade of "n" industries.

When intra-industry trade is measured under the condition where exports cannot be matched by imports in every commodity grouping, Grubel and Lloyd (1975) propose that all commodity trade must be adjusted. With a multilateral aggregate trade imbalance between exports and imports, intra-industry trade is expressed as a proportion of total trade minus the overall trade imbalance, that is:

$$GL_{(adj)} = \left[\frac{\sum_{i=1}^{n}\left(X_i + M_i\right) - \sum_{i=1}^{n}\left|X_i - M_i\right|}{\sum_{i=1}^{n}\left(X_i + M_i\right) - \left|\sum_{i=1}^{n} X_i - \sum_{i=1}^{n} M_i\right|} \right] 100 \qquad (5.10)$$

$$\text{Or } GL_{(adj)} = \frac{GL_W}{1-k}, \text{ where } \quad k = \frac{\left|\sum_{i=1}^{n} X_i - \sum_{i=1}^{n} M_i\right|}{\sum_{i=1}^{n}\left(X_i + M_i\right)}$$

GL_W is from equation (5.9).

The value of the adjusted index increases as the trade imbalance factor (k) increases as a proportion of total trade. In addition, the mean of the indexes is a biased downward measure of intra-industry trade. However, Greenaway and Milner (1986) argue that this adjusted index is not necessarily a downward biased measure of average intra-industry trade, since the industry and specialisation characteristics of an economy may induce individual industry and aggregate trade flow to be imbalanced but consistent with macro-equilibrium. They further argue that, if the aggregate trade imbalance in relation to a particular commodity would be expected to increase in order to restore overall equilibrium, the adjusted index is likely to be an overestimate, or upward biased measure of average intra-industry trade.

Aquino (1978) argues that the Grubel-Lloyd method fails to explain the principle in the context of more disaggregate commodity level. If the mean value of intra-industry trade (GL_W) index is a downward biased measure, then the elementary measure (GL_i) is also downward biased. Aquino suggests that the basic Grubel-Lloyd index (GL_i) should be adjusted on the assumption that the balancing effect is equiproportional to all industries. It requires an estimate of expected export (X_e) and expected import (M_e) values of each commodity before calculating the intra-industry trade index, that is:

$$X_e = X_i \frac{1}{2}\left[\frac{\sum_{i=1}^{n}(X_i + M_i)}{\sum_{i=1}^{n} X_i}\right]$$

$$M_e = M_i \frac{1}{2}\left[\frac{\sum_{i=1}^{n}(X_i + M_i)}{\sum_{i=1}^{n} M_i}\right]$$

where $\sum_{i=1}^{n}(X_e)_i = \sum_{i=1}^{n}(M_e)_i = \frac{1}{2}\sum_{i=1}^{n}(X_i + M_i)$.

Thus, the Aquino index is as follows:

$$A_i = 1 - \frac{\left|X_e - M_e\right|}{\left(X_e + M_e\right)} \tag{5.11}$$

This index gives a measure of the proportion of intra-industry trade of commodity i, without the imbalancing effects of the overall imbalance in a country's trade. It avoids the problem of the correction for overall trade imbalance, and it is independent on the values of $\sum_{i=1}^{n} \left|X_i - M_i\right|$. Some econometric studies (for example, Loertsher and Wolter, 1980; Balassa, 1986) use the Aquino adjustment procedure on a bilateral basis. But Greenaway and Milner (1986: 70) comment that:

> Bilateral imbalances are quite consistent with multilateral balance, or equilibrium, and there is a danger that the very factors (influencing product and industry specialization) that might explain IIT are being removed by the adjustment procedure.

According to Bergstrand (1983), bilateral trade flows at the industry level should be adjusted for multilateral trade imbalance. He is in favour of measuring intra-industry trade from bilateral rather than multilateral trade flows. He states that:

> In a multicountry, multicommodity, two factor, factor price nonequalized world, the commodity version of the HO theorem need not hold for a country's multilateral trade, but will hold for any pair of countries......The holding of this HO theorem's commodity version for bilateral trade suggests that the presence of bilateral intra-industry trade is interesting (Bergstrand 1983, p. 207).

Since the adjustment of disaggregate bilateral trade flows for bilateral trade imbalance is justified on theoretical grounds, Bergstrand takes justification from the trade theory in associating external equilibrium with multilateral trade balance. By using this procedure, an undesirable feature has been removed from the measurement. He considers that adapting Aquino's correction procedure to bilateral trade flows is theoretically convenient, but not appealing. The correction procedure of Aquino and Michaely which tries to solve the impact of trade imbalances still has the weakness of lacking a theoretical base. Bergstrand tackles this problem by measuring intra-industry trade from bilateral disaggregate trade flows, but still faces the problem of justifying the proportionality assumption.

Clark (1993), reviewing Kol and Mennes (1989) and Vona (1991), point out that, according to these authors, measures of intra-industry trade should not be corrected for the overall trade imbalance. Vona examines the pros and cons of the implications of trade imbalance for measuring intra-industry trade. He strongly recommends that the proposed corrections be rejected on both theoretical and empirical bases, since they are highly arbitrary and unrelated to any theoretical foundation. Vona shows some similar shortcomings of the Michaely and Aquino corrected indexes which are apparently unrelated to the pattern of trade flows that actually take place at a specific level, but depends entirely on the inter-sectoral composition of trade. He also criticises the adjustment procedure proposed by Bergstrand (1983) that it imposes an equilibrium of multilateral trade in a particular industry of each country within a narrowly defined industry level, and this equilibrium applies to each country on a bilateral basis within a limited sample (14 industrial countries considered). Vona uses the example to demonstrate the superiority of Grubel-Lloyd uncorrected index (GL_i) over the corrected indexes mentioned earlier. Vona (1991) claims that the uncorrected Grubel-Lloyd index has been found to be the best of those currently available.

Based on the arguments advanced by Vona (1991), and Kol and Mennes (1989), some recent studies do not correct intra-industry trade indexes for the overall trade imbalance.[4] As suggested by Globerman and Dean (1990: 28), the unadjusted Grubel and Lloyd index is somewhat lower than the adjusted measure for trade balance. The trend in intra-industry trade is virtually not affected by the measure chosen (adjusted or unadjusted). The Grubel-Lloyd index will be weaker when intra-industry trade is measured at highly disaggregated Standard Industrial Trade Classifications (SITC).

5.3.2 Intra-Industry Trade Indexes to Explain the Effects of Trade Liberalisation

The main purpose of trade liberalisation is to promote international trade and to increase economic welfare by reducing trade barriers among the countries involved. Free trade enables a participating country to increase specialisation by producing a large amount of a limited number of goods on which it has a comparative advantage and exchanging some of its productions for that of others. As a

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[4] See for example, Pagoulatos and Sorensen (1975); Globerman and Dean (1990); Hamilton and Kniest (1991); Ballance et al. (1992); Lundberg (1992); Clark (1993); Hughes (1993) and Somma (1994).

consequence, the participating countries can achieve an efficient scale of production. Trade among the countries expands and all countries involved gain from freer international trade. The studies of intra-industry trade in relation to trade liberalisation have attracted much attention in the recent economic literature. Among these studies, Lloyd (1971) reports empirical evidence that the regional trading arrangements between Australia and New Zealand increased the share of intra-industry trade. Grubel and Lloyd (1975) examine the changes in intra-industry trade in the European Economic Community (EEC) countries and suggest that the increase in the intra-industry share of total trade among these countries is due to the formation of the regional trading arrangements. However, the study of Caves (1981) provides weak statistical support for empirical relationships between the level of trade barriers and intra-industry trade, while Balassa and Bauwens (1987) argue that the extent of intra-industry trade and participation in economic unions are positively correlated with a high level of statistical significance. Marvel and Ray (1987), on the other hand, suggest that the effects of trade liberalisation on intra-industry trade depend upon how economies of scale are combined with comparative advantage.

Although empirical studies have developed various measures of intra-industry trade in order to examine the impact of trade liberalisation upon the growth of intra-industry trade over time, there is some debate over the most appropriate index to measure the structural changes in intra-industry trade. Hamilton and Kniest (1991) argue that the comparison of Grubel-Lloyd indexes over the different points in time is not the proper way to explain the structural changes in intra-industry trade. When an increase in inter-industry trade has reduced the level of trade imbalance, the increase in inter-industry trade flows is simply compatible with an increase in the Grubel-Lloyd index of intra-industry trade. As a result, the Grubel-Lloyd index does not provide conclusive results on the structure of the change in intra-industry trade. Brulhart (1994: 602) suggests that the comparison of Grubel-Lloyd indexes over time is appropriate in a comparative static analysis, that is a comparison of the structure of trade at different points in time; but the comparison of Grubel-Lloyd indexes over time is inappropriate in the comparative dynamic analysis where there is a structural change in trading patterns. Therefore, an alternative measure is needed in the analysis of intra-industry trade to explain adjustment costs of trade liberalisation, as adjustment costs depend upon comparative dynamic, rather than comparative static analysis.

To overcome the conceptual problem encountered in comparing Grubel-Lloyd indexes for different time periods, Hamilton and Kniest (1991) use a new index of marginal intra-industry trade ($MIIT_{HK}$) to investigate the impact of trade liberalisation between Australia and New Zealand under the Closer Economic Relations (CER) agreement. The measurement of marginal intra-industry trade is defined for each industry as:

$$MIIT_{HK} = \frac{X_t - X_{t-n}}{M_t - M_{t-n}} \quad \text{for} \quad M_t - M_{t-n} > X_t - X_{t-n} > 0 \qquad (5.12)$$

$$= \frac{M_t - M_{t-n}}{X_t - X_{t-n}} \quad \text{for} \quad X_t - X_{t-n} > M_t - M_{t-n} > 0 \qquad (5.13)$$

$= \text{undefined}$ for $X_t < X_{t-n}$ or $M_t < M_{t-n}$

where X_t, X_{t-n} = exports in years "t" and "t-n",

M_t, M_{t-n} = imports in years "t" and "t-n",

n = the number of years over which liberalisation is implemented.

The $MIIT_{HK}$ index equals one when new trade (under liberalisation) is intra-industry trade, and zero or undefined when it is inter-industry trade. By using the $MIIT_{HK}$ index, Hamilton and Kniest (1991) find some evidence of higher adjustment costs in trade liberalisation between Australia and New Zealand, as the trade between these two countries is characterised by more inter-industry trade rather than intra-industry trade.

Greenaway et al. (1994) argue that there are a number of weak properties of the Hamilton-Kniest index in terms of the trade flow data. Since this index employs changes in trade flows measured in nominal terms, not in real terms, it is upward biased and inappropriate from the standpoint of adjustment. Furthermore, the $MIIT_{HK}$ index also suffers from a weighting deficiency because it measures the shares of matched trade or intra-industry trade in the change in total trade. Greenaway et al. (1994) suggest an adjusted index of marginal intra-industry trade which can be calculated as follows:

$$MIIT_{GHME} = [(X_i + M_i) - /X_i - M_i/\,]_t \;-\; [\,(X_i + M_i) - /X_i - M_i/\,]_{t-n} \qquad (5.14)$$

Unlike the Hamilton-Kniest indexes, $MIIT_{GHME}$ reports intra-industry trade in absolute values rather than as a ratio, and the index is always defined. Although it resembles the Grubel-Lloyd index, this index fails to explain the relationship between inter-industry trade and intra-industry trade. As Brulhart (1994: 604) points out, "($MIIT_{GHME}$) says nothing about the proportion of (marginal) intra- relative to inter-industry trade, and it lacks the presentational appeal of a simple index contained between, say, 0 and 1".

Menon and Dixon (1994) offer alternative measures of intra-industry trade index for analysing the relationship between the changes in intra-industry trade and the formation of the Regional Trade Agreements between Australia and New Zealand. To overcome the problems associated with using the Grubel-Lloyd index over time, they derive the following formulae by decomposing the growth in total trade, net trade and intra-industry trade into the contribution terms:

$$Cmtt_{ijk} = \left(\frac{M_{ijk}}{TT_{ijk}}\right) m_{ijk} \quad (5.15)$$

$$Cxtt_{ijk} = \left(\frac{X_{ijk}}{TT_{ijk}}\right) x_{ijk} \quad (5.16)$$

$$Cmnt_{ijk} = \left(\frac{M_{ijk}}{M_{ijk} - X_{ijk}}\right) m_{ijk} \quad (5.17)$$

$$Cxnt_{ijk} = \left(\frac{X_{ijk}}{X_{ijk} - M_{ijk}} \right) x_{ijk} \tag{5.18}$$

$$Cmiit_{ijk} = \delta_{ijk} m_{ijk} \tag{5.19}$$

$$Cxiit_{ijk} = \left(1 - \delta_{ijk} \right) x_{ijk} \tag{5.20}$$

where, $Cmtt_{ijk}$ = contributions of import growth to growth in total trade in good i between nation j and nation k.

$Cxtt_{ijk}$ = contributions of export growth to growth in total trade in good i between nation j and nation k.

$Cmnt_{ijk}$ = contributions of import growth to growth in net trade.

$Cxnt_{ijk}$ = contributions of export growth to growth in net trade.

$Cmiit_{ijk}$ = contributions of import growth to growth in intra-industry trade.

$Cxiit_{ijk}$ = contributions of export growth to growth in intra-industry trade.

TT_{ijk} = total trade for good i between nations j and k.

M_{ijk} = imports of nation j from/to nation k of good i.

X_{ijk} = exports of nation j from/to nation k of good i.

m_{ijk} = growth rates over the period in M_{ijk}.

x_{ijk} = growth rates over the period in X_{ijk}.

$$\delta_{ijk} = 1, \text{ if } X_{ijk} > M_{ijk} \text{ and Zero if } X_{ijk} < M_{ijk}.$$

Then, $$TT_i = Cmtt_{ijk} + Cxtt_{ijk} \quad (5.21)$$

$$NT_i = Cmnt_{ijk} + Cxnt_{ijk} \quad (5.22)$$

$$IIT_i = Cmiit_{ijk} + Cxiit_{ijk} \quad (5.23)$$

where TT_i , NT_i and IIT_i are the percentage changes in total trade, net trade and intra-industry trade, respectively, of good i over the period.

These formulae clarify the patterns of imports and exports over time which the Grubel-Lloyd index ignores. Furthermore, these measures can be used as indicators of changes in the importance of intra-industry trade which contribute to the growth in total trade over the same period of time.

However, equations (5.17) through (5.23) will be invalid when there are "status switches", that is, when the product switches from a net import to a net export status, or *vice versa*. Status switches take place if:

$$m_{ijk} < [(X_i / M_i) - 1] + (X_i / M_i)\, x_{ijk} \,, \quad \text{for } M_i > X_i \quad (5.24)$$

and if $$x_{ijk} < [(M_i / X_i) - 1] + (M_i / X_i)\, m_{ijk} \,, \quad \text{for } X_i > M_i \quad (5.25)$$

In the case of status switches, the percentage changes in net trade (NT_i) and intra-industry trade (IIT_i) can be calculated as follows:

$$NT_i = -2 + [M_i / (X_i - M_i)]\, m_{ijk} + [X_i / (M_i - X_i)]\, x_{ijk} \qquad (5.26)$$

and

$$IIT_i = [(M_i / X_i) - 1] + (M_i / X_i)\, m_{ijk}, \text{ for } M_i > X_i \qquad (5.27)$$

$$IIT_i = [(X_i / M_i) - 1] + (X_i / M_i)\, x_{ijk}, \text{ for } X_i > M_i \qquad (5.28)$$

Equations (5.26) through (5.28) will be valid only when equations (5.24) and (5.25) exist, otherwise there is no conclusive solution to explain import and export contributions to growth in NT_i and IIT_i. Menon and Dixon (1996) used these indexes to measure the contributions of Australian manufacturing exports and imports to the growth in total trade, net trade and intra-industry trade over time.

5.4 Intra-Industry Trade in Pharmaceuticals

This section presents an analysis of the extent and growth of Australia's intra-industry trade in pharmaceuticals. To provide the necessary background for this analysis, relevant characteristics of Australia's pharmaceutical industry are discussed first.

5.4.1 Characteristics of Australia's Pharmaceutical Industry

The Australian pharmaceutical industry is a high technology industry dominated by a few large multinational corporations (MNCs) (see Chapter 2).

Hence, the industry can be considered as an imperfectly competitive industry. A large number of differentiated pharmaceutical products is derived from innovative products in which the pharmaceurtical companies invest in the form of R&D in order to maintain a product line. This in turn helps generate a variety of pharmaceutical products differentiated by quality, brand, and packaging.

In order to measure the level of scale economies in the pharmaceutical industry, a ratio of turnover to the number of establishments is calculated, while a ratio of total R&D expenditure to value added in pharmaceuticals is calculated to measure the level of product differentiation. As shown in Table 5.1, the measure of economies of scale for Australia's pharmaceuticals have increased from 8.43 in 1976 to 11.58 in 1988, reflecting a large expansion of pharmaceutical turnovers due to a cost advantage in production. On the other hand, the degree of product differentiation has significantly increased from 0.0175 in 1976 to 0.1071 in 1988. As a result, intra-industry trade in Australia's pharmaceutical industry is likely to grow in response to an increase in both economies of scale and product differentiation in this industry.

Table 5.1: Economies of Scale and Product Differentiation in the Australian Pharmaceutical Industry, Selected years during 1976-1988.

Industry characteristics	Unit	1976	1980	1984	1988
Economies of scale*	$million per establishment	8.43	10.14	11.21	11.58
Product differentiation**	ratio	0.0175	0.0255	0.0372	0.1071

Source: Estimates compiled from ABS data, cat. no. 8104.0 and 8202.0.
*Note: * the ratio of pharmaceutical turnover to the number of establishments.*
***the ratio of total R&D expenditure to value added in pharmaceuticals.*

5.4.2 Extent of Intra-Industry Trade in Pharmaceuticals

In this section, the standard Grubel-Lloyd index (GL_i) is used to measure the extent of: (i) Australia's intra-industry trade in pharmaceuticals with the rest of the world; (ii) eleven other OECD countries' intra-industry trade with the rest of the world; and (iii) bilateral intra-industry trade between Australia and twenty of its trading partners.

At the time of the analysis, a complete series of data for pharmaceutical exports and imports was available from the United Nations and the Australian Bureau of Statistics, only for the period 1975 to 1992. Thus, export and import data used in this analysis were confined to this period.

The trade data used in measuring the extent of intra-industry trade in pharmaceuticals for Australia and eleven other OECD countries were obtained from the United Nations, International Trade Statistics Yearbook (various years). These OECD countries consist of Belgium, France, Germany, Italy, the Netherlands, Switzerland, the U.K., the U.S., Canada, New Zealand and Japan.

The data on Australia's exports and imports in pharmaceuticals with its major trading partners were obtained from the Australian Bureau of Statistics (ABS), Foreign Trade Australia, Merchandise Exports and Imports, cat. no. 5436.0 and 5437.0. Annual bilateral trade data between Australia and its trading partners (Belgium, France, Germany, Italy, the Netherlands, Switzerland, the U.K., the U.S., Canada, New Zealand, Japan, Korea, China, Hong Kong, Taiwan, Indonesia, Malaysia, the Philippines, Singapore and Thailand) are reported in current prices at the 3-digit SITC, medical and pharmaceutical products, for 1975-1992. The data series used in the analysis are given in Appendix 5.1.

As the results presented in Table 5.2 reveal, almost all the net-exporters of pharmaceuticals (Belgium, France, Germany, Italy, the Netherlands, the U.K. and the U.S.) have relatively high intra-industry trade indexes. In contrast, the intra-industry trade index for Switzerland is relatively low. As explained in Chapter 3, Switzerland has the highest revealed comparative advantage of all pharmaceutical exporting countries. Thus, the intra-industry trade index is very low because the country's exports in pharmaceuticals have been very much greater than its imports throughout the last two decades.

