AN ECONOMETRIC STUDY OF THE AGGREGATE IMPORT DEMAND FUNCTION

- Some Methodological Aspects -

A dissertation submitted to the School of Economics,
Nagoya University, Japan, in partial
fulfillment of the requirement
for the
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by

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CHAPTER 1

INTRODUCTION

1.1. Aim

Since the end of World War II, an increasing number of empirical studies on aggregate import and export functions has been conducted to measure price and income elasticities in the international trade. Estimates of these elasticities are interesting and important to the researchers or policy makers who may wish to know what effects of income and price changes may have on the trade balance of different countries. Numerous studies to estimate price elasticities of import demand in straightforward ways have not proved successful.

In 1950, Orcutt expounded a number of reasons that caused the statistically estimated price elasticities for traded goods to be biased towards zero. This study is intended to be an extended investigation by econometric approach to the conventional aggregate import demand model to emphasize the importance of precise assessment of elasticity estimates in trade policy issues. Distinct aspects of the single-equation merchandise import demand model are separately considered in five chapters. My research has stressed the methodological aspects of estimating a single-equation model of import demand. I hope that this research has created a stepping-stone for further contributions in both theoretical and applied econometrics.

In the long course of foreign trade, the United Kingdom was the pioneer of the nineteenth century trading world, and free trade doctrine had originated from the United Kingdom.

During the period from 1873 to 1913, the United Kingdom had higher ratios of exports and imports to its national product. In 1913, the United States became to show a leading position in world trade and also, Japan headed the Asian trade. By this historical experience, aggregate data of these three nations are brought into empirical characterization of import demand.

1.2. Organization of the Research

In the classical econometric work of international trade, Polak developed an international adjustment mechanism through exports, imports and income. The process of adjustment produced equations for exports, imports and income for each nation; a causal relationship between exports and imports was linked by the national income. However, Polak's empirical work was based on prewar data and reflected a causal relation running from national income to imports. This causal behaviour between international trade and national income is retraced in Chapter 2 of my study, by the frequency domain approach. Annual data series are analyzed for long historical period, dividing prewar (1885-1939) and postwar(1947-1985) years. Causal patterns are explained at both current and constant prices. Turning from the short data series, the spectral analysis is continued to the long data series observed at quarterly base for the postwar period. Having analyzed by the application of spectral methods, causal models are established.

Chapter 3 discusses some econometric issues emerged from early empirical studies on single-equation aggregate import demand model. Criticisms on the prewar empirical estimates of price elasticities in international trade had been on the low-elasticity side. In fact, conventional demand theory had not been strictly employed in classical estimation of single-equation aggregate import demand function. Nevertheless, postwar empirical studies have justified the use of single-equation procedure with the assumption of infinitely elastic supply of imports, to remedy the bias arisen from simultaneous shifts in demand and supply curves. The theoretical framework for the determination of aggregate import demand is also mentioned in this chapter. Then, price and income elasticity estimates of import demand for the United Kingdom, the United States and Japan by the prewar and postwar data are reported. Hints are made for certain works to be treated in next chapters.

Chapter 4 deals with errors of measurement in the traditional aggregate import demand model. It begins with a discussion of previous studies on the bias in price and income elasticity estimates of import demand. Particularly, Kemp (1962) and Kakwani(1972) derived definite statements about the direction and magnitude of the bias due to the errors of measurement in the least-squares estimates of price elasticity of the import demand equation. They applied the statistical procedures to the specification that the quantity of imports was related to the price measured with errors. The point is made that omission of the income variable from the specification of import demand model is not subject to the relevant economic theory, and the correlation between the price and income variables affects the statistical properties of the resulting bias. This motivated to me to develop some propositions in Chapter 4, concerning with the measurement errors in the variables of the import demand relation. A case that true variable is correlated with its measurement error is considered by Proposition 3. A Monte Carlo experiment is also included in this chapter.

The functional form of the demand for imports is important on both economic and statistical grounds, because the assessment of accurate elasticity estimates plays a critical role for policy implications, and misspecification of the functional form violates the statistical properties of the estimates. Applied econometricians have suggested that the choice between linear and log-linear specifications of aggregate import demand relationship is an empirical issue since there is rare a priori economic rationale for the appropriate functional form. Testing linear versus log-linear is therefore treated in Chapter 5. Among many tests available in the literature, the Sargan's test, the Box-Cox test developed by Savin and White (1978), the Lagrange multiplier statistics and Andrews' test developed by Godfrey and Wicken (1980) are applied to the static and dynamic models of the United Kingdom, the United States and Japan by the quarterly data.