Table 5.2: Grubel-Lloyd Index of Intra-Industry Trade in Pharmaceuticals for Australia and Eleven OECD Countries (Selected Years)

Country	1975-76	1980-81	1985-86	1992-93	Exporter or importer
Australia	**52.12**	**66.14**	**51.08**	**46.97**	**net importer**
Belgium	94.86	98.94	90.49	90.60	net exporter
France	70.01	63.78	67.76	85.60	net exporter
Germany	58.95	72.43	73.01	77.28	net exporter
Italy	94.44	97.39	94.14	79.82	net exporter *
Netherlands	85.12	95.79	97.56	95.35	net exporter *
Switzerland	33.86	40.57	47.02	44.94	net exporter
U.K	41.31	45.93	58.38	57.60	net exporter
U.S.A.	42.59	56.89	75.33	82.97	net exporter
Canada	48.74	48.51	56.03	46.07	net importer
New Zealand	20.00	26.41	41.43	30.39	net importer
Japan	43.97	43.10	46.46	56.25	net importer

Source: Estimates compiled using trade data obtained from the United Nations, International Trade Statistics Yearbook (various years).
Note : (*) the value of imports exceeded those of exports in 1992-93.

Italy and the Netherlands used to be net exporters in pharmaceuticals during 1975-1991, but the values of imports have slightly exceeded those of exports since

1992-93. The very large intra-industry trade indexes for the Western European countries (Belgium, France, Germany, Italy, the Netherlands and the U.K.) are perhaps related to the similarity of country characteristics such as common borders, customs union and income levels. The increase in the extent of intra-industry trade in the U.S. is probably a result of the achievement of greater economies of scale in production and trade liberalisation. On the other hand, net-importers of pharmaceuticals, such as Australia, Canada, Japan and New Zealand, have relatively low levels of intra-industry trade, reflecting that pharmaceutical trade in these countries is based on trade complementarity which emphasises the gains from inter-industry trade.

Table 5.3 presents the Grubel-Lloyd indexes for Australia's bilateral intra-industry trade in pharmaceuticals with its twenty trading partners. The results show that most bilateral intra-industry trade indexes between Australia and each individual country are very low, except for those of Canada and Japan.

The values of Australia's pharmaceutical imports from the net-exporters of pharmaceuticals, such as Belgium, France, Germany, Italy, the Netherlands, Switzerland, the U.K. and the U.S. are considerably higher in comparison with those of pharmaceutical exports from Australia to these countries. On the other hand, more than a half of Australia's pharmaceutical exports is supplied to the neighbouring countries such as New Zealand, Hong Kong, Malaysia, the Philippines and Thailand. The values of pharmaceutical imports from these countries to Australia are very low compared to the values of pharmaceutical exports from Australia to these countries. As a result, intra-industry trade indexes for pharmaceuticals between Australia and these countries are very low. However, Australia's bilateral intra-industry trade indexes for Korea, Taiwan, Indonesia and Singapore are relatively high in some years, but have fluctuated over time. Australia's bilateral intra-industry trade index for Indonesia in 1975-76 is very high, as the values of exports and imports for pharmaceuticals are nearly equal in that period. Results presented in Table 5.3 also indicate that the indexes of Australia's bilateral intra-industry trade in pharmaceuticals with Canada and Japan are very high, compared to all other countries. This indicates that the values of Australia's pharmaceutical exports to, and imports from, these two countries appear to be almost equal during 1975-76 to 1992-93.

Table 5.3 : Bilateral Indexes of Intra-Industry Trade in Pharmaceuticals between Australia and Twenty Major Trading Partners (Selected years)

Country	1975-76	1980-81	1985-86	1992-93
Belgium	24.48	4.82	3.81	2.02
France	10.76	9.54	7.90	31.20
Germany	2.83	26.39	3.98	4.30
Italy	17.44	10.87	5.34	5.15
Netherlands	20.43	31.02	42.58	30.50
Switzerland	7.99	24.90	2.20	0.51
U.K.	15.81	55.57	12.75	23.93
U.S.A.	4.88	6.27	47.83	19.37
China	8.16	7.70	6.46	45.54
Canada	**86.35**	**74.85**	**54.51**	**86.87**
Japan	**81.75**	**79.63**	**60.00**	**70.09**
Korea	31.77	68.76	41.47	57.09
Taiwan	95.38	71.27	89.09	26.15
Hong Kong	11.72	18.36	20.45	7.52
New Zealand	19.69	19.33	40.72	19.97
Indonesia	94.73	59.91	68.34	10.67
Malaysia	26.35	19.50	23.28	30.44
Philippines	0.23	0.97	15.03	7.73
Singapore	54.08	23.80	53.48	15.40
Thailand	0.00	3.42	58.07	29.15

Source: Estimates compiled using data obtained from the ABS, Cat.no. 5436.0 and 5437.0.

5.4.3 Growth in Intra-Industry Trade in Pharmaceuticals

In explaining the growth in intra-industry trade over time, the use of the changes in Grubel-Lloyd index leads to biased and misleading results (Menon and Dixon, 1996: 161). Thus, the measures used in this analysis are based on the indexes developed in Menon and Dixon (1996) which express changes in intra-industry trade in terms of the contributions of exports and imports to growth in total trade, net trade and intra-industry trade. As explained in Section 5.3.2, Menon-Dixon indexes are no longer valid if there are status switches in the trade data. Therefore, trade data used in this analysis were first tested for status switches. The results reported in Appendix 5.2 confirm that there are no status switches in the trade data, except for Australia's bilateral trade with Belgium between 1974-78, and with Korea between 1979-83. Thus, there are no conclusive results on the growth of bilateral trade between Australia and each of these two countries over the two periods mentioned above.

All contribution measures of Menon-Dixon indexes for the periods 1974-1978, 1979-83 and 1984-92 are given in Appendixes 5.3, 5.4 and 5.5, respectively.

Table 5.4 presents the estimated contributions of exports and imports to growth in Australia's pharmaceutical trade for three different periods: 1974-78, 1979-83 and 1984-92.

Table 5.4: Percentage Growth in Total Trade (TT_i), Net Trade (NT_i) and Intra-Industry Trade (IIT_i) for Pharmaceuticals

Year	1974-78	1979-83	1984-92
Cxtt	2.23	1.40	3.49
Cmtt	-2.57	0.84	9.00
TT_i	-0.35	2.25	12.49
Cxnt	-5.19	-4.67	-7.54
Cmnt	-5.99	2.82	19.44
NT_i	-11.18	-1.85	11.89
Cxiit	7.80	4.00	13.00
Cmiit	0.00	0.00	0.00
IIT_i	7.80	4.00	13.00

Source: Estimates compiled using data from the United Nations, International Trade Statistics Yearbook (various years).

Note: TT_i = *Cxtt + Cmtt, where Cxtt and Cmtt are the contributions of export growth and import growth to growth in total trade.*

NT_i = *Cxnt + Cmnt, where Cxnt and Cmnt are the contributions of export growth and import growth to growth in net trade.*

IIT_i = *Cxiit + Cmiit, where Cxiit and Cmiit are the contributions of export growth and import growth to growth in intra-industry trade.*

With respect to the percentage growth in total pharmaceutical trade (TT_i), the contributions of export growth to total trade (Cxtt) are all positive but become lower than those of import growth to total trade (Cmtt) for the period 1984-92. This reflects the strong growth in pharmaceutical imports by Australia during 1984-92. The growth in total trade of pharmaceuticals increases from -0.35 per cent for 1974-78 to 12.49 per cent for 1984-92, of which import contributions increase from -2.57 per cent to 9.00 per cent, respectively. It is not surprising that the contributions of exports to the growth in net trade (Cxnt) are all negative in the three periods under consideration as imports are the dominant contributor to net trade.

The contributions of imports to the growth in intra-industry trade (Cmiit) are all zero. The contribution of exports to the growth in intra-industry trade (Cxiit) increases from 7.80 per cent from during 1974-78 to 13.00 per cent during 1984-92.

This confirms that all of the growth in intra-industry trade for Australia's pharmaceuticals is mainly due to export growth rather than import growth.

Table 5.5 summarises the percentage growth in total trade (TT_i) for Australia's bilateral trade in pharmaceuticals. The growth in Australia's pharmaceutical trade with each individual country increases, with particularly high rates in the period 1984-92. This reflects the changes in trade policy in terms of the reduction of trade barriers and the openness of Australia's trade to the rest of the world. An increase in pharmaceutical trade between Australia and most pharmaceutical exporting countries in Western Europe (Belgium, France, Germany, the Netherlands and the U.K.) results from an increase in the contributions of import growth to growth in total trade (Cmtt) rather than those of export growth. However, growth in total trade with some countries such as Italy, Switzerland, the U.S. and Canada declines due to a decrease in the contributions of import growth to growth in total trade, particularly in the period 1984-92.

Table 5.5: Percentage Growth in Total Trade (TT_i) for Australia's Bilateral Trade in Pharmaceuticals.

Country	1974-78			1979-83			1984-92		
	Cxtt	Cmtt	TTi	Cxtt	Cmtt	TTi	Cxtt	Cmtt	TTi
Belgium	*	*	*	3.25	-0.76	2.50	0.56	26.13	26.69
France	-0.90	16.04	15.14	-0.52	24.88	24.36	4.10	28.50	32.60
Germany	0.51	-4.78	-4.27	-0.85	13.22	12.37	0.33	14.39	14.72
Italy	-1.54	26.03	24.49	1.08	24.46	25.54	0.74	9.19	9.93
Netherlands	-1.97	2.67	0.70	0.48	2.70	3.17	3.29	28.50	32.79
Switzerland	-0.43	-8.07	-8.49	0.35	20.09	20.44	-0.01	12.98	12.97
U.K.	4.62	4.88	9.50	-0.78	-0.47	-1.25	2.71	17.36	20.07
U.S.A.	0.24	9.11	9.35	9.14	11.21	20.36	0.05	12.23	12.28
Canada	46.50	0.38	46.87	8.53	24.65	33.18	7.47	6.16	13.63
New Zealand	14.32	-0.21	14.11	8.42	5.16	13.57	14.24	0.45	14.70
Japan	3.82	10.45	14.26	-8.55	3.76	-4.79	2.73	5.87	8.60
Korea	36.94	41.42	78.35	*	*	*	9.52	12.79	22.30
China	0.00	20.48	20.48	0.64	9.36	10.00	5.54	16.02	21.56
Hong Kong	17.86	1.68	19.54	-18.87	-0.21	-19.08	22.93	0.84	23.77
Taiwan	40.85	14.82	55.67	-16.82	5.84	-10.98	24.73	2.13	26.86
Indonesia	11.71	-0.90	10.81	1.88	2.72	4.60	11.67	-3.39	8.28
Malaysia	18.78	0.33	19.11	-11.72	6.07	-5.65	11.72	2.59	14.30
Philippines	18.30	-0.49	17.81	-12.05	0.00	-12.05	21.76	0.23	21.99
Singapore	4.75	-4.66	0.08	-19.73	0.23	-19.50	16.98	6.23	23.21
Thailand	10.50	0.00	10.50	-9.65	16.09	6.44	19.37	2.38	21.75

Source: From Appendixes 5.3, 5.4 and 5.5.
*Note: * No conclusive results due to the presence of status switches.*

On the other hand, the percentage growth in total trade between Australia and its neighbouring countries (Japan, China, Hong Kong, Taiwan and other ASEAN) increases as a result of a rise in the export and import contributions to total trade with these countries.

Results presented in Table 5.6 show that the growth in net trade (NT_i) between Australia and most individual countries have been increasing over the three periods. The results imply that the contributions of export growth to growth in net trade (Cxnt) between Australia and pharmaceutical exporting countries are negative, indicating that imports exceed exports.

Table 5.6: Percentage Growth in Net Trade (NT_i) for Australia's Bilateral Trade in Pharmaceuticals.

Country	1974-78			1979-83			1984-92		
	Cxnt	Cmnt	NT_i	Cxnt	Cmnt	NT_i	Cxnt	Cmnt	NT_i
Belgium	*	*	*	-3.65	-0.85	-4.50	-0.58	27.29	26.71
France	1.01	18.08	19.10	0.56	26.36	26.92	-4.85	33.74	28.89
Germany	-0.54	-5.02	-5.56	0.96	14.88	15.84	-0.35	15.02	14.68
Italy	1.77	29.82	31.59	-1.15	25.98	24.84	-0.83	10.27	9.45
Netherlands	3.45	4.67	8.12	-0.81	4.60	3.79	-5.86	38.90	33.05
Switzerland	0.46	-8.76	-8.30	-0.39	22.22	21.83	0.01	13.23	13.23
U.K.	-5.95	6.29	0.34	1.39	-0.83	0.56	-3.39	21.72	18.33
U.S.A.	-0.25	9.71	9.46	12.38	15.18	2.80	-0.07	16.37	16.30
Canada	124.4	-1.01	123.4	-1042.8	3013.6	1970.8	-49.34	40.70	-8.64
New Zealand	17.38	0.26	17.63	11.73	-7.19	4.54	19.89	-0.63	19.26
Japan	-14.33	39.23	24.90	-69.58	30.61	-38.97	-7.45	16.05	8.60
Korea	207.3	-232.3	-25.13	*	*	*	-28.05	37.70	9.65
China	0.00	21.34	21.34	0.69	10.07	10.75	-7.01	20.28	13.27
Hong Kong	20.53	-1.93	18.59	20.17	0.23	20.40	24.96	-0.91	24.05
Taiwan	1633.5	-592.6	1040.8	71.05	-24.66	46.38	43.38	-3.73	39.65
Indonesia	53.37	4.09	57.46	-5.47	-7.92	-13.40	22.64	6.58	29.22
Malaysia	24.33	-0.43	23.90	16.48	-8.54	7.94	18.02	-3.98	14.04
Philippines	19.98	0.54	20.51	12.15	0.00	12.15	23.08	-0.24	22.84
Singapore	10.83	10.64	21.47	23.62	-0.28	23.35	43.34	-15.91	27.43
Thailand	10.51	0.00	10.51	13.92	-23.21	-9.28	29.24	-3.59	25.64

Source: From Appendixes 5.3, 5.4 and 5.5.
*Note: * No conclusive results due to the presence of status switches.*

In contrast, the contributions of import growth to growth in net trade (Cmnt) in pharmaceuticals between Australia and its neighbouring countries (Hong Kong and Taiwan) are all negative, reflecting that exports exceed imports from these countries in the three periods. However, the percentage growth in net trade (NT_i) over the three periods continues to rise, particularly between 1984-1992, while growth in net trade with some countries such as Italy, Switzerland, Canada and Taiwan decline over time.

The contributions of exports and imports to the growth in intra-industry trade for Australia's bilateral trade with its trading partners are reported in Table 5.7.

Table 5.7: Percentage Growth in Intra-Industry Trade (IIT_i) for Australia's Bilateral Trade in Pharmaceuticals.

Country	1974-78			1979-83			1984-92		
	Cxiit	Cmiit	IIT_i	Cxiit	Cmiit	IIT_i	Cxiit	Cmiit	IIT_i
Belgium	*	*	*	60.4	0.00	60.40	26.40	0.00	26.40
France	-15.90	0.00	-15.90	-18.7	0.00	-18.70	52.80	0.00	52.80
Germany	21.10	0.00	21.10	-15.3	0.00	-15.30	15.80	0.00	15.80
Italy	-24.30	0.00	-24.30	36.9	0.00	36.90	14.00	0.00	14.00
Netherlands	-9.20	0.00	-9.20	2.30	0.00	2.30	32.10	0.00	32.10
Switzerland	-10.70	0.00	-10.70	7.30	0.00	7.30	-0.90	0.00	-0.90
U.K.	41.30	0.00	41.30	-3.60	0.00	- 3.60	27.00	0.00	27.00
U.S.A.	7.70	0.00	7.70	70.0	0.00	70.00	0.40	0.00	0.40
Canada	0.00	1.20	1.20	17.20	0.00	17.20	17.60	0.00	17.60
New Zealand	0.00	-2.40	-2.40	0.00	36.50	36.50	0.00	3.20	3.20
Japan	10.40	0.00	10.40	19.50	0.00	19.50	8.60	0.00	8.60
Korea	0.00	100.80	100.80	*	*	*	28.80	0.00	28.80
China	0.00	0.00	0.00	-18.20	0.00	-18.20	52.80	0.00	52.80
Hong Kong	0.00	25.90	25.90	0.00	-6.60	-6.60	0.00	20.60	20.60
Taiwan	0.00	30.40	30.40	0.00	15.30	15.30	0.00	9.90	9.90
Indonesia	0.00	-2.30	-2.30	0.00	8.30	8.30	0.00	-14.00	-14.00
Malaysia	0.00	2.90	2.90	0.00	42.10	42.10	0.00	14.80	14.80
Philippines	0.00	-11.70	-11.70	0.00	0.00	0.00	0.00	8.00	8.00
Singapore	0.00	-16.60	-16.60	0.00	2.80	2.80	0.00	20.50	20.50
Thailand	0.00	0.00	0.00	0.00	104.90	104.90	0.00	14.10	14.10

Source: From Appendixes 5.3, 5.4 and 5.5.
*Note: * No conclusive results due to the presence of status switches.*

The results presented in Table 5.7 confirm that, during the three periods under consideration, most of the growth in intra-industry trade between Australia and pharmaceutical exporting countries is due to the contribution of exports to growth in intra-industry trade (Cxiit). The contributions of imports (Cmiit) are all zero for these countries, indicating that Australia is a net importer of pharmaceuticals from these countries. Pharmaceutical exports to Switzerland make a negative contribution to the growth in intra-industry trade between 1984-92 as exports are smaller than imports. On the other hand, all of the growth in intra-industry trade with other countries such as New Zealand, Hong Kong and Taiwan, is due to the contribution of import and zero contribution of export growth by these countries.

5.5 Conclusion

In this chapter the theory and measurements of intra-industry trade have been reviewed and the Grubel-Lloyd intra-industry trade index and Menon-Dixon indexes are calculated in order to examine the extent and growth in Australia's intra-industry trade in pharmaceuticals. Although Grubel-Lloyd index is commonly used, this index is sometimes biased and misleading when used to measure the growth in intra-industry trade over time. Menon-Dixon indexes, on the other hand, provide alternative measures by decomposing the growth in total trade, net trade and intra-industry trade into the contribution terms.

The analysis based on Grubel-Lloyd index and Menon-Dixon indexes suggest that, among the OECD countries, Australia has a relatively small extent of intra-industry trade in pharmaceuticals. Australia mainly imports pharmaceutical products from major pharmaceutical exporting countries, and hence the values of imports are very much higher than those of exports. The extent of bilateral intra-industry trade in pharmaceuticals between Australia and the majority of its trading partners is also small. However, the intra-industry trade indexes between Australia and Canada, and between Australia and Japan, are relatively large.

The growth of total trade and net trade in pharmaceuticals between Australia and each individual country has increased over time, resulting from an increase in the contributions of import growth from pharmaceutical exporting countries and the contributions of export growth to Australia's neighbouring countries. Similarly, the growth of Australia's intra-industry trade in pharmaceuticals has increased over time, due to the contributions of imports from pharmaceutical exporting countries and the contributions of exports to Australia's neighbouring countries.

Having examined the extent and growth of Australia's intra-industry trade in pharmaceuticals in Chapter 5, an analysis of the determinants of Australia's intra-industry trade in pharmaceuticals is undertaken in Chapter 6.

CHAPTER 6

DETERMINANTS OF INTRA-INDUSTRY TRADE IN PHARMACEUTICALS

6.1 Introduction

The determinants of Australia's intra-industry trade in manufactures have been analysed in several recent studies (Siriwardana, 1990; Ratnayake and Athukorala, 1992; Matthews, 1995). These studies attempt to explain the relationship between Australia's intra-industry trade in manufactures and its determinants in terms of country and industry characteristics. However, there has been no empirical work so far which provides an analysis of the determinants of Australia's intra-industry trade in one particular industry. As described in Chapter 2, pharmaceutical industry is one of Australia's elaborately transformed manufacturing industries, and Australia's international trade in pharmaceuticals has rapidly grown during the past two decades. As Chapter 5 shows, the pharmaceutical industry is characterised by a wide range of differentiated products, economies of scale and imperfect competition, giving rise to intra-industry trade.

The purpose of this chapter is to analyse the determinants of Australia's intra-industry trade in pharmaceuticals. In order to accomplish this purpose, two separate models are developed and estimated: Australia's intra-industry trade in pharmaceuticals with the rest of the world, and Australia's bilateral intra-industry trade in pharmaceuticals with its major trading partners. The chapter begins with an overview of empirical studies on the determinants of intra-industry trade, in Section 6.2. In Section 6.3, the econometric models of the determinants of intra-industry trade in pharmaceuticals are developed. Data and sources of data are described in Section 6.4. The results of the analysis are presented and discussed in Section 6.5. The final section summarises the major findings.

6.2 Determinants of Intra-Industry Trade: A Review

Analysing the determinants of intra-industry trade is a relatively new area of international economic research. Previous empirical studies have used either time-series or cross-sectional data. The studies that employ time-series data on trade flows have used annual data from 1970 onward to assess the propositions concerning intra-industry trade. On the other hand, the studies that use cross-sectional data have concentrated on specific year(s). Compared to the time-series analysis, cross-sectional analysis is less problematic as it normalises for time, and cross-sectional data are more consistent and suitable for testing the hypothesised relationships, especially between income per capita and intra-industry trade (Greenaway and Milner, 1986:94-95).

In previous studies, hypotheses in relation to the determinants of intra-industry trade have been tested at two principal levels of interest: country and industry. The country characteristics refer to major features belonging to a country concerned, such as market size, income, distance, trade barriers, and taste similarity; while the industry characteristics consists of product differentiation (by style, quality or technology), scale economies, market structure and multinational corporation (MNC) activities. Since the intensity of intra-industry trade for any given industry varies depending on country characteristics of the trading partners and industry characteristics of commodity demand and supply, both types of characteristics serve as independent variables in explaining the degree of intra-industry trade of a country (Loertscher and Wolter, 1980; Greenaway and Milner, 1986). Balassa and Bauwens (1987) have found important evidence of the interactions of these two sets of determinants.

6.2.1 Country Determinants

Among the country characteristics, per capita income is one of the most widely used determinants. It has been observed in the empirical work of Bergstrand (1990), Narayan and Dardis (1994), Somma (1994), Stone and Lee (1995), and Thorpe (1995) that the growth of per capita income has a positive relationship with the increase in intra-industry trade. According to Lancaster and Wolter (1980), as per capita income grows, total demand of each consumer for various products increases. More varieties of products are supplied to satisfy consumer's tastes according to consumer preferences which are affected by income. This phenomenon leads to two-way trade of differentiated products, that is intra-industry trade. Countries with similar levels of per capita income have an increasing tendency towards bilateral intra-industry trade. However, Greenaway and Milner (1986:95) suggest that this evidence is more consistent if cross-sectional data are used.

Loertscher and Wolter (1980) state that the market size of a country, measured in terms of average gross domestic product (GDP), can have a strong positive association with the extent of intra-industry trade. This proposition has been supported by Narayan and Dardis (1994), Somma (1994) and Hellvin (1994) that the larger the market size, the greater the extent of intra-industry trade. In contrast, the trading countries which have large differences in the market size tends to have a small extent of intra-industry trade.

Krugman (1981) and Helpman (1981) state that intra-industry trade is more noticeable between countries with similar factor endowments in terms of the ratio of total capital to the labour force (capital-labour ratio). Intra-industry trade tends to be larger between countries which have similar capital-labour ratios, rather than those with different ratios. Thus, the capital-labour ratio is used to represent the level of a country's factor endowments which affect the extent of intra-industry trade. However, studies which attempt to explain the impact of a country's factor endowment on intra-industry trade have come up with contradictory results. For example, Clark (1993) finds a negative association between the capital-labour ratio and intra-industry trade, but Narayan and Dardis (1994) find a positive relationship.

Other country characteristics such as natural barriers and trade restrictions are also important determinants of the extent of intra-industry trade. Natural barriers such as physical and cultural distances show significantly negative influences on intra-industry trade. Language barriers, border differences and transport costs measured by the distance between countries, are used as proxies for natural barriers. Loertscher and Wolter (1980), Clark (1993), Narayan and Dardis (1994), Stone and Lee (1995), and Thorpe (1995) establish a negative relationship between the distance and intra-industry trade. Balassa and Bauwens (1987) find a positive relationship between the use of offshore assembly provisions and intra-industry trade.

The effect of tariff and non-tariff barriers on intra-industry trade was expected to be negative by the studies of Pagoulatos and Sorensen (1975), Loertscher and Wolter (1980), Kim (1992), Clark (1993), Narayan and Dardis (1994), Stone and Lee (1995), and Thrope (1995). However, the effect of trade restrictions remains ambiguous, partly because of the absence of well-defined composite measurements of trade restrictions.

6.2.2 Industry Determinants

Apart from country characteristics, industry characteristics exert an important influence on intra-industry trade. The variations of intra-industry trade intensity depend upon commodity-specific demand and supply conditions across industries. This can be explained in terms of product differentiation and economies of scale which are two main explanatory factors of industry determinants.

Empirical analyses have attempted to use different indexes as proxies for product differentiation. One of the well-known proxies used is the Hufbauer index which refers to the ratio of standard deviation of export unit values of shipments and the unweighted mean of those unit values. This index represents the coefficient of variation of export unit values in the compositions of shipments among countries. It has been used in the empirical analyses of Pagoulatos and Sorensen (1975), Helleiner (1976), Caves (1981), Culem and Lundberg (1986), Tharakan (1984, 1986), Narayan and Dardis (1994). However, Gray and Martin (1980) argue that an export unit value index may not represent a reliable proxy for product differentiation because of its sensitivity problem to variations in the composition of trade within SITC categories. Greenaway (1989:233-234) contends that this index should proxy vertical and technological differentiation, rather than horizontal differentiation. Flam and Helpman (1987) developed another proxy for vertical product differentiation by using the relationship between income distribution and population growth. While there is some debate over the most appropriate proxy for product differentiation, a recent study by Greenaway et al. (1995) suggests that the determinants of vertical and horizontal intra-industry trade should be analysed separately in order to explain the presence of intra-industry trade. As the determinants of vertical and horizontal intra-industry trade are different, vertical intra-industry trade is positively related to a large number of firms in an industry, while horizontal intra-industry trade tends to be associated with an industry which consists of few firms.

In the studies of industrial organisation, the advertising-sales ratio has been used as a measure of product differentiation. Based on the assumption that advertising expenditure is directly related to the level of consumer's preferences, this proxy is used by Goodman and Ceyhun (1976), Helleiner (1976), Caves (1981), Kim (1992), Ratnayake and Athukorala (1992), and Clark (1993). Some researchers such as Caves and Khalizadeh-Shirazi (1977), and Greenaway (1989) have argued that the advertising-sales ratio is helpful only in the analysis of horizontal product differentiation because it consists of a large advertising intensity.

According to Hughes (1993), product differentiation can be represented by three variables: the ratio of R&D expenditure to value-added, the ratio of professional staff to total employment, and the ratio of operative staff to total employment. The ratio of R&D expenditure to value added has a positive effect on intra-industry trade when different countries have high technology in different parts of the same industry, and a negative effect on intra-industry trade when one country has a higher level of technology in production than the others. The other two measures involve the structure of labour force which produces and promotes product development and technological change generally.

The other industry determinant is the level of economies of scale, which appears to be used in almost all the studies concerned with industry determinants. Loertscher and Wolter (1980) discover that the relationship between intra-industry trade and economies of scale is negative and significant. Marvel and Ray (1987) employ midpoint plant shipments as a common variable in the industrial organisation to proxy scale economies. Hughes (1993) adopts two measures of economies of scale: the ratio of average plant size to total net output and the ratio of firm-seller concentration. The results show that both measures have a negative impact on intra-industry trade as the measures reflect the level of product standardisation. Examples of other studies yielding a similar result include Caves (1981), Greenaway and Milner (1984), Balassa (1986), and Balassa and Bauwens (1987).

A number of studies have been conducted by using either the country determinants or the industry determinants of intra-industry trade (Greenaway and Milner, 1984; Globerman and Dean, 1990; Matthews, 1995; and Stone and Lee,1995). In some cases, both industry and country determinants are analysed

(Pagoulatos and Sorensen, 1975; Balassa and Bauwens, 1987; Clark, 1993; Hughes, 1993; Narayan and Dardis, 1994; Somma, 1994; and Thorpe, 1995). Some researchers (for example, Greenaway and Milner, 1986) have suggested that the main empirical work should focus on industry, rather than country, determinants.

6.3 The Models

In this study, determinants of Australia's intra-industry trade in pharmaceuticals are analysed through the estimation of two separate models: Australia's intra-industry trade in pharmaceuticals with the rest of the world, and Australia's bilateral intra-industry trade in pharmaceuticals with its major trading partners.

6.3.1 Australia's Intra-Industry Trade in Pharmaceuticals with the Rest of the World

In the empirical studies of Pagoulatos and Sorensen (1975), Lundberg (1982), Toh (1982), Greenaway and Milner (1984), Ratnayake and Athukorala (1992), and Thorpe (1995), intra-industry trade of a country (i) with the rest of the world (w) is explained using the following function:

$$IIT_{iw} = f\{ PDIF_i, ES_i, MS_i, DFI_i, TR_i, CAT\} \quad (6.1)$$

where, IIT_{iw} = Grubel-Lloyd intra-industry trade index between country (i) and the rest of the world (w),

$PDIF_i$ = product differentiation,

ES_i = economies of scale,

MS_i = market structure,

DFI_i = direct foreign investment,

TR_i = trade barriers,

CAT = categorical aggregation of commodities.

The above model is modified for the purpose of this study, and the model of Australia's intra-industry trade in pharmaceuticals with the rest of the world is specified as:

$$IIT_{aw} = f\{ PDIF_a,\ ES_a,\ MS_a,\ DD_a,\ KL_a,\ RA_a \} \tag{6.2}$$

where, IIT_{aw} is the extent of intra-industry trade in pharmaceuticals between Australia (a) and the rest of the world (w). IIT_{aw} is hypothesised to depend upon the following explanatory variables:

Product Differentiation ($PDIF_a$)

As pharmaceutical productions are research-intensive activities, following Hughes (1993), in this study product differentiation in pharmaceuticals is measured by the ratio of research and development expenditure (RDX_a) to the value added (VA_a) in Australia's pharmaceutical and veterinary products:

$$PDIF_a = RDX_a \ / \ VA_a \tag{6.3}$$

Since the survey of R&D expenditure and value added for Australia's pharmaceutical and veterinary products was undertaken biennially by the Australian Bureau of Statistics during 1975-1992, the data series for RDX_a and VA_a are incomplete. Therefore, a complete set of data for RDX_a and VA_a, were generated through extrapolation.

It is hypothesised that an increase in R&D expenditure relative to value added will increase the variety of technologically differentiated pharmaceutical products which will have a positive effect on the extent of intra-industry trade.

Economies of Scale (ES_a)

Economies of scale occur when firms try to maximise profits and minimise production costs by reducing the unit cost of production. A large volume for a selected variety or quality of goods are produced in order to supply the local market and to exchange an excess amount for other varieties from overseas. If this is the case, then there will be a large number of differentiated products available in the market as a result of an increase in two-way trade within the same industry. According to Grubel and Lloyd (1975: 6), economies of scale can be measured by the size of firms, the size of plant or the length of production. In this study, economies of scale for Australia's pharmaceutical industry (ES_a) are calculated as the ratio of pharmaceutical turnover (TUR_a) in constant prices to the number of pharmaceutical establishments (MS_a), as shown in the following formula:

$$ES_a = TUR_a / MS_a \qquad (6.4)$$

In the absence of a complete series of data for TUR_a and MS_a, the technique of extrapolation through regression was applied in order to generate a complete set of data for TUR_a and MS_a. It is hypothesised that there is a positive relationship between economies of scale and intra-industry trade in pharmaceuticals.

Market Structure (MS_a)

The relationship between intra-industry trade and market structure in terms of numbers of firms, market size and entry conditions remain inconclusive in the literature of intra-industry trade. Theoretically, industries with a large number of firms producing differentiated products tend to engage in a higher degree of two-way trade rather than those with only a few firms (Greenaway and Milner, 1986: 112). When a large number of firms enter the market, they are associated with a great variety of differentiated products under imperfect competition. The market structure in Australia's pharmaceuticals is thus proxied by the number of pharmaceutical establishments (MS_a). It is expected that the number of pharmaceutical establishments will have a positive effect on the level of intra-industry trade.

Degree of Economic Development (DD_a)

The degree of economic development is directly related to the growth of per capita income of a country. In the view of Linder (1961) and Barker (1977), an increase in per capita income will result in a higher demand for more complex and differentiated products. Obviously, consumer tastes and preferences are dependent on and varied by income (Lancaster, 1980; Markusen, 1986 and Bergstrand, 1990).

The demand for differentiated products rises as income increases. Thus, the degree of economic development measured by per capita income is expected to have a positive effect on intra-industry trade. In this study, Australia's per capita GNP is used as a measure of the degree of Australia's economic development (DD_a), which is expected to have a positive relationship with intra-industry trade in pharmaceuticals.

Technological Advancement (KL_a)

In a high technology industry, manufacturers differentiate products mainly by the degree of technological advancement in each product line. The country with a higher capital stock relative to its labour force is more likely to produce differentiated products and engage in intra-industry trade (Helpman, 1981; Krugman, 1981). Pharmaceutical production, for instance, also depends on a country's level of capital formation. Hence, in this study the ratio of total capital to the labour force (Kl_a) is used to represent Australia's technological advancement:

$$KL_a = (K_a / L_a) \tag{6.5}$$

where, K_a is the real capital formation and L_a is the total labour force of Australia. The total capital to the labour force ratio is hypothesised to have a positive relationship with intra-industry trade.

Trade Barriers (RA_a)

Various aspects of commercial policy in terms of tariff and non-tariff trade barriers are expected to have a negative effect on intra-industry trade. The imposition of trade restrictions on a particular industry helps promote domestic production of the industry, but reduces the volume and range of traded products (Falvey, 1981). Following Matthews (1995), the average effective rate of assistance (RA_a) is used in this study to measure the extent of the government assistance including tariff, import restrictions and export incentives. Due to the incomplete data series for effective rate of assistance for Australia's pharmaceuticals, the average effective rate of assistance to chemical, petroleum and coal products (ASIC 27) is used as a proxy for the level of barriers to pharmaceutical trade. Medical and pharmaceutical products are a sub-category of ASIC 27 in all the classifications. It is hypothesised that RA_a is negatively related to Australia's intra-industry trade in pharmaceuticals.

In order to obtain an appropriate functional form for the model of Australia's intra-industry trade in pharmaceuticals with the rest of the world [equation (6.2)], the following log-linear and log-log functions are estimated and tested using diagnostic statistics:

Log-linear form:

$$E_1: LIIT_{aw} = \alpha_0 + \alpha_1 PDIF_a + \alpha_2 ES_a + \alpha_3 MS_a + \alpha_4 DD_a + \alpha_5 KL_a + \alpha_6 RA_a + u_a \quad (6.6)$$

Log-log form:

$$E_2: LIIT_{aw} = \alpha_0 + \alpha_1 LPDIF_a + \alpha_2 LES_a + \alpha_3 LMS_a + \alpha_4 LDD_a + \alpha_5 LKL_a + \alpha_6 LRA_a + u_a \quad (6.7)$$

Since the dependent variable used in this analysis is the standard Grubel-Lloyd index which is restricted to a theoretical range of 0-100, the logistic transformation of the Grubel-Lloyd index is applied as follows:

$$LIIT_{aw} = \log \frac{[IIT_{aw}]}{[100 - IIT_{aw}]} \quad (6.8)$$

α_0 is the intercept term, α_1, α_2, α_3, α_4, α_5, and α_6 are the slope coefficients, and u_a is an error term. α_1, α_2, α_3, α_4 and α_5 are expected to be positive because an acceleration of product differentiation, economies of scale, the number of firms, economic development and technological advancement will increase the extent of Australia's intra-industry trade in pharmaceuticals. α_6 is expected to be negative as trade barriers are hypothesised to reduce the extent of intra-industry trade in pharmaceuticals.

6.3.2 Australia's Bilateral Intra-Industry Trade in Pharmaceuticals

In the previous studies of bilateral intra-industry trade (Siriwardana, 1990; Hellvin, 1994; Narayan and Dardis, 1994; and Matthews, 1995), the extent of intra-industry trade between a pair of countries (that is, bilateral intra-industry trade) is modelled by the following function:

$$IIT_{ij} = f\{ AGNP_{ij},\ DGNP_{ij},\ APGNP_{ij},\ DPGNP_{ij},\ AKL_{ij},\ DKL_{ij},\ DIS_{ij},\ TR_{ij},\ CBOR_{ij},\ LANG_{ij},\ PDIF_{ij},\ ES_{ij}\} \quad (6.9)$$

where, i and j = trading countries i and j,

IIT_{ij} = Grubel-Lloyd index of intra-industry trade,

$AGNP_{ij}$ = average value of GNP,

$DGNP_{ij}$ = absolute difference in GNP,

$APGNP_{ij}$ = average value of per capita GNP,

$DPGNP_{ij}$ = absolute difference in per capita GNP,

AKL_{ij} = average value of the ratio of total capital to the labour force,

DKL_{ij} = absolute difference in the ratio of total capital to the labour force,

DIS_{ij} = distance,

TR_{ij} = trade restriction,

$CBOR_{ij}$ = common border,

$LANG_{ij}$ = common language,

$PDIF_{ij}$ = product differentiation,

ES_{ij} = economies of scale.

Due to the unavailability of data regarding pharmaceutical industry characteristics ($PDIF_{ij}$ and ES_{ij}) of Australia's trading partners, the analysis here will concentrate only on country characteristics. Thus, the model of Australia's bilateral intra-industry trade in pharmaceuticals is specified as:

$$IIT_{aj} = f\{ AGNP_{aj}, DGNP_{aj}, APGNP_{aj}, DPGNP_{aj}, AKL_{aj}, DKL_{aj}, DIS_{aj}, LANG_{aj}, TRRA_{aj} \} \quad (6.10)$$

where, IIT_{aj} is the standard Grubel-Lloyd index of intra-industry trade in pharmaceuticals between Australia ($_a$) and each individual trading partner ($_j$). The 14 trading partners, for which data are available, are France, Germany, Italy, Belgium, Switzerland, the Netherlands, the U.K., the U.S.A., Canada, New Zealand, Japan, Korea, the Philippines and Thailand. Following the studies of Narayan and Dardis (1994), and Matthews (1995), the extent of bilateral intra-industry trade in pharmaceuticals between Australia and its 14 trading partners is hypothesised to depend upon the following explanatory variables:

Market Size

$AGNP_{aj}$ and $DGNP_{aj}$ are the average real GNP and the absolute difference in real GNP between Australia and country j, respectively. GNP is used to measure the market size of a country. According to Lancaster (1980), and Loertscher and Wolter (1980), products tend to be differentiated as two countries have the similar market size. As a result, the extent of intra-industry trade is expected to be high. In other words, the greater the average real GNP the greater the extent of intra-industry trade between these two countries. On the other hand, larger absolute differences in market size are expected to have a negative impact on intra-industry trade. This proposition has been supported by Helpman (1987), Lundberg (1992) and Kim (1992).

Income

$APGNP_{aj}$ and $DPGNP_{aj}$ are the average per capita GNP and the absolute difference in per capita GNP between Australia and country j. Per capita GNP is used to measure income of a country. Linder (1961), Lancaster (1980) Markusen (1986) and Bergstrand (1990) show that income affects consumer tastes and preferences. As income increases the demand for differentiated products will increase. Hence, it is hypothesised that the higher the average of per capita incomes between Australia and country j, the larger the share of intra-industry trade. In contrast, a wide absolute difference in income means a small extent of intra-industry trade between two trading countries.

Factor Endowment

AKL_{aj} and DKL_{aj} are the average of, and the absolute difference in, the total capital to total labour force ratio between Australia and country j, respectively. The capital-labour ratios represent the nations' relative factor endowments. As pointed out by Dixit and Norman (1980), Helpman (1981), and Helpman and Krugman (1985), differentiated products are likely to be more capital-intensive. Consequently, the production of differentiated goods will expand in relation to capital endowments. Any two countries with high total capital to total labour force ratios are more likely to produce more differentiated products and engage in intra-industry trade to a large extent. It is expected that the average of total capital to total labour force ratios will have a positive effect, while the absolute difference in the ratios will have a negative effect, on the extent of intra-industry trade in pharmaceuticals between Australia and country j.