Dynamic elements are introduced in Chapter 6. There are two reasons : (i) significant serial correlation is observed in the residuals of estimated models in Chapter 5 and **(ii)** the responsiveness of demand for imports to price or income changes may be delayed by recognition lags, decision lags, delivery lags, replacement lags and production lags. The dynamic model for each country is explored by Almon lags, partial adjustment mechanism and adaptive expectation hypothesis. Then parameter stability of dynamic specifications is tested by the cusum of squares test.

Finally, some of the main statistical and theoretical problems are discussed in Chapter 7.

1.3. Early Development of World Trade

The history of trade had been associated with the history of human civilization. The early scenery of trade was seen in the caravan trade or the caravel trade. The trade of the Mediterranean was restrained by political disorder during the period, so-called Dark Ages, between the sixth and the eighth century, and after this period, the beginning of modern trade arose in Western Europe. In the long course of trade, though the expansion of world trade had first moved from Europe since the twelfth century, Asia and Africa had a wealthier trade than Europe at that time. The rise of nation states during the fourteenth century, the discovery of new lands during the fifteenth century, and colonization since the sixteenth century were causes of early development of international trade.

As consequences of the development in human culture and technology, expansion in socio-economic institutions and colonization, a great increase in world population, production and trade had been achieved during the nineteenth century. In 1800, world total population was 906 million and it became nearly double, estimated to be 1608 million in 1900. According to Kuznets' estimation, the volume of foreign trade per capita grew 25 times and world product per capita, 2.2 times, within 113 years during the period 1800-1913. The estimated annual average growth rates in volume of world trade during this period are presented in Table 1.1. During this period, the rate peaked in the midcentury and sharply declined towards the end of the century,but rose again in 1900-1913.

Table 1.1. Estimated Annual Average Growth Rates in Volume of World Trade, 1800-1913 (per cent per year)

Period	Growth Rate
1800 - 1820	1.5
1820 - 1840	2.8
1840 - 1860	4.8
1860 - 1880	3.9
1880 - 1900	3.3
1900 - 1913	4.4

Source : J. R. Hanson II, Trade in Transition : Exports from the Third World, 1840-1900, Academic Press, 1980, p. 14.

A rapid expansion of international trade had started during the nineteenth century and it was dominated by Western Europe, especially the United Kingdom. As we mentioned above, the nineteenth century trade was characterized by a higher rate than the rate of world output. The free trade doctrine, first applied in the United Kingdom, was regarded as the distinctive feature of the nineteenth century trade and the United Kingdom had monopolized the world's trade by nearly about 25 per cent till 1900 and its position declined after 1900.

Table 1.2 represents the regional shares in world trade from 1820 to 1913. According to this table, nearly 60 per cent of world trade was from Europe, and France, Germany and the United Kingdom were seen as leading trade nations. Among them,

Table 1.2. Estimated Percentages of Regional Share in World Trade
1800 - 1913

Regions	1820	1840	1860	1880	1900*	1913
France	9	11	11	11	9	7
Germany	11	8	9	10	11	12
United Kingdom	27	25	25	23	22	16
Other Western Europe	14	16	13	15	16	15
Other Europe	15	14	11	12	11	14
North America	6	7	9	10	9	14
Latin America	8	8	6	5	5	8
Asia	3	3	3	4	4	9
Others	7	8	6	3	4	5

* Figures in 1899

Source : W. W. Rostow, The World Economy : History & Prospect, The Macmillan Press, 1978, Table II-8, pp. 70-73.

the United Kingdom was the greatest trading nation for this period. The role of colonial trade seemed predominant for the United Kingdom since the economic life of British colonies was built up on the production of exports. For instance, British colonies' trade constituted 33 per cent of her exports and nearly 23 per cent of her imports in the years between 1892 and 1896.

However, colonial trade involved small portions in other empires as shown in Table 1.3.