Distance

Following Hellvin (1994), Narayan and Dardis (1994), and Matthews (1995), DIS_{aj} is specified as the distance between Sydney, Australia and the major port of country j, measured in nautical miles. As suggested by Conlon (1985), Siriwardana (1990), and Ratnayake and Athukorala (1992), distances between Australia and the trading partners have an important impact on intra-industry trade. Geographical characteristics of countries determine production costs and transportation time. Located in the southern hemisphere, Australia is at a disadvantage for trade in terms of transport costs. Therefore, it is expected that the distance between Australia and country j (DIS_{aj}) will have a negative effect on intra-industry trade.

Common Language

$LANG_{aj}$ represents the common language (English) shared by Australia and country j. It is expected that the existence of a common language between Australia and its trading partners will have a positive impact on the extent of intra-industry trade. $LANG_{aj}$ is specified as one for the English speaking countries, and as zero for the non-English speaking countries.

Special Trading Arrangements

In this analysis, $TRRA_{aj}$ is used to indicate the special trading arrangements between Australia and country j. $TRRA_{aj}$ is specified as one for New Zealand (because Australia and New Zealand have engaged in the Australia-New Zealand Closer Economic Relations Trading Agreement), and as zero for other trading partners. It is expected that the special trading arrangement will have a positive impact on Australia's intra-industry trade in pharmaceuticals.

According to Grubel and Lloyd (1975, 129-131), special trading arrangements, such as customs unions and regional trading arrangements, will result in an increase in intra-industry trade among the countries involved. A number of studies has used a dummy variable to capture the impact of economic integration, or special trading arrangements among countries (Loertscher and Wolter, 1980; Havrylyshyn and Civan, 1983; and Globerman and Dean, 1990).

The hypotheses in relation to the bilateral intra-industry trade in pharmaceuticals between Australia and its 14 trading partners are tested, using pooled cross-section and time-series data for the period 1975-1992. In order to obtain an appropriate functional form, the following log-linear and log-log forms are estimated and tested using diagnostic statistics:

Log-linear form:

$$E_1: \ LIIT_{aj} = \beta_0 + \beta_1 AGNP_{aj} + \beta_2 DGNP_{aj} + \beta_3 APGNP_{aj} + \beta_4 DPGNP_{aj} + \beta_5 AKL_{aj} + \beta_6 DKL_{aj} + \beta_7 DIS_{aj} + \beta_8 LANG_{aj} + \beta_9 TRRA_{aj} + u_{aj} \qquad (6.11)$$

Log-log form:

$$E_2: \ LIIT_{aj} = \beta_0 + \beta_1 LAGNP_{aj} + \beta_2 LDGNP_{aj} + \beta_3 LAPGNP_{aj} + \beta_4 LDPGNP_{aj} + \beta_5 LAKL_{aj} + \beta_6 LDKL_{aj} + \beta_7 LDIS_{aj} + \beta_8 LANG_{aj} + \beta_9 TRRA_{aj} + u_{aj} \qquad (6.12)$$

The dependent variable used in the model is the logistic transformation of the Grubel-Lloyd index which is ranged between 0-100, as shown in equation (6.8). β_0 is the intercept term. β_1, β_2, β_3, β_4, β_5, β_6, β_7, β_8 and β_9 are coefficients associated with the independent variables, and u_{aj} is an error term. It is expected that β_1, β_3, β_5, β_8 and β_9 will be positive, and β_2, β_4, β_6 and β_7 will be negative.

6.4 Data and Sources

Data to be used in the estimation of the model of Australia's intra-industry trade in pharmaceuticals with the rest of the world were obtained from the Australian Bureau of Statistics (ABS), Foreign Trade, Merchandise Exports and Imports. Bilateral trade data between Australia and its 14 trading partners were collected from the ABS, Foreign Trade, Merchandise Exports and Imports, Detailed Commodity Tables. Both series of trade data are published annually, and available in the two-digit SITC 54, medical and pharmaceutical products.

At the time of the analysis, complete time-series data for all the variables were available only for the period 1975 to 1992. Thus, all data series used in this analysis were confined to this period.

The total GNP and per capita GNP for Australia and its trading partners were collected from the World Bank, World Tables. Data on net capital formation in Australia and other countries are available in the Yearbook of National Accounts Statistics published by the United Nations.

Data on the labour force in each country were obtained from the World Bank, World Tables. The distances between Australia and its trading partners are measured in nautical miles of sea distance from Sydney, Australia to the major port of each trading partner. Data on the sea distances were collected from Conlon (1985), and Atlas and Encyclopaedia of the Sea, published by Times Book in 1989.

Data series of value added and R&D expenditure for Australia's pharmaceutical industry between 1975 and 1992 are incomplete because the surveys are conducted biennially by the ABS. Therefore, a complete set of data were generated through linear extrapolation. The ABS data for pharmaceutical turnover and the number of establishments in pharmaceutical industry are available only from 1975 to 1989. The 1990-1992 series of pharmaceutical turnovers and establishments were, therefore, derived from an estimated regression.

The data on GNP, capital formation, value added, R&D expenditure and turnover are recorded in current prices, and are converted into constant prices by using the GDP deflator, and adjusted to the common base year of 1987.

The data series used in the analysis are presented in Appendix 6.1. Data sources are described in Appendix 6.2. Summary statistics of data are provided in Appendix 6.3.

6.5 Results and Discussion

6.5.1 Results of the Diagnostic Tests for Functional Forms

To select suitable functional forms for the models of Australia's intra-industry trade in pharmaceuticals, the log-linear (E_1) and log-log (E_2) forms are tested by using the diagnostic statistics. The results of the diagnostic test statistics for regressions of both log-linear and log-log forms, and the results of the regressions, are reported in Appendixes 6.4, 6.5 and 6.6, respectively.

The results of diagnostic tests in Appendix 6.4 suggest that, for the model of Australia's intra-industry trade with the rest of the world, the log-linear form (E_1) is the preferred functional form as there is no evidence of problems associated with functional form mis-specification (RESET), non-normality and heteroscedasticity. However, E_1 is found to have a statistically significant auto-correlation problem. Therefore, the results were corrected for "first order" serial correlation, using the Cochrane-Orcutt procedure (Cochrane and Orcutt, 1949).

For the model of Australia's bilateral intra-industry trade, the test statistics indicate that the log-log form (E_2) is the preferred form [the log-linear (E_1) form suffers from the problems of auto-correlation, non-normality and heteroscedasticity]. However, E_2 shows a significant serial correlation, and therefore, the results were corrected for first order serial correlation, using the Cochrane-Orcutt procedure. Since pooled cross-sectional and time-series data are used in the analysis, the problem of non-normality in both E_1 and E_2 is unavoidable.

6.5.2 Estimation Results

The regression results, corrected for serial correlation, are reported in Tables 6.1 and 6.2. Both the corrected models show a significant improvement in terms of F-test and adjusted R^2. Moreover, the t-ratio for autoregressive error specification in both the functions are significant at the 1 per cent level, suggesting that the corrected models are statistically well-performed.

6.5.2.1 Australia's Intra-Industry Trade in Pharmaceuticals with the Rest of the World

The estimated coefficients of the function for Australia's intra-industry trade in pharmaceuticals with the rest of the world are reported in Table 6.1. The expected signs for the coefficients of the explanatory variables are given in the first column, followed by the estimated coefficients.

Table 6.1 : Intra-Industry Trade in Pharmaceuticals: Australia and the Rest of the World (E_1: log-linear)

Variable	Expected sign	Regression coefficients
Constant		-8.249 (-4.668)***
Product differentiation ($PDIF_a$)	+	-19.111 (-9.996)***
Economies of scale (ES_a)	+	0.322 (4.826)***
Market Structure (MS_a)	+	0.034 (5.017)***
Degree of economic development (DD_a)	+	0.000169 (7.262)***
Technological advancement (KL_a)	+	-0.111 (-2.777)**
Trade barriers (RA_a)	-	-0.039 (-2.218)**

(Figures in parentheses are the t-ratios: ***Significant at the 1 per cent level; ** Significant at the 5 per cent level).

$R^2 = 0.920$; Adjusted $R^2 = 0.858$; $F_{(7,9)} = 14.849$; DW = 2.637
Autoregressive Error Specification: t-ratio: -2.235 (prob: 0.049), based on asymptotic standard errors.

Four of the variables, economies of scale (ES_a), market structure (MS_a), degree of economic development (DD_a) and trade barriers (RA_a) stand out as the major determinants of Australia's intra-industry trade in pharmaceuticals. The coefficients of two variables, product differentiation ($PDIF_a$) and technological advancement (KL_a), are significant but do not have the expected signs.

The coefficient of ES_a is highly significant with a positive sign, indicating that economies of scale in Australia's pharmaceutical industry have a significantly positive influence on the extent of intra-industry trade. The coefficient of MS_a, measured by the number of pharmaceutical establishments in Australia, is highly significant and positive as expected, supporting the view that a larger number of firms tends to promote a higher degree of intra-industry trade (Greenaway and Milner, 1986:112).

The significant and positive coefficient of DD_a, measured in terms of per capita GNP, supports the hypothesis that the degree of economic development has a positive effect on intra-industry trade. This finding is consistent with the view of Linder (1961) and Barker (1977) which suggests that an increase in income will result in a large demand for a variety of goods. The coefficient of RA_a is negative and significant at the 5 per cent level, reflecting that protection has a negative influence on the extent of Australia's intra-industry trade in pharmaceuticals. The negative impact of trade barriers was also found by Ratnayake and Athukorala (1992) in their analysis of Australia's intra-industry trade in manufacturing industries.

In the results reported in Table 6.1, there are two notable exceptions to the theoretical expectations. First, product differentiation ($PDIF_a$), measured by the ratio of R&D expenditure to value added in pharmaceuticals, seems to have a negative impact on Australia's intra-industry trade. Hughes (1993:563) points out that using the ratio of R&D expenditure to value added as a measure for product differentiation may result in a negative effect on intra-industry trade when a country has a high technological advancement throughout the industry concerned. The results obtained for this variable suggest that Australia may have a technological intensity in pharmaceutical production to some extent, but such technological advantage encourages Australia to engage in less intra-industry trade in pharmaceuticals than other developed countries. The negative impact of product differentiation was also found by Tharakan (1984), and Narayan and Dardis (1994).

The second exception pertains to the level of technological advancement of the country, measured by the ratio of total capital to the labour force (KL_a). Australia's capital-labour ratio steadily declined relative to the level of intra-industry trade in pharmaceuticals over the period of study. The relationship between Australia's intra-industry trade in pharmaceuticals and the ratio of total capital to the labour force is, therefore, significantly negative. In this context, the role of technology, based on the ratio of total capital to the labour force, is not supported by the model as the estimated coefficient associated with KL_{aj} is negative. This finding of a negative impact of the ratio of total capital to the labour force is similar to that obtained by Clark (1993) in his analysis of the determinants of intra-industry trade for the United States.

6.5.2.2 Australia's Bilateral Intra-Industry Trade in Pharmaceuticals

The regression results, based on the correction for serial correlation, for the model of Australia's bilateral intra-industry trade in pharmaceuticals, are presented in Table 6.2.

As shown in Table 6.2, the coefficients of average GNP ($LAGNP_{aj}$), difference in GNP ($LDGNP_{aj}$), distance ($LDIS_{aj}$) and common language ($LANG_{aj}$) have statistically significant impacts on Australia's bilateral intra-industry trade in pharmaceuticals. However, the coefficients of average per capita GNP ($LAPGNP_{aj}$), difference in per capita GNP ($LDPGNP_{aj}$), average capital-labour ratio ($LAKL_{aj}$) and difference in capital-labour ratio ($LDKL_{aj}$) are statistically not significant. The coefficient of special trading arrangement ($TRAA_{aj}$) is statistically significant, but does not have the expected sign.

Table 6.2 : Bilateral Intra-Industry Trade in Pharmaceuticals: Australia and its 14 Trading Partners@ (E_2: log-log)

Variable	Expected sign	Regression coefficients
Constant		31.487 (3.107)***
Average GNP ($LAGNP_{aj}$)	+	1.422 (1.853)*
Difference in GNP ($LDGNP_{aj}$)	-	-1.019 (-2.610)***
Average per capita GNP ($LAPGNP_{aj}$)	+	-2.446 (1.597)
Difference in per capita GNP ($LDPGNP_{aj}$)	-	-0.017 (-0.121)
Average capital-labour ratio ($LAKL_{aj}$)	+	0.373 (0.823)
Difference in capital-labour ratio ($LDKL_{aj}$)	-	-0.368 (-0.383)
Distance ($LDIS_{aj}$)	-	-0.177 (-1.817)*
Common language ($LANG_{aj}$)	+	1.800 (2.268)**
Special trading arrangement ($TRRA_{aj}$)	+	-4.268 (-1.883)*

(Figures in parentheses are the probability values of t-ratio: ***Significant at the 1 per cent level; ** Significant at the 5 per cent level; * Significant at the 10 per cent level).

@ Australia's 14 trading partners are France, Germany, Italy, Belgium, Switzerland, the Netherlands, the U.K., the U.S.A., Canada, New Zealand, Japan, Korea, the Philippines and Thailand.

$R^2 = 0.575$; Adjusted $R^2 = 0.557$; $F_{(10,246)} = 32.478$; DW = 2.124
Autoregressive Error Specification: t-ratio: 14.770 (prob: 0.000), based on asymptotic standard errors.

As expected, Australia's bilateral intra-industry trade in pharmaceuticals is positively related to the average market size ($LAGNP_{aj}$), but negatively related to the difference in market size ($LDGNP_{aj}$). These results confirm that, the similar the market size in the form of economic base and technological sophistication between Australia and its trading partners, the larger the extent of the intra-industry trade in pharmaceuticals. In contrast, differences in market size between Australia and its trading partners results in small extent of bilateral intra-industry trade in pharmaceuticals. These findings are similar to those of Narayan and Dardis (1994) in their analysis of intra-industry trade in the textile industry.

The results in Table 6.2 also indicate that distance ($LDIS_{aj}$) between Australia and its trading partners has a significantly negative effect on bilateral intra-industry trade in pharmaceuticals. It is evident that the geographical distances between Australia and its trading partners result in a reduction in the extent of Australia's bilateral intra-industry trade in pharmaceuticals because of the high transport cost (Conlon, 1985). These results are consistent with the findings of Ratnayake and Athukorala (1992), and Matthews (1995), that distance between Australia and other countries have a negative influence on Australia's intra-industry trade in manufactured products.

As expected, the coefficient of common language ($LANG_{aj}$) is positive and significant, indicating that Australia and other countries using English as a common language engage in greater bilateral intra-industry trade in pharmaceuticals. Contrary to expectations, the coefficient of special trading arrangement ($TRRA_{aj}$) is negative and significant. This result may be due to the limited number of observations, measuring special trading arrangement between Australia and New Zealand (ANZCERTA), which was introduced in 1983 (Menon and Dixon, 1994:5).

6.6 Conclusion

Empirical models of Australia's intra-industry trade in pharmaceuticals with the rest of the world and Australia's bilateral intra-industry trade in pharmaceuticals were developed and estimated in this chapter. The results of diagnostic tests indicate that the log-linear form is the appropriate functional form for the model of Australia's intra-industry trade with the rest of the world, while the log-log form is the appropriate functional form for the model of Australia's bilateral intra-industry trade in pharmaceuticals.

With regard to Australia's intra-industry trade with the rest of the world, economies of scale, market structure and the degree of the economic development have a significantly positive influence on Australia's intra-industry trade in pharmaceuticals, while trade barriers have a significantly negative impact. The estimated coefficients for product differentiation and the level of technological advancement of the country are significant, but do not have the expected positive signs. However, product differentiation need not increase intra-industry trade in every case, as it depends upon the context in which the index is used. The negative impact of the ratio of total capital to the labour force on Australia's intra-industry trade in pharmaceuticals is due to the steady decline in the ratio of total capital to the labour force in Australia relative to the level of intra-industry trade in pharmaceuticals, during the study period.

As far as the determinants of Australia's bilateral intra-industry trade in pharmaceuticals are concerned, the results indicate that country characteristics in terms of average GNP and a common language have a positive and significant impact on Australia's bilateral intra-industry trade, while the difference in GNP and distance have a negative and significant impact. Australia's bilateral intra-industry trade in pharmaceuticals is more likely to occur with the countries whose market size and a common language are similar to Australia's. In contrast, Australia's bilateral intra-industry trade in pharmaceuticals is unlikely to occur with the countries whose market size is different from Australia's.

Moreover, it appears that, as Australia is located in the southern hemisphere, in terms of bilateral intra-industry trade the country is disadvantaged by the geographical distance from its trading partners. The results also indicate that there is no significant impact of per capita GNP and the ratio of total capital to the labour force on Australia's bilateral intra-industry trade in pharmaceuticals. Failure to establish the theoretically expected positive relationship between bilateral intra-industry trade in pharmaceuticals and special trading arrangement, in the form of the regional trading arrangement between Australia and New Zealand, may be due to the limited number of observations used in the analysis. In summary, the results of this chapter shows that, although the extent of Australia's intra-industry trade in pharmaceuticals is small compared to that of other industrial countries, Australia's intra-industry trade in pharmaceuticals is influenced by both country and industry characteristics.

Chapter 7 presents the conclusions and limitations of the study, and some suggests for further research.

CHAPTER 7

SUMMARY AND CONCLUSIONS

7.1 Introduction

The purpose of this concluding chapter is to draw conclusions from the analyses of the preceding chapters of the thesis, in relation to the pattern and determinants of Australia's international trade in pharmaceuticals. To this end, the chapter begins with an overview of the development of the study in Section 7.2. Section 7.3 summarises the major findings of the thesis. Limitations of the study are discussed in Section 7.4, and some suggestions for further research are included in the final section.

7.2 Development of the Study

In this thesis, the patterns and determinants of Australia's international trade in pharmaceuticals during 1975 to 1992 were analysed, based on economic theories of both inter-industry trade and intra-industry trade.

In Chapter 2, the world pharmaceutical industry, the patterns of world trade in pharmaceutical products, Australia's pharmaceutical industry and Australia's international trade in pharmaceuticals were reviewed. Several issues regarding Australia's industrial and trade policies in relation to the pharmaceutical industry were discussed. In Chapter 3, trade specialisation index, export propensity, import penetration and export/import ratio were used as one set of indicators in the analysis of Australia's comparative advantage in pharmaceuticals. Balassa's index was used to analyse Australia's revealed comparative advantage in pharmaceuticals, while

Vollrath's revealed competitive advantage indexes were used to measure Australia's international competitiveness in pharmaceuticals.

An econometric analysis of Australia's exports and imports of pharmaceuticals, was conducted in Chapter 4. The coefficients of Australia's export supply, export demand, and import demand functions for pharmaceuticals were estimated separately, using the time series data for the period 1975-1992. The use of time series data can lead to misleading regressions, known as "spurious regressions". To overcome this problem, all of the variables used in the models were tested for stationarity and cointegration, using the Dickey-Fuller, Augmented Dickey-Fuller and Johansen ML tests. In the absence of cointegrating relationships among the variables, the unrestricted error correction model (UECM) was employed to estimate the short run and long run responses of export supply, export demand and import demand.

Empirical analyses of the extent of Australia's intra-industry trade in pharmaceuticals, and the growth of bilateral intra-industry trade in pharmaceuticals between Australia and its trading partners, were conducted in Chapter 5. The Grubel-Lloyd index of intra-industry trade was employed to measure the extent of Australia's intra-industry trade in pharmaceuticals, while the Menon-Dixon indexes were used to examine the growth of Australia's bilateral intra-industry trade in pharmaceuticals over time.

In Chapter 6, the determinants of Australia's intra-industry trade in pharmaceuticals with the rest of the world, and Australia's bilateral intra-industry trade in pharmaceuticals with its trading partners, were analysed using two separate regression models. The logistic transformation of the Grubel-Lloyd index was used as the dependent variable. Two functional forms, log-linear and log-log, were tested in order to select the appropriate functional form for the models. To overcome the problem of serial correlation, estimated functions were corrected using the Cochrane-Orcutt procedure. Hypotheses in relation to the country and industry determinants of intra-industry trade were tested, based on the estimated models.

7.3 Conclusions

Pharmaceutical products are classified as one of Australia's elaborately transformed manufactured commodities. Since the mid 1980s, several policies in the form of government assistance, particularly the Factor (f) scheme, have played an important role in enhancing pharmaceutical manufacturing and exports. Australian pharmaceutical exports show a significant increase during the period 1988 to 1996, partly due to the impact of these policies upon the pharmaceutical industry. The major export destinations for Australia's pharmaceuticals are New Zealand, the U.K., the U.S. and the countries in East Asia. Despite the rapid growth of pharmaceutical exports, the value of pharmaceutical imports by Australia has exceeded its exports during the past three decades. Most of the pharmaceutical imports are in the form of active ingredients and finished goods from the countries in Western Europe and North America. This reflects Australia's dependence on overseas R&D and technology for pharmaceutical manufacturing.

The calculated trade specialisation indexes show that Australia is a net-importer of pharmaceutical products. The propensity to export is low, while import penetration of pharmaceuticals is high. Both export propensity and import penetration have slightly declined during the period 1990 to 1993 due to a substantial growth in the consumption of domestically produced pharmaceuticals in Australia. In contrast, the international competitiveness of Australia's pharmaceuticals has significantly increased over the same period, measured by the export/import ratio. This may have resulted from the impact of trade and industry policy reform on Australia's pharmaceutical exports.

The estimates of Balassa's revealed comparative advantage index show that, among industrial countries, Australia has a high degree of comparative disadvantage in pharmaceutical products. The revealed comparative advantage index for Australia's pharmaceuticals is less than one, indicating Australia has a lower export share of pharmaceuticals than the total world exports. On the other hand, the negative values of Vollrath's revealed competitive advantage indexes indicate that Australia has a competitive disadvantage in pharmaceutical products due to a small export share of pharmaceuticals over the total world exports. Therefore, based on the analysis of Balassa's revealed comparative advantage and Vollrath's revealed competitive advantage, it is concluded that Australia has a comparative disadvantage in pharmaceutical products.

According to the results of the unrestricted error correction model (UECM) estimation, Australia's export price relative to domestic price has a positive impact on the supply of Australia's pharmaceutical exports. An increase in the long run production capacity in terms of infrastructure and technological improvement leads to a rise of pharmaceutical export supply. Although the Factor (f) scheme appears to have a positive impact on pharmaceutical export supply, it is not statistically significant. However, Australia's supply of pharmaceutical exports seems to respond only slowly to changes in the relative price of exports, as shown by the estimate of long run price elasticity of pharmaceutical export supply which is less than one (0.95).

Foreign demand for Australia's pharmaceutical exports exhibits a greater response to the relative price (Australia's export price relative to competitors' export price), and to foreign income. This indicates that an increase in foreign income and/or a decline in the relative price result in a rise of export demand for Australian pharmaceuticals. The long run price elasticity of export demand is -1.06, and the income elasticity of export demand is 2.56, indicating that the demand for Australia's pharmaceutical exports is more responsive to foreign income than to relative price of exports.

These results imply that, as Australia is only a small country in the world pharmaceutical market which is unable to influence world prices or foreign income, future increases in Australia's pharmaceutical exports may have to depend upon domestic supply shifts which may be achieved through the implementation of appropriate domestic industry policies.

The demand for pharmaceutical imports by Australia is very responsive to Australia's income, but not to the price of imports relative to domestic price. Although the acceleration of trade liberalisation during the late 1980s is found to have a positive influence on import demand, it is not statistically significant. According to the regression results, after the deletion of the dummy variable for trade liberalisation, The long run price elasticity of import demand is -0.73, indicating that import demand for pharmaceuticals by Australia is inelastic with respect to the relative price. However, the long run income elasticity of import demand by Australia is high (4.76).

Results of the analysis of Australia's intra-industry trade in pharmaceuticals, based on Grubel-Lloyd index and Menon-Dixon indexes indicate that, among industrial countries, Australia has a relatively low extent of intra-industry trade in pharmaceuticals. The extent of bilateral intra-industry trade in pharmaceuticals between Australia and its trading partners is low, reflecting that the pattern of Australia's pharmaceutical trade is more of inter-industry trade rather than intra-industry trade. However, the growth in Australia's total trade and net trade in pharmaceuticals is due to the large increase in pharmaceutical imports over the past several decades. Meanwhile, the growth of Australia's intra-industry trade in pharmaceuticals was due to the large increase in the contributions of pharmaceutical exports rather than imports. In terms of bilateral trade in pharmaceuticals between Australia and its trading partners, the growth in total trade and net trade is due to an increase in the contributions of import growth from pharmaceutical exporting countries to Australia and the contributions of export growth from Australia to its neighbouring countries. Therefore, the growth of Australia's intra-industry trade in pharmaceuticals is due to the contributions of Australia's imports from pharmaceutical exporting countries and the contributions of exports to Australia's neighbouring countries.

In the analysis of the determinants of Australia's intra-industry trade in pharmaceuticals, the log-linear form is the preferred functional form for the model of Australia's intra-industry trade with the rest of the world; while the log-log form is the preferred from for the model of Australia's bilateral intra-industry trade. With regard to Australia's intra-industry trade in pharmaceuticals with the rest of the world, the results of estimated regression lend support to the hypothesis that economies of scale, market structure and the degree of the economic development have a significantly positive impact on Australia's intra-industry trade, while the level of trade barriers has a negative and significant impact. However, the negative influence of the capital-labour ratio on Australia's intra-industry trade is due to the steady decline in that ratio relative to the level of intra-industry trade in pharmaceuticals. Product differentiation, measured by the ratio of R&D expenditure to value added in pharmaceuticals, shows a negative impact on Australia's intra-industry trade. This indicates that technological intensity which Australia has in pharmaceutical production leads the country to engage in less intra-industry trade in pharmaceuticals.

With respect to the determinants of bilateral intra-industry trade in pharmaceuticals between Australia and its trading partners, the estimated results suggest that Australia is more likely to engage in bilateral intra-industry trade with the countries whose market size and language are similar to Australia's. Per capita GNP and the capital-labour ratio appear to have no significant impact on the extent of bilateral intra-industry trade in pharmaceuticals between Australia and its trading partners. The results also show that, in terms of intra-industry trade, Australia appears to be disadvantaged by the geographical distance from its trading partners. The variable in relation to special trade arrangement between Australia and New Zealand does not seem to be significant in explaining Australia's bilateral intra-industry trade in pharmaceuticals. This may be due to the limited number of observations used in the analysis.

7.4 Limitations of the Study

The major limitation of this study arises from the nature of data used in the analysis. The analysis in this thesis is based on secondary data and information obtained from several sources, mainly from the Australian Bureau of Statistics (ABS) and the United Nations. Some difficulties emerged in the collection of data. The data on export and import price indexes of Australia's pharmaceuticals are reported only under the broad category of chemical and related products (Australian Export Commodity Classification, AECC, and Australian Import Commodity Classification, AICC, section 5), while the data on domestic price index are reported under chemical and other chemical products (Australian Standard Industrial Classification, ASIC 275-276). In the absence of data for price indexes of Australia's pharmaceuticals, the relative prices of Australia's pharmaceutical exports and imports were constructed by using the data of AECC and AICC, section 5, and ASIC 275-276, of which medical and pharmaceutical products are a sub-category in all the above classifications.

The bilateral trade data on pharmaceutical industry characteristics between Australia and its trading partners are simply not available. The unavailibility of data arises mainly from the fact that individual pharmaceutical firms and the pharmaceutical industry as a whole do not publish or disclose their data to the public.

Another limitation arises from the available time-series data themselves. At the time of the analysis, a complete set of time-series data were available only for the period 1975 to 1992. Therefore, the analysis in this thesis is confined to that period.

Many of the statistical and diagnostic tests and estimation procedures are strictly valid only for large samples. The author acknowledges that the small sample sizes used in this study may reduce the roburstness of the econometric tests and hence the conclusions reached, particularly in Chapters 4 and 6.

7.5 Directions for Further Research

Although this thesis has provided a comprehensive analysis of Australia's international trade in pharmaceuticals, there are several other areas of research that could be pursued in future studies.

Australia's pharmaceutical industry is dominated by multinational corporations (MNCs). The multinational pharmaceutical firms play an important part in shaping the development of Australia's pharmaceutical industry. Thus, there is a considerable scope for a separate research project to explore the area of intra-firm trade in pharmaceuticals, or trade among pharmaceutical subsidiaries within the same MNC. A study at the individual firm level could be conducted in order to examine the role, importance, and factors determining, intra-firm trade in Australia's pharmaceutical industry. Such research may also concentrate on the industry characteristics of the MNCs which mainly contribute to Australia's exports in pharmaceuticals.

Another area for further research is the direction of and opportunities for Australia's pharmaceutical exports in the Asia-Pacific region. As the regional trade among Asia-Pacific countries is increasing, there is a large number of potential benefits for Australia in expanding its pharmaceutical trade opportunities in this region. The econometric analysis of determinants of Australia's exports and imports in pharmaceuticals could be extended specifically to the bilateral trade in pharmaceuticals between Australia and its trading partners in the Asia-Pacific region. This will be important in the context of impending trade liberalisation among the countries under the Asia-Pacific Economic Cooperation (APEC). Such econometric analysis should, however, be able to use a larger number of data points (number of observations) for the relevant variables than were available for this study.

Appendix for Chapter 3

Appendix 3.1: Data Series used in the Analysis of Comparative Advantage

Appendix 3.1.1: Pharmaceutical Exports (X_i) and Imports (M_i) for Australia and Major Exporting Countries, SITC 541: Medical and Pharmaceutical Products (in U.S.$ million).

Year	Australia		Belgium		France		Germany		Italy		Japan		Netherlands		Switzerland		U.K.		U.S.A.	
	X_i	M_i	X_i	M_i	X_i	M_i	X_i	M_i	X_i	M_i	X_i	M_i	X_i	M_i	X_i	M_i	X_i	M_i	X_i	M_i
1975	43	122	314	348	635	342	1060	532	380	340	124	440	332	246	839	171	826	215	876	237
1976	47	120	329	379	628	355	1195	582	416	389	145	550	400	285	874	177	812	250	1010	271
1977	49	114	405	399	743	415	1350	722	471	378	180	612	427	341	1027	216	968	303	1115	320
1978	64	142	507	515	929	538	1641	969	528	500	223	821	499	438	1417	301	1255	386	1534	686
1979	79	157	565	591	1189	603	1981	1139	613	585	264	924	533	529	1506	340	1358	487	1699	710
1980	84	170	669	655	1497	701	2272	1290	688	653	295	1074	619	569	1615	411	1734	517	2020	803
1981	94	161	619	562	1402	712	2115	1184	688	656	330	1150	561	478	1608	407	1718	599	2275	919
1982	89	181	616	525	1368	695	2098	1165	694	657	304	1249	565	488	1560	398	1708	656	2390	932
1983	95	187	640	563	1401	723	2126	1189	708	745	348	1214	568	493	1573	437	1626	713	2611	1171
1984	93	219	637	536	1396	716	2160	1224	749	798	335	1258	585	502	1508	431	1639	728	2759	1500
1985	83	242	662	547	1536	787	2367	1361	860	967	391	1292	609	580	1604	493	1846	761	2843	1718
1986	95	302	893	720	2009	1073	3287	1862	1036	1336	513	1724	827	821	2370	710	2246	997	3263	2084
1987	104	387	1082	897	2376	1342	4053	2251	1183	1582	589	2110	1052	1007	3011	855	2663	1291	3389	2498
1988	156	538	1158	1010	2734	1684	5074	2504	1321	2006	930	2658	1224	1114	3207	916	3662	1562	4200	3235
1989	189	573	1291	1160	2916	1981	4738	2650	1240	2152	767	2732	1074	1134	3348	828	3296	1738	3719	2117
1990	222	705	1633	1510	3665	2646	11722	6793	1517	2817	878	2836	1377	1447	4360	1068	4040	2064	4177	2540
1991	287	728	1912	1767	3956	3085	6575	4227	1630	3030	1089	3114	1513	1541	4658	1229	4515	2422	4679	3092
1992	287	935	2550	2112	4829	3613	7461	4698	2472	3722	1367	3673	1826	2004	5686	1648	5254	2929	5446	3861

Source: United Nations (various years), International Trade Statistics Yearbook.
Note: X_i *= Exports of SITC 541.*
M_i *= Imports of SITC 541.*

Appendix 3.1.2: Total Exports of All Commodities by Country (in U.S.$ million).

Year	Australia	Belgium	France	Germany	Italy	Japan	Netherlands	Switzerland	U.K.	U.S.A
1975	11945	28804	52227	90178	34995	55840	35099	12957	43417	109317
1976	13158	32888	55699	102166	37281	67224	40215	14845	45372	115413
1977	13351	37542	63437	118070	45327	80493	43702	17682	55867	121293
1978	14415	44961	76502	142454	56072	97544	50151	23561	67912	143766
1979	18667	56705	97572	171799	72243	103045	63697	26507	86422	182025
1980	21945	64653	116036	192930	78114	129810	73952	29632	110149	225566
1981	21767	55705	101371	176043	75187	152016	68732	27042	102215	233739
1982	22002	52364	92629	176428	73431	138911	66322	26024	97075	212275
1983	20594	51929	91231	169422	72681	146676	65465	25595	91711	200538
1984	23114	51778	97570	169784	74562	169706	65872	25853	93864	223976
1985	22613	53762	101709	184009	76742	177202	68418	27446	101414	218815
1986	22573	68960	124863	243303	97631	210813	80612	37484	106975	227158
1987	26624	83308	148402	294045	116413	231352	93096	45474	131210	254122
1988	33238	92149	167813	323277	127886	264903	103586	50712	145482	322427
1989	37134	100095	173073	365029	140624	273982	108285	51536	153299	363812
1990	39760	118328	210169	422041	170386	287648	131783	63793	185326	393592
1991	41855	118355	213441	402845	169538	315163	133684	61532	185306	421730
1992	42839	123564	231913	430272	178165	339911	139967	61403	190542	448163

Source: United Nations (various years), International Trade Statistics Yearbook.

Appendix 3.1.3: Total Imports of All Commodities by Country (in U.S.$ million).

Year	Australia	Belgium	France	Germany	Italy	Japan	Netherlands	Switzerland	U.K.	U.S.A
1975	9831	30190	53606	74208	37928	57864	35161	13272	53188	96903
1976	15139	35511	64404	87782	43425	64797	39574	14774	55986	128872
1977	13057	40140	70276	100701	46683	70560	45499	17962	63625	147862
1978	14188	48278	81864	120667	55115	78731	53041	23791	78352	182194
1979	18379	60183	106711	157682	76158	110108	67281	29306	102412	217387
1980	22017	71192	134328	185922	98118	139891	76889	36148	117902	250280
1981	23486	61417	120279	162691	88996	140830	66109	30607	101153	271213
1982	23672	57213	115454	154049	83834	130318	62583	28577	99101	253033
1983	19116	53653	105272	152010	78322	125017	61585	28934	99444	267971
1984	22659	54746	103612	152872	81971	134257	62136	29625	105687	338189
1985	23094	55561	107588	157596	88592	127512	65212	30625	109109	358705
1986	26109	68729	129435	190852	99404	127588	75690	41053	126367	382295
1987	26834	82598	157524	227334	122211	140048	91316	50557	154406	422407
1988	33157	91097	176745	248980	135498	183252	99743	56325	189747	459017
1989	39869	99336	190186	268601	149426	207356	104220	58150	199195	491511
1990	39739	119725	232524	341248	176153	231235	125909	69427	224771	515635
1991	39450	121037	230257	387882	178240	234103	125838	66284	209981	506242
1992	43808	125153	238875	408305	188521	233265	134412	61763	221638	553923

Source: United Nations (various years), International Trade Statistics Yearbook.

Appendix 3.1.4: Total World Exports and Imports of Pharmaceuticals Products (SITC 541) and All Commodities (in U.S.$ million).

Year	Total world exports of SITC 541	Total world imports of SITC 541	Total world exports of all commodities	Total world imports of all commodities
1975	6502	6820	876065	849130
1976	7065	7255	991009	1016939
1977	8135	8444	1126988	1128085
1978	10339	10509	1299139	1300818
1979	11915	12367	1641180	1643975
1980	13918	14294	2011382	1973874
1981	14085	14817	3665377	1976754
1982	14027	14611	1776682	1838110
1983	14399	15098	1817081	1813416
1984	14784	15125	1935165	1912571
1985	15779	16308	1935209	1929422
1986	20284	20803	2129410	2199871
1987	24208	25078	2490806	2559636
1988	29042	28739	2826984	2912521
1989	31246	33653	3044013	3161473
1990	43615	44106	3437400	3566693
1991	41352	46577	3421117	3545855
1992	49711	51201	3654821	3804201

Source: United Nations (various years), International Trade Statistics Yearbook.

Appendix for Chapter 4

Appendix 4.1: Data Series used in the Econometric Estimation of the Models

Year	EXPT[(a)]	AREEXP[(b)]	AREX[(c)]	GDPW[(d)]	IMPT[(e)]	RIMP[(f)]	ARIMP[(g)]	GDPA[(h)]
1975	51.624	151.09	112.89	3706.00	164.698	121.32	144.40	78.48
1976	63.294	160.25	129.92	3880.78	162.250	126.10	150.12	83.19
1977	62.871	150.24	122.90	4130.54	162.088	125.77	149.67	84.86
1978	80.305	150.92	123.09	4552.41	172.205	119.42	142.01	87.07
1979	77.715	145.02	135.51	4640.28	156.277	116.27	136.12	90.03
1980	81.728	115.00	115.00	4619.11	141.044	99.96	115.00	92.20
1981	80.457	102.57	125.43	4748.95	156.238	90.92	103.67	95.15
1982	88.578	99.66	135.82	4599.73	182.239	87.91	100.21	94.47
1983	91.165	102.61	151.34	4772.90	208.537	85.13	95.37	97.16
1984	88.891	103.77	169.55	5013.72	256.154	87.48	97.98	104.96
1985	100.170	105.82	177.58	5167.03	297.754	96.83	108.46	108.98
1986	105.206	73.55	94.32	5825.05	351.029	113.42	124.74	110.63
1987	120.535	82.80	97.69	6333.98	425.209	112.32	123.56	115.69
1988	125.828	140.33	157.07	6951.30	458.890	111.88	120.87	120.28
1989	138.103	134.31	158.93	7022.62	537.642	108.08	116.72	127.38
1990	158.811	127.24	138.18	7095.39	615.553	103.64	111.94	130.23
1991	221.735	111.69	124.37	7388.31	686.649	103.21	105.29	128.68
1992	271.539	111.11	121.22	7688.00	860.219	107.85	110.01	128.19

Source: See the sources of data outlined in Appendix 4.2.

Note: (a) Real exports of Pharmaceuticals in $ million.
(b) Price of Australian exports relative to Australian domestic price (index).
(c) Price of Australian exports relative to competitors' export price (index).
(d) Total real GDP of countries that import pharmaceuticals from Australia in $billion.
(e) Real imports of pharmaceuticals in $million.
(f) Price of Australia's imports relative to Australian domestic price (index).
(g) Adjusted price of Australia's imports relative to Australian domestic price (index).
(h) Australia's real GDP in $billion.

Appendix 4.2 : Description of Data Series and Their Sources

Data Series	Unit	Sources
Australia's pharmaceutical exports	Current dollars	ABS, Foreign Trade, Australia, Merchandise Exports, cat. 5424.0, various issues.
Australia's pharmaceutical imports	Current dollars	ABS, Foreign Trade, Australia, Merchandise Imports, cat. 5426.0, various issues.
Export price index of chemical and related products (AECC, section 5)	Index	ABS, Export Price Index, cat. 6405.0, various issues.
Import price index of chemical and related products (AICC, section 5)	Index	1975-80 data from Reserve Bank of Australia, Statistical Bulletin. 1981-92 data from ABS, Import Price Index, cat. 6414.0, various issues.
Domestic price index of chemical and other chemical products (ASIC 275-276)	Index	ABS, Price Index of Articles produced by manufacturing Industry, Australia, cat. 6412.0, various issues.
GDP for Australia and her trading partners	Current dollars	World Bank, World Tables 1995 and Organization for Economic Cooperation and Development (OECD), 1993, National Accounts: Main Aggregates, volume I.
GDP deflator	Index	World Bank, World Tables, 1995.
Quantum index of manufactured exports for Australia's competing countries	Index	United Nations, International Statistics Yearbook, volume I, various years.
Unit price index of manufactured exports for Australia's competing countries	Index	United Nations, International Statistics Yearbook, volume I, various years
Average nominal rates of assistance (NRA) and average effective rates of assistance (ERA) for Australia's industry subdivision (chemical, petroleum and coal products, ASIC 27)	Per cent	Industries Assistance Commission (IAC), Annual Reports, various years, Australian Government Publishing, Canberra.