Table 1.3. Total Trade Compared with Colonial Trade for Selected Countries, Annual Average, 1892-1896.

Imperial Power	Exports (%)	Imports (%)	Colonial Area (1000 sq. miles)	Colonial Population (millions)
Britain	33.20	22.50	11 095	325.10
France	9.50	9.50	1 195	36.15
Holland	5.00	14.50	785	34.50
Portugal	9.20	15.80	834	7.90
Spain	24.00	9.70	323	8.50
Denmark	1.60	1.10	41	0.13
Germany	0.09	0.05	1 026	9.80

Source : J. Foreman-Peck, A History of the World Economy : International Economic Relations Since 1850, Wheatsheaf Books Ltd., 1983, Table 4.5, p. 115.

If a table for colonial trade per square mile was prepared, France and Spain accounted for a greater portion than other colonial empires in exports, and France and Holland, in imports as in Table 1.4. The share of Germany's colonial trade value had been pitifully tiny compared with others between 1892 and 1896.

Table 1.4. Colonial Exports and Imports Per Square Mile (Annual Average) 1892 - 1896

Imperial Power	Area of Colonial Empires (sq. miles)	Imports from Colonies (£)	Imports Per Square Mile (£)	Exports to Colonies (£)	Exports Per Square Mile (£)
Britain	11 090 490	94 437 000	8.5151	74 804 000	6.7449
France	1 195 702	14 725 000	12.3149	12 607 000	10.5436
Holland	785 884	17 433 000	22.1827	4 945 000	6.2923
Portugal	834 541	1 714 000	2.0538	517 000	0.6195
Spain	323 750	3 078 000	9.5073	7 166 000	22.1344
Denmark	41 079	221 000	5.3799	232 000	5.6476
Germany	1 026 709	110 000	0.1071	146 000	0.1422

Source : A. W. Flux, The Flag and Trade, Journal of the Royal Statistical Society, Vol. 62 (1899).

In the late nineteenth century, Japan became an industrialized economy and its share of trade rose among Asian nations. Basically, it seemed that the early development of world trade was in harmony with the industrial revolution and world trade grew 3.3 per cent during the period 1873 to 1913. The nineteenth century trade leaders, the United Kingdom, France and Germany, had higher ratios of exports and imports to their national products than other nations during this period. For the United Kingdom and Germany, the ratio of imports to national product was bigger than that of exports to national product. In the case of France, these ratios were equally high of ove 20 per cent between 1880 and 1913 for both exports and imports. The figures for these countries are shown in Table 1.5.

Table 1.5. Estimated Percentages of Trade in National Product for France, Germany and the United Kingdom, 1820-1913

Year	France		Germany		United Kingdom	
	Exports	Imports	Exports	Imports	Exports	Imports
1820	7.0	5.0	-	-	10.0	13.0
1840	7.0	8.0	7.0	6.0	9.0	12.0
1860	16.0	14.0	-	-	16.0	22.0
1880	24.0	28.0	16.0	22.0	16.0	25.0
1900	24.0	25.0	13.0	17.0	13.0	21.0
1913	26.0	28.0	18.0	20.0	19.0	25.0

Source : S. Kuznets, The Level and Structure of Foreign Trade : X. Long-Term Trends, Economic Development and Cultural Change, Vol. 14 (1967), Appendix Table I.

1.4. Patterns of Trade

As mentioned earlier, an accelerated expansion of international trade had originated in the nineteenth century as consequence of developments in transportation, communication, and industrialization and it was fostered by the device of free trade policies. However, it is hard to manifest the general structure of world trade since it varies over time according to the stage of industrialization of nations and also the political and socio-economic process. If the expansion of world trade was traced through the rate of growth, the trade grew more rapidly in post-war years than prewar years. The rate of growth had lost through wars and economic crisis during the period 1913-1948. Though the postwar period, so-called the golden age of the international trade, has been generally marked by a high growth rate, a series of structural changes in world trade pattern took place continuously.

If we traced back into the nineteenth century, the Western Europe exhibited its most powerful position in world trade. Among the Western Europe, the United Kingdom established her welfare state by strenghtening colonial power, and her colonial empire area was 91 times her own area till the end of the nineteenth century. In the case of the United Kingdom, it seemed to have a close correlation between trade and colonization. Historically, most of the colonial governments had adopted colonial economic policies, oriented towards the export economies of their colonies. During the time of the British colonialism Myanmar(formerly Burma) had been well-known as the world's rice bowl due to its laizzez-faire and free trade policies. Actually, free trade doctrine had greatly favoured the United Kingdom in trading with her colonies to enrich the mother country.