Appendix 4.3: Summary Statistics of Data

Variable	Unit	Minimum	Maximum	Mean	Standard Deviation
EXPT[(a)]	$million	51.62	271.54	111.59	56.80
AREEXP[(b)]	Index	73.55	160.25	120.44	25.38
AREX[(c)]	Index	94.32	177.58	132.82	22.88
GDPW[(d)]	$billion	3706.00	7688.00	5452.00	1294.00
IMPT[(e)]	$million	141.04	860.22	333.04	217.83
RIMP[(f)]	Index	85.13	126.10	106.53	13.09
ARIMP[(g)]	Index	95.37	150.12	119.79	17.92
GDPA[(h)]	$billion	78.48	130.23	104.31	17.46

Note: (a) Real exports of Pharmaceuticals.
(b) Price of Australian exports relative to Australian domestic price.
(c) Price of Australian exports relative to competitors' export price.
(d) Total real GDP of countries that import pharmaceuticals from Australia.
(e) Real imports of pharmaceuticals.
(f) Price of Australia's imports relative to Australian domestic price.
(g) Adjusted price of Australia's imports relative to Australian domestic price.
(h) Australia's real GDP in $billion.

Appendix 4.4 : Results of Unit Root Tests

Variable	DF	ADF	Johansen [(a)]
LEXPT	-0.1074	1.0121	1.7322
ΔLEXPT	-4.6113**	-1.0038	10.9980**
LAREEXP	-1.8622	-2.2827	3.7716**
ΔLAREEXP	-3.5491	-3.8639**	10.3739**
LAREX	-2.9761	-4.2270**	8.5555**
ΔLAREX	-3.7442**	-4.5906**	11.6761**
LGDPW	-1.4248	-2.0534	0.0654
ΔLGDPW	-2.7061	-2.0490	7.1354**
LIMPT	-1.8106	-1.9311	5.4107**
ΔLIMPT	-2.5974	-2.3389	13.3931**
LRIMP	-1.0895	-2.4727	2.0759
ΔLRIMP	-2.2640	-2.1765	4.2466**
LARIMP	-1.1415	-2.5973	2.1217
ΔLARIMP	-2.1457	-2.0908	4.2619**
LGDPA	-1.5832	-2.7556	1.5116
ΔLGDPA	-2.9192	-2.9438	7.8695**

Note: For the level form, 95% critical value of the DF test = -3.7119.
95% critical value of the ADF test = -3.7347.
For the first difference (Δ), 95% critical value of the DF test = -3.7347.
95% critical value of the ADF test = -3.7612.

The Johansen test, 95% critical value = 3.7620.

(a) Cointegration LR test based on maximum eigenvalue of the stochastic matrix (the values are similar based on trace of the stochastic matrix).
** show stationarity (no unit root).

Appendix for Chapter 5

Appendix 5.1: Data Series used in the Analysis of the Extent and Growth of Intra-industry Trade

Appendix 5.1.1: Pharmaceutical Exports (X_i) and Imports (M_i) for Australia and Eleven OECD Countries, SITC 541: Medical and Pharmaceutical Products (in U.S.$ million).

Year	Australia		Belgium		France		Germany		Italy		Japan		Netherlands		Switzerland		U.K.		U.S.A.		Canada		New Zealand	
	X_i	M_i	X_i	M_i	X_i	M_i	X_i	M_i	X_i	M_i	X_i	M_i	X_i	M_i	X_i	M_i	X_i	M_i	X_i	M_i	X_i	M_i	X_i	M_i
1975	43	122	314	348	635	342	1060	532	380	340	124	440	332	246	839	171	826	215	876	237	58	180	6	54
1976	47	120	329	379	628	355	1195	582	416	389	145	550	400	285	874	177	812	250	1010	271	58	192	6	54
1977	49	114	405	399	743	415	1350	722	471	378	180	612	427	341	1027	216	968	303	1115	320	72	228	7	61
1978	64	142	507	515	929	538	1641	969	528	500	223	821	499	438	1417	301	1255	386	1534	686	69	242	7	72
1979	79	157	565	591	1189	603	1981	1139	613	585	264	924	533	529	1506	340	1358	487	1699	710	90	303	10	87
1980	84	170	669	655	1497	701	2272	1290	688	653	295	1074	619	569	1615	411	1734	517	2020	803	114	356	14	92
1981	94	161	619	562	1402	712	2115	1184	688	656	330	1150	561	478	1608	407	1718	599	2275	919	163	378	17	92
1982	89	181	616	525	1368	695	2098	1165	694	657	304	1249	565	488	1560	398	1708	656	2390	932	156	403	20	98
1983	95	187	640	563	1401	723	2126	1189	708	745	348	1214	568	493	1573	437	1626	713	2611	1171	182	461	25	93
1984	93	219	637	536	1396	716	2160	1224	749	798	335	1258	585	502	1508	431	1639	728	2759	1500	166	479	29	108
1985	83	242	662	547	1536	787	2367	1361	860	967	391	1292	609	580	1604	493	1846	761	2843	1718	165	424	29	111
1986	95	302	893	720	2009	1073	3287	1862	1036	1336	513	1724	827	821	2370	710	2246	997	3263	2084	170	525	28	151
1987	104	387	1082	897	2376	1342	4053	2251	1183	1582	589	2110	1052	1007	3011	855	2663	1291	3389	2498	218	605	30	171
1988	156	538	1158	1010	2734	1684	5074	2504	1321	2006	930	2658	1224	1114	3207	916	3662	1562	4200	3235	202	688	30	188
1989	189	573	1291	1160	2916	1981	4738	2650	1240	2152	767	2732	1074	1134	3348	828	3296	1738	3719	2117	187	699	35	212
1990	222	705	1633	1510	3665	2646	11722	6793	1517	2817	878	2836	1377	1447	4360	1068	4040	2064	4177	2540	256	860	34	241
1991	287	728	1912	1767	3956	3085	6575	4227	1630	3030	1089	3114	1513	1541	4658	1229	4515	2422	4679	3092	254	1011	44	259
1992	287	935	2550	2112	4829	3613	7461	4698	2472	3722	1367	3673	1826	2004	5686	1648	5254	2929	5446	3861	387	1293	50	279

Source: United Nations (various years), International Trade Statistics Yearbook.
Note: X_i *= Exports of SITC 541.*
M_i *= Imports of SITC 541.*

Appendix 5.1.2: Bilateral Pharmaceutical Trade between Australia and its Major Trading Partners, Current dollars, (in A$'000).

Year	Belgium		France		Germany		Italy		Netherlands		Switzerland	
	X_{al}	M_{al}	X_{al}	M_{al}	X_{al}	M_{al}	X_{al}	M_{al}	X_{al}	M_{al}	X_{al}	M_{al}
1973	47	357	66	866	304	14614	427	500	266	1676	593	14030
1974	4	383	108	1353	425	22602	192	801	968	2102	500	14143
1975	102	731	75	1319	262	18264	77	806	208	1828	491	11791
1976	41	816	164	1734	311	14670	11	1245	317	1619	482	7437
1977	226	1426	137	2206	392	16429	41	1548	68	1732	381	8016
1978	507	1277	36	2448	996	18599	78	2316	1067	2558	333	11240
1979	25	2055	189	3328	1004	22141	56	3588	583	2447	181	7684
1980	52	2107	136	2715	3257	21430	244	4246	365	1988	1087	7643
1981	36	2240	137	3897	1534	22248	75	6176	1014	2065	526	9415
1982	347	2017	38	6165	749	33110	152	9268	376	2194	402	11739
1983	198	2021	140	7952	973	35925	449	8551	646	2768	428	17790
1984	401	2846	308	7702	631	44497	441	9340	487	3620	630	26514
1985	86	4428	551	13399	1463	72006	243	8851	2373	8773	537	48221
1986	29	13644	308	32859	3445	91668	343	8860	2964	12614	579	70411
1987	59	19664	366	51594	2049	110004	519	11685	2327	24702	978	68237
1988	369	24824	631	48491	2019	109401	735	12103	1452	29449	472	69185
1989	691	31722	1010	54487	2322	124801	1366	13735	4813	44989	856	82740
1990	1112	27275	1407	92392	2563	146644	1564	11504	8922	40430	899	94371
1991	680	25866	19367	87836	3615	152522	667	14591	5809	37579	431	94673
1992	392	26213	21190	114656	3877	176426	618	23349	14745	81929	537	94588

Source: ABS, cat. no. 5436.0 and 5437.0.

Note : X_{al} *= pharmaceutical exports from Australia.*

M_{al} *= pharmaceutical imports to Australia.*

Appendix 5.1.2: Bilateral Pharmaceutical Trade between Australia and its Major Trading Partners, Current dollars, (in A$'000).

Year	U.K.		U.S.A.		China		Canada		Japan		Korea		Taiwan	
	X_{al}	M_{al}	X_{al}	M_{al}	X_{al}	M_{al}	X_{al}	M_{al}	X_{al}	M_{al}	X_{al}	M_{al}	X_{al}	M_{al}
1973	1648	18621	1338	12028	9	170	178	383	1277	1916	52	19	27	0
1974	1582	30815	635	17366	0	468	57	511	1765	2833	70	13	22	184
1975	2047	23849	470	18799	8	188	820	623	1613	2333	180	34	102	93
1976	3973	30500	652	24148	3	467	2640	487	2078	3669	368	406	207	146
1977	5256	34470	1011	21003	0	467	1669	506	2191	4049	520	478	203	382
1978	7779	33768	636	26313	44	844	1177	602	2549	4917	949	535	839	415
1979	8633	38568	1178	27917	102	1727	1182	571	3990	7196	505	224	1062	705
1980	12466	32398	1004	31038	113	2822	1662	994	4114	6219	584	306	789	1425
1981	10012	32517	4907	35708	108	2107	1352	1126	5149	5711	229	829	931	506
1982	8219	34011	10695	43321	24	3315	2318	3092	7428	7149	945	631	4837	1364
1983	8868	36462	11975	45060	89	2589	2363	3728	7861	9369	982	1016	1674	1546
1984	6790	53224	15877	61352	38	2565	3707	6133	6351	10888	774	1718	2270	1836
1985	5310	78004	18279	58148	88	2635	2921	7796	6485	15132	478	1827	2084	1674
1986	5179	98803	9547	69905	51	3749	5647	6861	9020	16428	584	2182	3286	2031
1987	10653	123662	9688	85463	91	4593	5975	8381	6805	19668	947	3712	6186	2032
1988	13364	149048	15395	85601	296	5008	5841	7089	7362	18942	1611	3329	8153	1825
1989	15961	157900	14188	112648	459	4245	5023	10502	6778	18782	2407	3037	8399	2142
1990	20252	187614	11612	115265	409	5540	8772	8322	8502	18101	3360	3055	11641	2652
1991	40054	235582	10606	135556	1032	8443	12402	12015	12800	24611	3959	6958	17907	3875
1992	39264	288842	20832	194272	3882	13167	14621	19040	14301	26504	3948	9883	24945	3753

Source: ABS, cat. no. 5436.0 and 5437.0.
Note : X_{al} = pharmaceutical exports from Australia.
M_{al} = pharmaceutical imports to Australia.

Appendix 5.1.2: Bilateral Pharmaceutical Trade between Australia and its Major Trading Partners, Current dollars, (in A$'000).

Year	Hong Kong		New Zealand		Indonesia		Malaysia		Philippines		Singapore		Thailand	
	X_{al}	M_{al}	X_{al}	M_{al}	X_{al}	M_{al}	X_{al}	M_{al}	X_{al}	M_{al}	X_{al}	M_{al}	X_{al}	M_{al}
1973	1211	70	15099	1709	968	114	1153	166	615	1	1059	1475	1112	0
1974	1452	79	14965	2241	493	412	1746	287	727	39	1212	333	1040	0
1975	1751	109	14823	1619	485	539	1476	224	858	1	1144	424	1253	0
1976	1663	97	20897	1706	601	306	1349	238	1093	76	882	56	1945	0
1977	2171	54	20768	1666	925	449	2677	345	1114	118	1067	1507	1298	1
1978	3382	410	27698	1962	931	403	3739	268	1661	2	1742	77	1725	3
1979	4317	207	29465	2650	800	467	3251	250	1744	0	1806	245	2022	0
1980	5724	416	30167	3228	1031	441	2527	273	2048	10	1895	256	3336	58
1981	8128	90	31464	5657	1441	374	3362	596	3404	0	2657	157	2243	329
1982	8450	65	37015	6444	1108	633	4278	1111	2906	7	3599	258	3299	1328
1983	9406	377	43509	11643	671	592	4956	1015	2678	36	3850	281	3588	1204
1984	9109	202	44528	14485	1092	590	6212	1153	2297	146	4195	544	4121	914
1985	10749	1224	50507	12914	1597	829	6619	872	3416	283	4624	1688	2173	889
1986	13258	402	59251	14660	1311	1522	8414	1948	4683	205	6314	2708	2158	715
1987	16423	613	75810	13128	1412	688	8715	2404	7284	71	14336	9139	4633	1106
1988	20241	1453	87768	11300	2091	357	9756	2986	8597	190	17556	10873	6931	1473
1989	22475	1252	106249	17479	1881	562	10938	2840	8523	147	18839	13666	7031	1613
1990	27984	746	121669	14544	2306	410	14725	2675	9156	69	17297	12250	8032	1133
1991	51225	1341	136849	16756	3410	420	16871	3143	13900	534	21871	4529	10719	1738
1992	65316	2551	162426	18022	4347	245	18487	3319	15928	432	28645	2389	19302	3293

Source: ABS, cat. no. 5436.0 and 5437.0.
Note : X_{al} *= pharmaceutical exports from Australia.*
M_{al} *= pharmaceutical imports to Australia.*

ndix 5.2: Results of Status Switch Test

Ki	1974-1978			1979-1983			1984-1992		
	mijk	[(Xi/Mi) - 1] + (Xi/Mi) xijk	status	mijk	[(Xi/Mi) - 1] + (Xi/Mi) xijk	status	mijk	[(Xi/Mi) - 1] + (Xi/Mi) xijk	status
um	0.31	0.63	switch	-0.01	-0.91	no switch	0.27	-0.97	no switch
e	0.17	-0.95	no switch	0.26	-0.98	no switch	0.31	-0.87	no switch
any	-0.05	-0.96	no switch	0.14	-0.95	no switch	0.15	-0.97	no switch
	0.28	-0.94	no switch	0.25	-0.96	no switch	0.09	-0.94	no switch
rlands	0.03	-0.75	no switch	0.03	-0.73	no switch	0.33	-0.79	no switch
erland	-0.08	-0.96	no switch	0.21	-0.95	no switch	0.13	-0.99	no switch
	0.05	-0.82	no switch	-0.01	-0.73	no switch	0.19	-0.86	no switch
.	0.09	-0.96	no switch	0.13	-0.74	no switch	0.14	-0.85	no switch
	0.21	-0.13	no switch	0.10	-0.97	no switch	0.17	-0.82	no switch
alia	-0.04	-0.56	no switch	0.01	-0.44	no switch	0.12	-0.58	no switch

i	1974-1978			1979-1983			1984-1992		
	xijk	[(Mi/Xi) - 1] + (Mi/Xi) mijk	status	xijk	[(Mi/Xi) - 1] + (Mi/Xi) mijk	status	xijk	[(Mi/Xi) - 1] + (Mi/Xi) mijk	status
da	0.67	-0.54	no switch	0.48	0.15	no switch	0.11	-0.13	no switch
a	0.16	-0.36	no switch	0.07	-0.06	no switch	0.08	-0.51	no switch
Zealand	0.15	-0.90	no switch	0.09	-0.77	no switch	0.16	-0.82	no switch
a	0.63	0.40	no switch	0.18	0.24	switch	0.19	-0.36	no switch
Kong	0.19	-0.91	no switch	0.19	-0.96	no switch	0.23	-0.94	no switch
an	0.79	0.24	no switch	0.27	-0.28	no switch	0.31	-0.69	no switch
esia	0.19	-0.37	no switch	-0.03	-0.47	no switch	0.15	-0.72	no switch
ysia	0.21	-0.86	no switch	0.13	-0.76	no switch	0.14	-0.75	no switch
pines	0.19	-0.96	no switch	0.12	-0.32	no switch	0.22	-0.96	no switch
pore	0.06	-0.67	no switch	0.21	-0.91	no switch	0.24	-0.47	no switch
and	0.10	-0.21	no switch	0.11	-0.63	no switch	0.23	-0.76	no swotch

Appendix 5.3: Contribution Measures of Menon-Dixon Indexes, 1974-1978

Country	Cxtt	Cmtt	TT_i	Cxnt	Cmnt	NT_i	Cxiit	Cmiit	IIT_i
Belgium	15.78	26.16	41.94	-22.57	37.43	14.86	104.80	0.00	104.80
France	-0.90	16.04	15.14	1.01	18.08	19.10	-15.90	0.00	-15.90
Germany	0.51	-4.78	-4.27	-0.54	-5.02	-5.56	21.10	0.00	21.10
Italy	-1.54	26.03	24.49	1.77	29.82	31.59	-24.30	0.00	-24.30
Neth.land	-1.97	2.67	0.70	3.45	4.67	8.12	-9.20	0.00	-9.20
Swiz.land	-0.43	-8.07	-8.49	0.46	-8.76	-8.30	-10.70	0.00	-10.70
UK.	4.62	4.88	9.50	-5.95	6.29	0.34	41.30	0.00	41.30
USA.	0.24	9.11	9.35	-0.25	9.71	9.46	7.70	0.00	7.70
Canada	46.50	0.38	46.87	124.44	-1.01	123.43	0.00	1.20	1.20
NZ.	14.32	-0.21	14.11	17.38	0.26	17.63	0.00	-2.40	-2.40
Japan	3.82	10.45	14.26	-14.33	39.23	24.90	10.40	0.00	10.40
Korea	36.94	41.42	78.35	207.35	-232.38	-25.13	0.00	100.80	100.80
China	0.00	20.48	20.48	0.00	21.34	21.34	0.00	0.00	0.00
Hongkong	17.86	1.68	19.54	20.53	-1.93	18.59	0.00	25.90	25.90
Taiwan	40.85	14.82	55.67	1633.52	-592.67	1040.85	0.00	30.40	30.40
Indonesia	11.71	-0.90	10.81	53.37	4.09	57.46	0.00	-2.30	-2.30
Malaysia	18.78	0.33	19.11	24.33	-0.43	23.90	0.00	-2.90	2.90
Philippines	18.30	-0.49	17.81	19.98	0.54	20.51	0.00	-11.70	-11.70
Singapore	4.75	-4.66	0.08	10.83	10.64	21.47	0.00	-16.60	-16.60
Thailand	10.50	0.00	10.50	10.51	0.00	10.51	0.00	0.00	0.00

Appendix 5.4 :Contribution Measures of Menon-Dixon Indexes, 1979-1983

Country	Cxtt	Cmtt	TT_i	Cxnt	Cmnt	NT_i	Cxiit	Cmiit	IIT_i
Belgium	3.25	-0.76	2.50	-3.65	-0.85	-4.50	60.40	0.00	60.40
France	-0.52	24.88	24.36	0.56	26.36	26.92	-18.70	0.00	-18.70
Germany	-0.85	13.22	12.37	0.96	14.88	15.84	-15.30	0.00	-15.30
Italy	1.08	24.46	25.54	-1.15	25.98	24.84	36.90	0.00	36.90
Netherland	0.48	2.70	3.17	-0.81	4.60	3.79	2.30	0.00	2.30
Switzerland	0.35	20.09	20.44	-0.39	22.22	21.83	7.30	0.00	7.30
U.K.	-0.78	-0.47	-1.25	1.39	-0.83	0.56	-3.60	0.00	- 3.60
U.S.A.	9.14	11.21	20.36	12.38	15.18	2.80	70.00	0.00	70.00
Canada	8.53	24.65	33.18	-1042.81	3013.62	1970.82	17.20	0.00	17.20
NZ.	8.42	5.16	13.57	11.73	-7.19	4.54	0.00	36.50	36.50
Japan	-8.55	3.76	-4.79	-69.58	30.61	-38.97	19.50	0.00	19.50
Korea	-9.50	17.81	8.31	190.35	-356.87	-166.52	0.00	37.50	37.50
China	0.64	9.36	10.00	0.69	10.07	10.75	-18.20	0.00	-18.20
Hongkong	-18.87	-0.21	-19.08	20.17	0.23	20.40	0.00	-6.60	-6.60
Taiwan	-16.82	5.84	-10.98	71.05	-24.66	46.38	0.00	15.30	15.30
Indonesia	1.88	2.72	4.60	-5.47	-7.92	-13.40	0.00	8.30	8.30
Malaysia	-11.72	6.07	-5.65	16.48	-8.54	7.94	0.00	42.10	42.10
Philippines	-12.05	0.00	-12.05	12.15	0.00	12.15	0.00	0.00	0.00
Singapore	-19.73	0.23	-19.50	23.62	-0.28	23.35	0.00	2.80	2.80
Thailand	-9.65	16.09	6.44	13.92	-23.21	-9.28	0.00	104.90	104.90

Appendix 5.5 : Contribution Measures of Menon-Dixon Indexes, 1984-1992

Country	Cxtt	Cmtt	TT_i	Cxnt	Cmnt	NT_i	Cxiit	Cmiit	IIT_i
Belgium	0.56	26.13	26.69	-0.58	27.29	26.71	26.40	0.00	26.40
France	4.10	28.50	32.60	-4.85	33.74	28.89	52.80	0.00	52.80
Germany	0.33	14.39	14.72	-0.35	15.02	14.68	15.80	0.00	15.80
Italy	0.74	9.19	9.93	-0.83	10.27	9.45	14.00	0.00	14.00
Netherlands	3.29	28.50	32.79	-5.86	38.90	33.05	32.10	0.00	32.10
Switzerland	-0.01	12.98	12.97	0.01	13.23	13.23	-0.90	0.00	-0.90
U.K.	2.71	17.36	20.07	-3.39	21.72	18.33	27.00	0.00	27.00
U.S.A.	0.05	12.23	12.28	-0.07	16.37	16.30	0.40	0.00	0.40
Canada	7.47	6.16	13.63	-49.34	40.70	-8,64	17.60	0.00	17.60
NZ.	14.24	0.45	14.70	19.89	-0.63	19.26	0.00	3.20	3.20
Japan	2.73	5.87	8.60	-7.45	16.05	8.60	8.60	0.00	8.60
Korea	9.52	12.79	22.30	-28.05	37.70	9.65	28.80	0.00	28.80
China	5.54	16.02	21.56	-7.01	20.28	13.27	52.80	0.00	52.80
Hongkong	22.93	0.84	23.77	24.96	-0.91	24.05	0.00	20.60	20.60
Taiwan	24.73	2.13	26.86	43.38	-3.73	39.65	0.00	9.90	9.90
Indonesia	11.67	-3.39	8.28	22.64	6.58	29.22	0.00	-14.00	-14.00
Malaysia	11.72	2.59	14.30	18.02	-3.98	14.04	0.00	14.80	14.80
Philippines	21.76	0.23	21.99	23.08	-0.24	22.84	0.00	8.00	8.00
Singapore	16.98	6.23	23.21	43.34	-15.91	27.43	0.00	20.50	20.50
Thailand	19.37	2.38	21.75	29.24	-3.59	25.64	0.00	14.10	14.10

Appendix for Chapter 6

Appendix 6.1 : Data Series used in the Econometric Estimation of the Models

Appendix 6.1.1: Australia's Intra-Industry Trade in Pharmaceutical with the Rest of the World

Year	IIT_{aw}	$PDIF_a$	ES_a	MS_a	DD_a	KL_a	RA_a
1975	52.19	0.0188	6.47	126	21,036	5.13	20
1976	60.44	0.0175	8.43	124	19,741	4.74	20
1977	59.51	0.0216	9.41	120	17,949	3.15	19
1978	66.54	0.0243	10.13	121	18,294	4.44	19
1979	63.08	0.0246	9.81	125	18,245	3.90	17
1980	73.37	0.0255	10.14	121	19,167	4.39	15
1981	72.58	0.0268	10.36	127	18,861	5.06	14
1982	71.85	0.0281	9.72	131	16,201	2.40	14
1983	69.82	0.0335	10.76	127	15,182	2.63	12
1984	58.77	0.0372	11.21	124	14,515	3.03	12
1985	54.57	0.0510	12.11	116	13,134	2.60	12
1986	49.33	0.0625	12.92	109	12,448	2.08	13
1987	48.13	0.0863	11.09	145	12,610	2.36	12
1988	50.26	0.1071	11.58	142	13,636	3.75	10
1989	49.61	0.1029	11.13	144	14,189	3.51	8
1990	50.77	0.0991	11.57	135	14,371	1.89	8
1991	60.48	0.1048	11.92	136	14,329	1.25	7
1992	57.67	0.1099	12.36	137	14,541	1.25	7

Source: Data sources are outlined in Appendix 6.2.
Note: IIT_a *= Grubel-Lloyd index,*
$PDIF_a$ *= Product differentiation,*
ES_a *= Economies of scale,*
MS_a *= Market structure,*
DD_a *= Degree of economic development,*
KL_a *= Technological advancement,*
RP_a *= Trade Barriers.*

Appendix 6.1.2: Australia's Bilateral Intra-Industry Trade in Pharmaceuticals

Trading partner: France

Year	IIT_{aj}	$AGNP_{aj}$	$DGNP_{aj}$	$APGNP_{aj}$	$DPGNP_{aj}$	AKL_{aj}	DKL_{aj}	DIS_{aj}	$LANG_{aj}$	TRRA
1975	10.76	621,507	658,226	19,537	2,997	5.13	0.01	9,808	0	0
1976	17.28	596,402	638,832	18,521	2,440	4.84	0.19	9,808	0	0
1977	11.69	590,134	671,801	17,683	532	3.90	1.50	9,808	0	0
1978	2.90	606,498	689,854	18,055	479	4.53	0.19	9,808	0	0
1979	10.75	661,919	797,174	19,008	1,525	4.68	1.56	9,808	0	0
1980	9.54	715,152	871,825	20,265	2,197	5.05	1.32	9,808	0	0
1981	6.79	662,023	766,622	19,085	448	4.22	1.67	9,808	0	0
1982	1.23	549,416	613,153	15,969	464	2.66	0.52	9,808	0	0
1983	3.46	454,817	448,022	13,801	2,760	2.28	0.71	9,808	0	0
1984	7.69	410,728	373,803	12,700	3,632	2.26	1.53	9,808	0	0
1985	7.90	385,129	359,404	11,686	2,896	2.04	1.12	9,808	0	0
1986	1.86	410,769	426,129	11,846	1,202	2.13	0.11	9,808	0	0
1987	1.41	489,386	572,024	13,255	1,290	2.53	0.32	9,808	0	0
1988	2.57	596,350	746,042	15,459	3,645	3.53	0.45	9,808	0	0
1989	3.64	613,455	754,958	15,879	3,379	3.52	0.01	9,808	0	0
1990	3.00	629,076	772,753	16,137	3,532	2.99	2.20	9,808	0	0
1991	36.13	635,845	781,022	16,173	3,687	2.31	2.12	9,808	0	0
1992	31.20	685,113	865,437	17,038	4,995	2.09	1.68	9,808	0	0

Trading partner: Germany

Year	IIT_{aj}	$AGNP_{aj}$	$DGNP_{aj}$	$APGNP_{aj}$	$DPGNP_{aj}$	AKL_{aj}	DKL_{aj}	DIS_{aj}	$LANG_{aj}$	TRRA
1975	2.83	575,226	565,665	15,971	10,130	3.18	3.90	11,800	0	0
1976	4.15	579,487	605,001	15,481	8,520	3.13	3.22	11,800	0	0
1977	4.66	582,532	656,597	14,774	6,351	2.37	1.56	11,800	0	0
1978	10.17	638,738	754,335	15,622	5,345	3.16	2.56	11,800	0	0
1979	8.68	744,666	962,668	16,944	2,603	3.27	1.26	11,800	0	0
1980	26.39	821,131	1,083,784	18,287	1,760	3.49	1.81	11,800	0	0
1981	12.90	764,746	972,067	17,430	2,862	3.30	3.51	11,800	0	0
1982	4.42	647,395	809,110	14,840	2,723	1.72	1.37	11,800	0	0
1983	5.27	575,324	689,035	13,493	3,377	1.89	1.49	11,800	0	0
1984	2.80	555,562	663,471	12,960	3,110	2.03	1.99	11,800	0	0
1985	3.98	533,839	656,825	12,118	2,032	1.76	1.69	11,800	0	0
1986	7.24	579,672	763,934	12,388	119	1.70	0.75	11,800	0	0
1987	3.66	704,920	1,003,093	14,005	2,790	1.99	0.75	11,800	0	0
1988	3.62	889,106	1,331,553	16,699	6,126	2.81	1.88	11,800	0	0
1989	3.65	925,625	1,379,297	17,315	6,252	2.77	1.48	11,800	0	0
1990	3.44	961,833	1,438,266	17,776	6,809	2.24	0.70	11,800	0	0
1991	4.63	862,424	1,234,181	16,434	4,210	2.35	2.20	11,800	0	0
1992	4.30	923,761	1,342,732	17,209	5,337	2.31	2.12	11,800	0	0

Trading partner: the Netherlands

Year	IIT_{aj}	$AGNP_{aj}$	$DGNP_{aj}$	$APGNP_{aj}$	$DPGNP_{aj}$	AKL_{aj}	DKL_{aj}	DIS_{aj}	$LANG_{aj}$	TRRA
1975	20.43	218,311	148,166	15,800	10,472	4.14	1.98	11,595	0	0
1976	32.75	211,051	131,871	15,147	9,187	3.96	1.56	11,595	0	0
1977	7.56	202,136	104,195	14,392	7,114	3.48	0.66	11,595	0	0
1978	58.87	213,881	95,380	15,105	6,377	4.44	0.01	11,595	0	0
11,595	38.48	230,271	66,122	16,144	4,203	4.18	0.56	11,595	0	0
1980	31.02	248,343	61,793	17,270	3,793	4.47	0.15	11,595	0	0
1981	65.87	237,412	82,600	16,330	5,063	3.74	2.64	11,595	0	0
1982	29.26	203,235	79,209	13,829	4,744	2.22	0.36	11,595	0	0
1983	37.84	187,067	87,479	12,584	5,195	2.31	0.64	11,595	0	0
1984	23.72	180,586	86,481	12,019	4,992	2.50	1.05	11,595	0	0
1985	42.58	169,059	72,736	11,145	3,978	2.36	0.49	11,595	0	0
1986	38.05	174,081	47,246	11,382	2,130	2.46	0.76	11,595	0	0
1987	17.22	196,041	14,666	12,735	250	2.72	0.72	11,595	0	0
1988	9.40	229,364	12,068	14,789	2,306	3.69	0.12	11,595	0	0
1989	19.33	242,273	12,593	15,459	2,540	3.63	0.24	11,595	0	0
1990	36.16	250,601	15,802	15,830	2,918	3.24	2.69	11,595	0	0
1991	26.78	254,850	19,032	15,941	3,224	2.81	3.13	11,595	0	0
1992	30.50	269,426	34,063	16,712	4,343	2.96	3.42	11,595	0	0

Trading partner: the U.K.

Year	IIT_{aj}	$AGNP_{aj}$	$DGNP_{aj}$	$APGNP_{aj}$	$DPGNP_{aj}$	AKL_{aj}	DKL_{aj}	DIS_{aj}	$LANG_{aj}$	TRRA
1975	15.81	508,123	431,459	16,955	8,162	3.73	2.79	11,558	1	0
1976	23.05	461,548	369,124	15,614	8,254	3.52	2.45	11,558	1	0
1977	26.46	427,118	345,768	14,306	7,286	2.65	0.99	11,558	1	0
1978	37.45	437,039	350,938	14,588	7,413	3.27	2.34	11,558	1	0
1979	36.58	476,042	425,419	15,238	6,014	3.31	1.19	11,558	1	0
1980	55.57	503,108	447,737	16,036	6,261	2.95	2.88	11,558	1	0
1981	47.08	504,573	451,721	15,908	5,907	2.97	4.18	11,558	1	0
1982	38.92	461,471	437,263	14,125	4,152	1.65	1.51	11,558	1	0
1983	39.13	411,800	361,989	12,836	4,691	1.80	1.65	11,558	1	0
1984	22.63	379,208	310,762	11,984	5,064	2.01	2.03	11,558	1	0
1985	12.75	353,518	296,182	10,997	4,274	1.83	1.54	11,558	1	0
1986	9.96	372,421	349,434	11,042	2,811	1.68	0.80	11,558	1	0
1987	15.86	423,933	441,119	11,965	1,290	2.01	0.71	11,558	1	0
1988	16.46	493,857	541,055	13,512	247	3.27	0.96	11,558	1	0
1989	18.36	503,430	534,908	13,827	724	3.04	0.93	11,558	1	0
1990	19.49	505,214	525,027	13,872	999	2.24	0.69	11,558	1	0
1991	29.06	493,322	495,977	13,602	1,455	1.80	1.11	11,558	1	0
1992	23.93	516,113	527,435	14,018	1,045	1.82	1.13	11,558	1	0

Trading partner: The U.S.

Year	IIT_{aj}	$AGNP_{aj}$	$DGNP_{aj}$	$APGNP_{aj}$	$DPGNP_{aj}$	AKL_{aj}	DKL_{aj}	DIS_{aj}	$LANG_{aj}$	TRRA
1975	4.88	1,889,665	3,194,544	18,589	4,892	3.33	3.59	6,456	1	0
1976	5.26	1,882,411	3,210,850	17,870	3,742	3.43	2.62	6,456	1	0
1977	9.19	1,903,913	3,299,359	17,014	1,870	2.94	0.42	6,456	1	0
1978	4.72	2,000,367	3,477,592	17,531	1,527	3.82	1.24	6,456	1	0
1979	8.10	2,109,298	3,691,931	17,912	666	3.38	1.04	6,456	1	0
1980	6.27	2,150,647	3,742,815	18,404	1,526	3.15	2.48	6,456	1	0
1981	24.16	2,117,045	3,676,665	18,029	1,664	3.59	2.94	6,456	1	0
1982	39.60	1,958,623	3,431,567	16,020	363	1.64	1.51	6,456	1	0
1983	41.99	1,950,384	3,439,157	15,433	502	1.88	1.50	6,456	1	0
1984	41.12	2,070,195	3,692,736	15,555	2,080	2.73	0.59	6,456	1	0
1985	47.83	2,141,604	3,872,353	15,134	4,000	2.46	0.29	6,456	1	0
1986	24.03	2,315,287	4,235,165	15,421	5,946	2.03	0.10	6,456	1	0
1987	20.36	2,508,602	4,610,456	16,210	7,200	2.18	0.37	6,456	1	0
1988	30.49	2,619,223	4,791,787	17,053	6,834	2.85	1.81	6,456	1	0
1989	22.37	2,639,169	4,806,385	17,261	6,143	2.68	1.66	6,456	1	0
1990	18.30	2,598,329	4,711,258	17,093	5,445	1.68	0.42	6,456	1	0
1991	14.51	2,565,545	4,640,422	16,820	4,982	1.36	0.23	6,456	1	0
1992	19.37	2,653,253	4,801,717	17,180	5,280	1.39	0.29	6,456	1	0

Trading partner: Canada

Year	IIT_{aj}	$AGNP_{aj}$	$DGNP_{aj}$	$APGNP_{aj}$	$DPGNP_{aj}$	AKL_{aj}	DKL_{aj}	DIS_{aj}	$LANG_{aj}$	TRRA
1975	86.35	338,524	92,261	18,805	4,462	5.15	0.05	6,800	1	0
1976	31.15	334,702	115,432	18,227	3,028	5.26	1.04	6,800	1	0
1977	46.53	320,599	132,731	17,120	1,658	3.83	1.37	6,800	1	0
1978	67.68	327,528	131,915	17,334	1,919	4.29	0.31	6,800	1	0
1979	65.15	327,374	128,083	17,173	2,145	4.31	0.83	6,800	1	0
1980	74.85	334,172	109,866	17,494	3,346	4.23	0.32	6,800	1	0
1981	90.88	330,089	102,753	17,103	3,515	4.81	0.49	6,800	1	0
1982	85.69	291,810	97,940	14,882	2,638	2.33	0.15	6,800	1	0
1983	77.59	284,024	106,436	14,231	1,901	2.51	0.24	6,800	1	0
1984	75.35	289,964	132,275	14,195	641	2.92	0.21	6,800	1	0
1985	54.51	286,941	163,028	13,668	1,069	2.61	0.03	6,800	1	0
1986	90.29	289,912	184,414	13,488	2,081	2.40	0.65	6,800	1	0
1987	83.24	307,949	209,149	14,040	2,860	2.83	0.94	6,800	1	0
1988	90.35	340,042	233,424	15,265	3,258	3.95	0.41	6,800	1	0
1989	64.71	354,733	237,513	15,731	3,085	4.17	1.33	6,800	1	0
1990	97.37	362,541	239,682	15,864	2,986	2.81	1.84	6,800	1	0
1991	98.42	364,650	238,633	15,771	2,883	2.16	1.84	6,800	1	0
1992	86.87	370,931	237,072	15,873	2,665	1.80	1.09	6,800	1	0

Trading partner: New Zealand

Year	IIT_{aj}	$AGNP_{aj}$	$DGNP_{aj}$	$APGNP_{aj}$	$DPGNP_{aj}$	AKL_{aj}	DKL_{aj}	DIS_{aj}	$LANG_{aj}$	TRRA
1975	19.69	182,139	220,509	22,176	2,281	7.86	5.47	1,260	1	1
1976	15.10	167,596	218,781	19,292	898	6.54	3.59	1,260	1	1
1977	14.85	150,753	206,962	16,611	2,676	4.87	3.45	1,260	1	1
1978	13.23	154,077	214,987	16,658	3,272	5.18	1.48	1,260	1	1
1979	16.50	156,965	212,734	17,265	1,960	5.35	2.90	1,260	1	1
1980	19.33	165,690	227,098	17,958	2,417	4.86	0.94	1,260	1	1
1981	30.48	164,057	229,310	17,300	3,123	5.79	1.47	1,260	1	1
1982	29.66	143,140	199,400	14,961	2,481	4.09	3.38	1,260	1	1
1983	42.22	134,227	193,159	13,486	3,391	3.89	2.51	1,260	1	1
1984	49.09	128,914	189,824	12,537	3,956	4.05	2.05	1,260	1	1
1985	40.72	117,210	176,434	11,031	4,205	3.18	1.15	1,260	1	1
1986	39.67	112,569	170,271	10,420	4,055	2.82	1.48	1,260	1	1
1987	29.52	116,847	173,055	10,910	3,400	2.95	1.17	1,260	1	1
1988	22.81	129,449	187,761	12,184	2,903	3.44	0.63	1,260	1	1
1989	28.25	136,522	198,909	12,649	3,081	3.61	0.20	1,260	1	1
1990	21.35	139,933	205,533	12,716	3,310	2.55	1.33	1,260	1	1
1991	21.82	140,264	210,138	12,337	3,984	2.09	1.68	1,260	1	1
1992	19.97	144,202	216,386	12,498	4,085	2.08	1.65	1,260	1	1