World trade expanded to include a great variety of commodities during the period 1870-1913, the golden age of capitalism. The spice trade had dominated at the end of seventeenth century; sugar and tobacco were key trading items in the eighteenth century. When there involved several items of commodity in international trade during the nineteenth century, it became very difficult to describe the pattern of world trade at micro level. Generally, the export pattern was highly affected by the progress of industrialization and the import pattern was influenced by resource endowments and import demand of the country. The most common structure of world trade was that in the non-industrial or developing group, primary products constituted a large share in their exports, and manufactures, a large share in their imports. The contrary was obvious for the industrial or developed group. If we selected 1913, the year before the outbreak of the World War I, this pattern of world trade is illustrated in Figure 1.1.

Figure 1.1 shows that in 1913, the industrial nations provided 92 per cent of world manufactured exports of which 45 per cent was traded among the same group, and the non-industrial nations, 8 per cent only. World manufactured imports

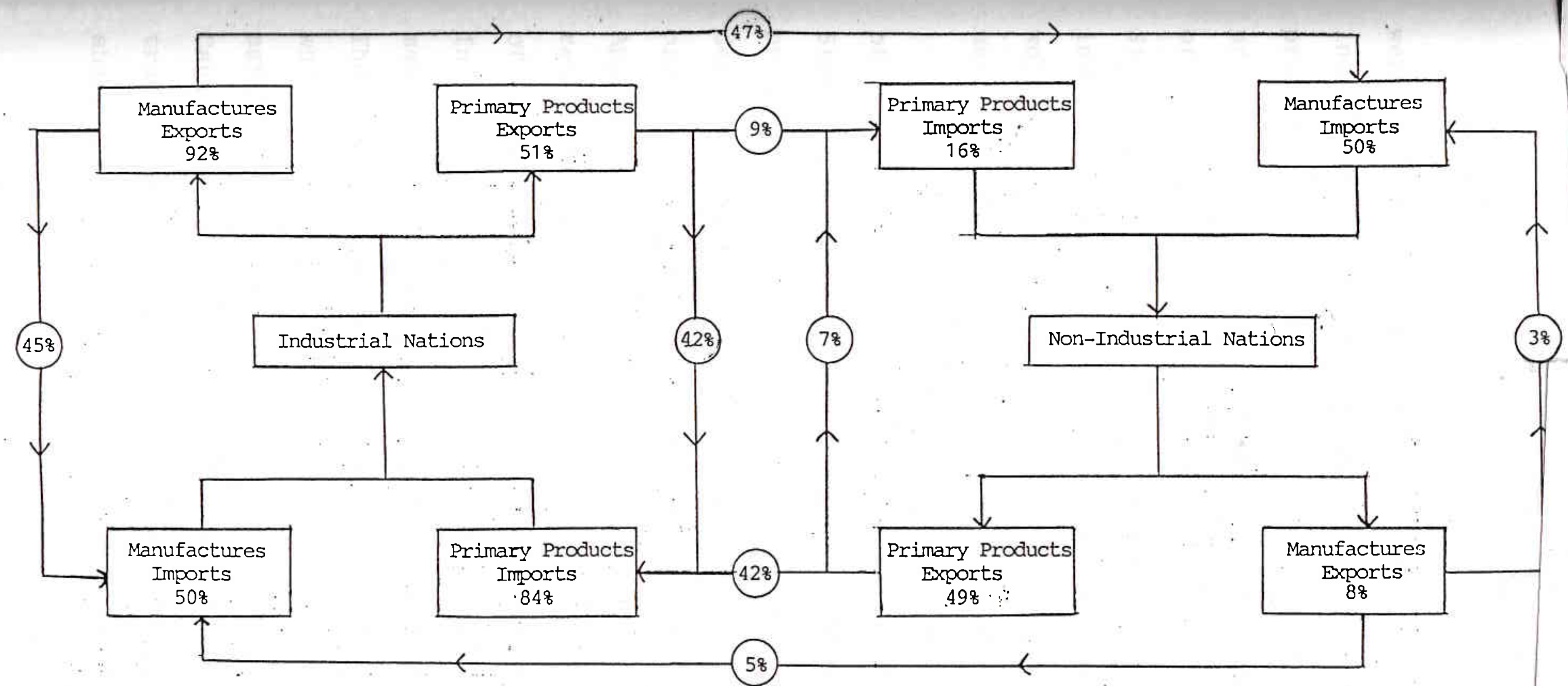


Figure 1.1. Direction of 1913 World Trade

Note. Industrial nations include the United Kingdom, the United States, Belgium, France, Germany, Austria, Hungry, Netherland, Italy, Sweden, Switzerland and Japan.

Source : Computed from P. L. Yates, Fifty Years of Foreign Trade, George Allen & Unwin Ltd., London (1959), Tables 29 and 30, pp. 57-58.

were equally shared between the two groups, industrial and non-industrial, and also, equal share could be seen in exports of primary products. Nevertheless, four-fifths of world imports of primary products were demanded by the industrial group and half of these came from the same group, mostly supplied by the United States and Canada. It is clear from the figure that the industrial nations had been participating most significantly in world trade and the percentage contribution among the industrial nations was greater than that among the non-industrial nations.

If we looked at the regional trade pattern in terms of value in 1913, the developed countries except the United States and Canada, mainly exported manufactures and imported primary products. The reverse pattern was exhibited in the developing countries. Regional composition of world trade in primary products and manufactures is shown in Table A.1 of Appendix A. Roughly, primary products included food, agricultural raw materials, minerals, and metals. Also, manufactures consisted of metal products, chemicals, textiles, and other manufactures. In 1913, the United States and Canada concentrated on food and metal product exports and mainly imported minerals and metals. The main exports of the United Kingdom and Japan were textiles while food was a top item in the United Kingdom's imports, and agricultural raw materials for Japan. The United States and Canada, in 1913, became to show their leading position in world trade and also, Japan headed the Asia trade, accounting for her share of over 17 per cent in exports and imports.