Trading partner: Japan

Year	IIT_{aj}	$AGNP_{aj}$	$DGNP_{aj}$	$APGNP_{aj}$	$DPGNP_{aj}$	AKL_{aj}	DKL_{aj}	DIS_{aj}	$LANG_{aj}$	TRRA
1975	81.75	551,708	518,630	14,138	13,794	3.88	2.50	4,379	0	0
1976	72.32	537,398	520,824	13,401	12,681	3.70	2.09	4,379	0	0
1977	70.22	542,310	576,153	12,617	10,665	3.02	0.25	4,379	0	0
1978	68.28	628,811	734,481	13,478	9,633	4.17	0.54	4,379	0	0
1979	71.34	752,923	979,182	14,478	7,534	4.06	0.32	4,379	0	0
1980	79.63	829,955	1,101,432	15,484	7,366	4.24	0.31	4,379	0	0
1981	94.83	823,069	1,088,714	15,225	7,273	4.51	1.09	4,379	0	0
1982	98.09	758,420	1,031,161	13,499	5,405	2.85	0.91	4,379	0	0
1983	91.25	729,077	996,543	12,748	4,868	2.86	0.45	4,379	0	0
1984	73.68	732,560	1,017,467	12,430	4,171	3.11	0.17	4,379	0	0
1985	60.00	777,057	1,143,260	12,140	1,988	2.96	0.73	4,379	0	0
1986	70.89	892,689	1,389,969	12,784	674	3.33	2.50	4,379	0	0
1987	51.41	1,155,157	1,903,566	14,940	4,660	4.08	3.44	4,379	0	0
1988	55.98	1,545,134	2,643,610	18,568	9,864	5.78	4.05	4,379	0	0
1989	53.04	1,651,423	2,830,893	19,561	10,745	5.66	4.30	4,379	0	0
1990	63.92	1,672,539	2,859,677	19,695	10,648	5.01	6.23	4,379	0	0
1991	68.43	1,694,826	2,898,985	19,843	11,028	4.99	7.49	4,379	0	0
1992	70.09	1,774,981	3,045,173	20,567	12,053	4.80	7.10	4,379	0	0

Trading partner: Italy

Year	IIT_{aj}	$AGNP_{aj}$	$DGNP_{aj}$	$APGNP_{aj}$	$DPGNP_{aj}$	AKL_{aj}	DKL_{aj}	DIS_{aj}	$LANG_{aj}$	TRRA
1975	17.44	700,331	815,875	20,513	1,045	4.80	0.66	9,273	0	0
1976	1.75	625,850	697,728	18,630	2,222	4.87	0.25	9,273	0	0
1977	5.16	563,983	619,498	16,799	2,301	3.54	0.79	9,273	0	0
1978	6.52	562,491	601,840	16,851	2,886	4.08	0.73	9,273	0	0
1979	3.07	613,241	699,817	17,686	1,118	4.25	0.70	9,273	0	0
1980	10.87	645,593	732,707	18,549	1,235	5.29	1.80	9,273	0	0
1981	2.40	575,121	592,818	17,143	3,436	4.21	1.70	9,273	0	0
1982	3.23	469,836	453,992	14,260	3,883	2.41	0.02	9,273	0	0
1983	9.98	396,379	331,147	12,552	5,259	2.13	1.00	9,273	0	0
1984	9.02	367,119	286,585	11,758	5,514	2.36	1.33	9,273	0	0
1985	5.34	345,508	280,161	10,844	4,580	2.10	1.01	9,273	0	0
1986	7.45	362,933	330,457	10,871	3,152	2.25	0.35	9,273	0	0
1987	8.51	424,151	441,554	11,975	1,270	2.69	0.64	9,273	0	0
1988	11.45	508,528	570,397	13,790	308	3.53	0.43	9,273	0	0
1989	18.09	521,776	571,598	14,182	14	3.34	0.34	9,273	0	0
1990	23.94	527,354	569,308	14,306	131	2.71	1.64	9,273	0	0
1991	8.74	531,576	572,485	14,332	4	2.25	2.01	9,273	0	0
1992	5.16	564,495	624,200	14,948	814	2.04	1.58	9,273	0	0

Trading partner: Belgium

Year	IIT_{aj}	$AGNP_{aj}$	$DGNP_{aj}$	$APGNP_{aj}$	$DPGNP_{aj}$	AKL_{aj}	DKL_{aj}	DIS_{aj}	$LANG_{aj}$	TRRA
1975	24.49	204,273	176,241	16,463	9,146	4.46	1.33	11,569	0	0
1976	9.57	198,039	157,895	15,942	7,598	4.36	0.76	11,569	0	0
1977	27.36	187,074	134,319	15,082	5,736	3.60	0.90	11,569	0	0
1978	56.84	197,577	127,988	15,942	4,705	4.55	0.21	11,569	0	0
1979	2.40	210,027	106,611	17,085	2,320	4.38	0.96	11,569	0	0
1980	4.82	229,120	100,238	18,668	998	4.89	0.99	11,569	0	0
1981	3.16	218,850	119,725	17,499	2,725	3.92	2.27	11,569	0	0
1982	29.36	184,593	116,494	14,511	3,379	2.24	0.31	11,569	0	0
1983	17.85	165,940	129,732	12,719	4,925	2.00	1.26	11,569	0	0
1984	24.70	156,784	134,085	11,810	5,410	2.19	1.67	11,569	0	0
1985	3.81	144,439	121,977	10,800	4,668	1.92	1.35	11,569	0	0
1986	0.42	145,383	104,643	10,935	3,025	1.83	0.50	11,569	0	0
1987	0.60	160,655	85,438	12,265	690	2.32	0.09	11,569	0	0
1988	2.93	187,795	71,069	14,498	1,724	3.33	0.84	11,569	0	0
1989	4.26	195,840	80,274	14,933	1,488	3.49	0.04	11,569	0	0
1990	7.83	202,079	81,242	15,298	1,854	3.20	2.63	11,569	0	0
1991	5.12	207,421	75,824	15,655	2,650	2.67	2.85	11,569	0	0
1992	2.95	218,819	67,151	16,519	3,956	2.77	3.03	11,569	0	0

Trading partner: Switzerland

Year	IIT_{aj}	$AGNP_{aj}$	$DGNP_{aj}$	$APGNP_{aj}$	$DPGNP_{aj}$	AKL_{aj}	DKL_{aj}	DIS_{aj}	$LANG_{aj}$	TRRA
1975	8.00	187,565	209,658	17,044	7,984	4.23	1.79	11,900	0	0
1976	12.17	181,118	191,737	16,599	6,284	3.76	1.97	11,900	0	0
1977	9.07	173,852	160,763	16,357	3,185	2.98	0.33	11,900	0	0
1978	5.75	183,312	156,517	17,449	1,690	4.44	0.01	11,900	0	0
1979	4.60	196,088	134,489	19,311	2,132	4.90	2.01	11.900	0	0
1980	24.90	217,725	123,029	21,944	5,554	6.05	3.31	11,900	0	0
1981	10.58	211,711	134,003	20,804	3,885	5.44	0.77	11,900	0	0
1982	6.62	183,164	119,352	17,741	3,079	3.70	2.59	11,900	0	0
1983	4.70	171,651	118,310	16,314	2,265	3.83	2.41	11,900	0	0
1984	4.64	166,945	113,762	15,735	2,438	3.75	1.46	11.900	0	0
1985	2.20	156,774	97,305	14,838	3,409	3.54	1.89	11,900	0	0
1986	1.63	158,619	78,171	15,286	5,677	4.74	5.31	11,900	0	0
1987	2.83	176,511	53,726	17,550	9,880	6.08	7.43	11.900	0	0
1988	1.36	208,211	30,237	21,200	15,128	7.01	6.52	11,900	0	0
1989	2.05	215,961	40,031	21,560	14,741	6.86	6.69	11.900	0	0
1990	1.89	220,775	43,850	21,734	14,726	7.12	10.46	11,900	0	0
1991	0.91	219,175	52,316	21,139	13,620	6.15	9.80	11.900	0	0
1992	1.13	229,908	44,974	22,131	15,180	6.12	9.73	11,900	0	0

Trading partner: Korea

Year	IIT_{aj}	$AGNP_{aj}$	$DGNP_{aj}$	$APGNP_{aj}$	$DPGNP_{aj}$	AKL_{aj}	DKL_{aj}	DIS_{aj}	$LANG_{aj}$	TRRA
1975	31.78	190,874	203,039	11,784	18,503	8.16	6.07	4,350	0	0
1976	95.09	184,751	184,471	11,161	17,159	7.91	6.34	4,350	0	0
1977	95.79	174,946	158,575	10,289	15,321	7.50	8.71	4,350	0	0
1978	72.10	183,823	155,495	10,582	15,424	10.06	11.24	4,350	0	0
1979	61.45	191,310	144,044	10,711	15,067	10.27	12.74	4,350	0	0
1980	68.76	209,974	138,531	11,429	15,476	10.10	11.42	4,350	0	0
1981	43.29	195,789	165,847	10,891	15,941	10.08	10.05	4,350	0	0
1982	80.08	167,551	150,577	9,278	13,846	7.40	9.99	4,350	0	0
1983	98.30	163,077	135,458	8,791	12,781	6.98	8.70	4,350	0	0
1984	62.12	162,069	123,514	8,504	12,023	7.29	8.53	4,350	0	0
1985	41.48	153,202	104,451	7,804	10,659	7.22	9.24	4,350	0	0
1986	42.23	155,429	84,552	7,597	9,702	9.08	14.00	4,350	0	0
1987	40.65	168,902	68,945	7,920	9,380	11.23	17.74	4,350	0	0
1988	65.22	192,640	61,380	8,744	9,783	15.21	22.92	4,350	0	0
1989	88.43	209,658	52,636	9,254	9,870	14.94	22.86	4,350	0	0
1990	95.25	221,713	41,975	9,527	9,689	14.48	25.17	4,350	0	0
1991	72.53	229,126	32,415	9,624	9,411	14.98	27.47	4,350	0	0
1992	57.09	235,723	33,343	9,776	9,529	14.16	25.81	4.350	0	0

Trading partner: the Philippines

Year	IIT_{aj}	$AGNP_{aj}$	$DGNP_{aj}$	$APGNP_{aj}$	$DPGNP_{aj}$	AKL_{aj}	DKL_{aj}	DIS_{aj}	$LANG_{aj}$	TRRA
1975	0.23	183,344	218,100	11,381	19,308	3.02	4.20	4,228	0	0
1976	13.00	177,393	199,187	10,754	17,974	2.90	3.69	4,228	0	0
1977	19.16	165,667	177,133	9,830	16,238	2.06	2.18	4,228	0	0
1978	0.24	171,904	179,333	10,039	16,511	2.73	3.42	4,228	0	0
1979	0.01	175,763	175,139	10,057	16,377	2.54	2.71	4,228	0	0
1980	0.97	185,808	186,863	10,539	17,255	2.76	3.26	4,228	0	0
1981	0.00	185,417	186,590	10,361	17,001	3.03	4.06	4,228	0	0
1982	0.48	164,264	157,152	8,945	14,513	1.68	1.45	4,228	0	0
1983	2.65	150,189	161,235	8,259	13,845	1.70	1.87	4,228	0	0
1984	11.95	132,042	183,569	7,635	13,761	1.65	2.76	4,228	0	0
1985	15.30	118,442	173,970	6,855	12,558	1.35	2.51	4,228	0	0
1986	8.39	115,659	164,092	6,525	11,846	1.09	1.98	4,228	0	0
1987	1.93	119,083	168,583	6,610	12,000	1.25	2.23	4,228	0	0
1988	4.32	129,732	187,195	7,128	13,016	1.96	3.59	4,228	0	0
1989	3.39	135,911	200,131	7,396	13,587	1.87	3.28	4,228	0	0
1990	1.50	138,171	209,059	7,462	13,818	1.05	1.69	4,228	0	0
1991	7.40	137,663	215,340	7,406	13,846	0.70	1.09	4,228	0	0
1992	5.28	141,217	222,355	7,507	14,067	0.70	1.10	4,228	0	0

Trading partner: Thailand

Year	IIT_{aj}	$AGNP_{aj}$	$DGNP_{aj}$	$APGNP_{aj}$	$DPGNP_{aj}$	AKL_{aj}	DKL_{aj}	DIS_{aj}	$LANG_{aj}$	TRRA
1975	0.01	161,958	260,871	10,899	20,273	2.69	4.87	4,689	0	0
1976	0.01	155,505	242,963	10,272	18,938	2.49	4.51	4,689	0	0
1977	0.15	144,645	219,177	9,378	17,142	1.72	2.86	4,689	0	0
1978	0.35	150,023	223,095	9,579	17,430	2.38	4.11	4,689	0	0
1979	0.00	152,098	222,469	9,571	17,349	2.14	3.53	4,689	0	0
1980	3.42	161,516	235,447	10,052	18,229	2.38	4.03	4,689	0	0
1981	25.58	161,336	234,751	9,893	17,936	2.68	4.75	4,689	0	0
1982	57.40	142,551	200,577	8,540	15,321	1.31	2.17	4,689	0	0
1983	50.25	136,511	188,590	8,021	14,322	1.45	2.37	4,689	0	0
1984	36.31	133,883	179,887	7,698	13,636	1.65	2.75	4,689	0	0
1985	58.07	124,586	161,682	6,998	12,273	1.41	2.37	4,689	0	0
1986	49.77	121,823	151,763	6,669	11,558	1.15	1.87	4,689	0	0
1987	38.54	127,422	151,904	6,795	11,630	1.32	2.09	4,689	0	0
1988	35.05	141,665	163,328	7,380	12,512	2.08	3.33	4,689	0	0
1989	37.32	150,596	170,762	7,695	12,988	2.00	3.01	4,689	0	0
1990	24.72	156,940	171,520	7,830	13,082	1.28	1.23	4,689	0	0
1991	27.90	160,444	169,780	7,837	12,984	0.94	0.61	4,689	0	0
1992	29.15	167,478	169,834	7,993	13,095	0.94	0.62	4,689	0	0

Appendix 6.2 : Summary Description of Data Series and Their Sources

Data Series	Unit	Sources
Australia's pharmaceutical exports and imports	current dollars	ABS, Foreign Trade, Australia, Merchandised Exports and Imports, cat. no. 5424.0 and 5426.0
Australia's bilateral pharmaceutical exports and imports with its 14 trading partners.	current dollars	ABS, Foreign Trade, Australia, Merchandised Exports and Imports, Detailed Commodity Tables, cat. no. 5436.0 and 5437.0
GNP and per capita GNP for Australia and 14 trading partners	current dollars	World Bank, World Tables, 1995.
Total capital formation for Australia and 14 trading partners	current dollars	United Nations, Yearbook of National Accounts Statistics, vol. 1, part 1-2, United Nations, New York.
Labour force	persons	World Bank, World Tables, 1995.
Number of establishments in Australia's pharmaceutical industry	Establishments	ABS. Manufacturing Industry: Summary of Operations, Australia, cat. no. 8202.0
Australia's pharmaceutical R&D expenditure	current dollars	ABS, Research and Experimental Development: Business Enterprises, Australia, cat. no. 8104.0
Australia's turnovers and value added in pharmaceutical industry	current dollars	ABS, Manufacturing Industry: Summary of Operations, Australia, cat. no. 8202.0
Implicit GNP deflator	index	World Bank, World Tables, 1995.
Average effective rates of assistance (ERA) for Australia's chemical, petroleum and coal products, ASIC 27.	per cent	Industries Assistance Commission (IAC), Annual Reports, various years, Australian Government Publishing, Canberra.
Distance	Nautical miles	Times Books (1989), Atlas and Encyclopaedia of the Sea, Times Books Limited, London. Conlon, R.M. (1979), "Transport Costs as Barriers to Australian Trade," Centre of Applied Economic Research (CAER), Paper no. 8, Sydney.

Appendix 6.3: Summary Statistics of Data

Variable	Unit	Minimum	Maximum	Mean	Standard Deviation
IIT_{aw}	index	48.13	73.37	59.38	8.61
$PDIF_a$	ratio	0.02	0.11	0.05	0.04
ES_a	ratio	6.47	12.92	10.62	1.54
MS_a	establishments	109.00	145.00	128.33	9.87
DD_a	dollars	12,448.00	21,036.00	16,024.90	2,693.60
KL_a	ratio	1.25	5.13	3.19	1.24
RA_a	per cent	7.00	20.00	13.28	4.38
IIT_{aj}	index	0.001	98.42	28.31	27.68
$AGNP_{aj}$	$million	112,569.00	2,653,253.00	503.346.90	560,195.00
$DGNP_{aj}$	$million	12,068.00	4,806,385.00	655,920.10	1,045,308.00
$APGNP_{aj}$	dollars	6,525.00	22,176.00	14,155.00	3,648.20
$DPGNP_{aj}$	dollars	4,000.00	20,273.00	6339.60	5167.20
AKL_{aj}	ratio	0.70	15.21	3.68	2.39
DKL_{aj}	ratio	0.01	27.47	2.74	4.09
DIS_{aj}	nautical miles	11,900.00	1,260.00	7,833.20	3,525.8

Appendix 6.4: Results of Diagnostic Tests

Australia-Rest of the World Intra-industry Trade

Model	serial correlation	RESET	Non-normality	Heteroscedasticity
E_1: Log-linear	4.482 (0.034)**	1.576 (0.238)	0.665 (0.717)	0.911 (0.340)
E_2: Log-log	0.189 (0.664)	5.168 (0.046)**	0.965 (0.617)	3.791 (0.050)**

Australia's Bilateral Intra-industry Trade

Model	serial correlation	RESET	Non-normality	Heteroscedasticity
E_1: Log-linear	92.409 (0.000)***	1.256 (0.264)	3.939 (0.000)***	7.723 (0.005)***
E_2: Log-log	100.05 (0.000)***	0.087 (0.767)	482.9 (0.000)***	0.333 (0.564)

(Figures in parentheses are the probability values of t-ratio: ***Significant at the 1 per cent level,
** Significant at the 5 per cent level).

Appendix 6.5 : Australia-Rest of the World Intra-industry Trade (E_1: log-linear)

Variable	Expected sign	Regression coefficients
Constant		-6.978 (-3.487)***
Product differentiation ($PDIF_a$)	+	-17.148 (-6.453)***
Economies of scale (ES_a)	+	0.291 (4.083)***
Market Structure (MS_a)	+	0.027 (3.454)***
Degree of economic development (DD_a)	+	0.166E-3 (4.916)***
Technological advancement (KL_a)	+	-0.092 (-1.779)
Trade barriers (RA_a)	-	-0.045 (-1.812)*

(Figures in parentheses are the probability values of t-ratio: ***Significant at the 1 per cent level. * Significant at the 10 per cent level).

R^2 = 0.890; Adjusted R^2 = 0.830; $F_{(6,11)}$ = 14.868; DW = 2.850

Lagrange multiplier test of serial correlation : χ^2(1) : 4.482 (prob: 0.034)

Ramsey's Specification Error : RESET(1) : $F_{(1,10)}$: 1.576 (prob: 0.239)

Normality : χ^2(2) : 0.665 (prob: 0.717)

Heteroscedasticity: χ^2(1) : 0.911 (prob: 0.340)

Appendix 6.6 : Bilateral Intra-Industry Trade of Australia and its 14 Trading Partners[@] (E_2: log-log)

Variable	Expected sign	Regression coefficients
Constant		19.088 (3.234)***
Average GNP ($LAGNP_{aj}$)	+	1.810 (-3.525)***
Difference in GNP ($LDGNP_{aj}$)	-	-0.962 (-3.393)***
Average per capita GNP ($LAPGNP_{aj}$)	+	-2.315 (-2.444)**
Difference in per capita GNP ($LDPGNP_{aj}$)	-	-0.076 (-0.528)
Average capital-labour ratio ($LAKL_{aj}$)	+	1.338 (3.675)***
Difference in capital-labour ratio ($LDKL_{aj}$)	-	-0.242 (-2.068)**
Distance ($LDIS_{aj}$)	-	-1.220 (-2.304)**
Common language ($LANG_{aj}$)	+	1.544 (4.091)***
Special trade arrangement ($TRRA_{aj}$)	+	-1.699 (-1.335)

(Figures in parentheses are the probability values of t-ratio: ***Significant at the 1 per cent level, ** Significant at the 5 per cent level).

[@] Australia's trading partners include France, Germany, Italy, Belgium, Switzerland, Netherlands, the U.K., the U.S.A., Canada, New Zealand, Japan, Korea, Philippines and Thailand.

$R^2 = 0.261$; Adjusted $R^2 = 0.233$; $F_{(9,242)} = 9.492$; DW = 0.744

Lagrange multiplier test of serial correlation : $\chi^2(1)$: 100.05 (prob: 0.000)

Ramsey's Specification Error : RESET(1) : $F_{(1,241)}$: 0.087 (prob: 0.767)

Normality : $\chi^2(2)$: 482.914 (prob: 0.000)

Heteroscedasticity: $\chi^2(1)$: 0.333 (prob: 0.564)

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