The leading industrial nations' products shifted to war materials during World War I, 1914-18. After the war, the United States and Canada had occupied the dominant position in world trade. Moreover, technological change in the industrial nations and high rate of industrial growth in the newly industrialized nations, Brazil, Finland, India, New Zealand in the 1920's prevailed. If we compare the trade pattern in 1928 with the position in 1913, the export share of the United Kingdom and Northwest Europe in world trade had declined and that of other regions had risen in 1928. Moreover, a decline in import share of world trade was seen in Northwest Europe and Ocenia regions. An increase in the exports of manufactures at the expense of the exports of primary products was evident in the United States. The trade pattern in 1928 is presented in Table A.2 of Appendix A. The depression in the 1930s reflected the expansion of the U.S. trade and a slight decrease of its share in regional pattern of world trade in primary products and manufactures can be seen in 1937 figures.
In 1937, the United States' shares of exports and imports in value had slightly fallen from 19.73 to 17.12 per cent and from 15.13 to 13.92 per cent, respectively.

In the postwar period, world trade was growing at a rapidly higher rate than the prewar period. According to Arthur Lewis (1981), the annual average growth rate of world trade for the periods 1873-1913, 1913-1939, 1953-1973 were 3.3 per cent, 0.9 per cent, and 8.0 per cent, respectively. Various classifications of countries according to their economic structure came to exist in the postwar trade studies. Generally, developing countries are classified into oil-exporting countries and non-oil developing countries. According to international financial statistics prepared by the International Monetary Fund (IMF), the international trade position for the period 1950-1980 is shown in Table 1.6.

Table 1.6. Annual Percentage Change in Value of World Trade by Regions, 1950 - 1980*

Region	1950-60	1960-70	1970-80	1950-80
World	7.1	9.4	20.7	12.3
Industrial Countries				
Exports	8.7	10.1	18.9	12.5
Imports	8.0	10.3	19.7	12.5
Oil-Exporting Countries				
Exports	5.5	9.1	33.0	15.2
Imports	8.9	6.1	30.2	14.6
Non-Oil Developing Countries				
Exports	3.4	6.5	21.0	10.1
Imports	5.7	7.2	20.8	11.0

* : in U. S. current dollars

Source : International Financial Statistics : Supplement on Trade Statistics, International Monetary Fund, 1982.

As shown in Table 1.6, the growth rate of trade in industrial countries was bigger than that in both oil-exporting countries and non-oil developing countries during the 1950s and 1960s. But the reverse pattern and considerable difference in the rate of growth of trade between industrial countries and oil-exporting countries were visible during the 1970s. Unexpected rising oil prices in late 1973 gave a dramatic increase in value of exports in oil-exporting countries and a rapid rise in commodity prices during this decade, also, affected the trends of foreign trade in all regions. The trends of exports and imports in terms of value for three regions during the postwar period, 1950-1980, are depicted in Figures 1.2 and 1.3. Rapidly upward trends of trade after 1972 in world total and industrial nations can be easily seen in these figures.

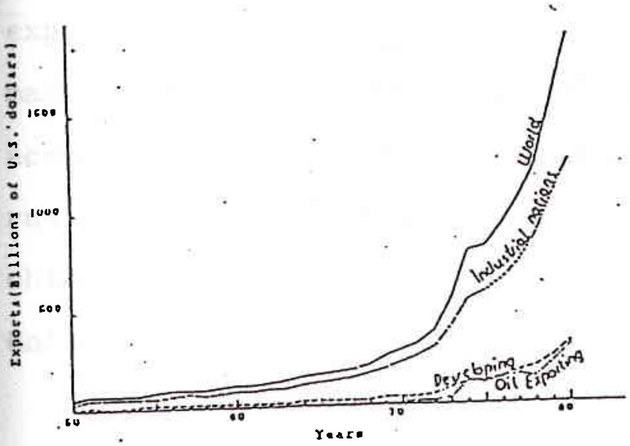


Figure 1.2. Exports of Three Regions, 1950 - 1980

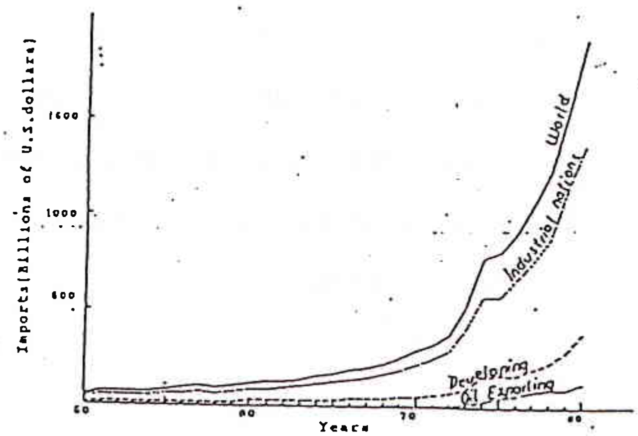


Figure 1.3. Imports of Three Regions, 1950 - 1980

Data Source : International Financial Statistics : Supplement on Trade Statistics, International Monetary Fund, 1982.

However, import demand conditions, inflationary pressures, and oil-shocks have affected the price movements of the international economy and then, the value of exports and imports. Overall prices in world trade were stable from 1953 to 1963; a slow increase in prices happened during the period between 1963 and 1968; accelerated rising price level had been met after 1968, and the level of prices began to decline after 1980.

Trade performance in 1953 can be seen in Table 1.7, based on the Standard International Trade Classification (SITC). A common character of large proportions of manufactured exports and imports of primary products in the trade composition of industrialized countries can also be viewed in this table. Major exports of the United States and the United Kingdom were machinery while food was their principal import. Textiles accounted for a large share in Japan's exports and agricultural raw materials, in her imports. Until 1953, Japan had concentrated chiefly on exports of textiles; the main item of exports of the United States and the United Kingdom shifted to machinery.

Again, as given in Table A.3 of Appendix A, during 1963-1984, three-fifths of world trade could be attributed to the industrial countries, and the rest, by three other groups, oil-exporting, non-oil developing and eastern countries, approximately in equal share. The share of exports in the industrial countries had been declining in value between 1973 and 1981; then rose again after 1981. On the contrary, rising trend in export share of the oil-exporting and non-oil developing countries was observed during the period from 1973 to 1981, this trend continued in non-oil developing countries after 1981. However, a conspicuous trend in trade share of eastern trading

Table 1.7. Regional Composition of World Trade in Primary Products and Manufactures in Percentages, 1953

Region	Exports				Imports				Total Exports			Total Imports		
	SITC 0-4	SITC 5-8	SITC 9	Total	SITC 0-4	SITC 5-8	SITC 9	Total	SITC 0-4	SITC 5-8	SITC 9	SITC 0-4	SITC 5-8	SITC 9
United States & Canada	18.29	36.55	30.54	27.32	20.66	21.27	34.43	21.11	33.57	65.20	1.23	53.71	44.17	2.12
United Kingdom & Ireland	3.74	16.63	34.92	10.36	19.61	6.43	8.53	13.69	18.08	78.21	3.71	78.59	20.60	0.81
Other Europe	20.61	36.92	23.91	28.60	34.29	29.24	3.20	31.68	36.14	62.94	0.92	59.40	40.47	0.13
Oceania	7.29	0.64	1.50	3.99	1.27	4.14	1.07	2.53	91.79	7.80	0.41	27.65	71.80	0.55
Latin America	21.08	1.37	1.00	11.25	7.29	13.21	14.92	9.98	93.97	5.93	0.10	40.05	58.00	1.95
Africa	10.86	2.19	1.00	6.53	3.89	12.21	15.99	7.69	83.44	16.39	0.17	27.74	69.56	2.70
Asia	17.52	2.76	7.01	10.21	7.71	12.49	20.79	9.97	86.06	13.19	0.75	42.43	54.86	2.71
Japan	0.61	2.94	0.12	1.74	5.28	1.01	1.07	3.35	17.69	82.23	0.08	86.35	13.23	0.42
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	50.16	48.74	1.10	54.87	43.83	1.30

Note : Primary products and manufactures are grouped according to the United Nations' Standard International Trade Classification (SITC).
SITC 0-4 = Primary Products
SITC 5-8 = Manufactures
SITC 9 = Miscellaneous

Source : Computed from P. L. Yates, Forty Years of Foreigh Trade, London, 1959, Tables A.23 and A.24, pp. 231-232.

countries has not been experienced all through the years. The main cause of rising export share of oil-exporting countries was the threefold rise in petroleum's price in late 1973.

For the case of non-oil developing countries, the increase in volume of exports and also, as well as the rapid rise in the commodity prices in the early years of 1970s, elevated their exports share in world trade. Moreover, the role of the newly industrialized economies (NIEs) from Asia, Latin America, and Europe in the 1970s, has become more important ,showing their rising shares of manufactured exports. The Mediterranean, Greece, Yugoslavia, Spain and Portugal achieved high growth rate in industrial production in the 1960s and had started their swift rates of exportation of manufatcured since 1970s. Also, the Latin American countries, Argentina, Brazil, and Mexico, showed their concentration on the manufactured exports. The east Asia group, South Korea, Taiwan, Hong Kong and Singapore - Gang of Four, also stimulated their strong achievement in exports of manufactures in the 1970s. The so-called ASEAN Four (Association of South East Asian Nations), Malaysia, the Phillippines, Thailand, and Indonesia, obtained their NIEs' position in the late 1970s and early 1980s. A general background on trade position of these countries will not be included in my study.

1.5. Commodity Pattern of Trade in The United Kingdom, The United States and Japan

A pioneer study on the structure of world trade in manufactures and primary products was done by Hilgert in 1945. In this section, an attempt was made to provide a little inquiry on the patterns of imports and exports in nominal value over the period from 1955 to 1983 for the three nations, the United Kingdom, the United States and Japan. Commodity classification is similar to that of the General Agreement on Tariffs and Trade (GATT). A study on the commodity composition of trade for some industrial nations between 1900 and 1954 can be seen in Baldwin (1958).

The shares of the United Kingdom, the United States and Japan in the export and import trade by commodity group in 1913 and 1953 are shown in Table 1.8. In these countries, machinery and other manufactured exports rose rapidly during the forty years period; in the United Kingdom and the United States, machinery exports were one-third of total exports in 1953. On the export side, a large decline was seen in textiles for the United Kingdom, food and agricultural materials for the United States, agricultural materials and metals for Japan. Between 1913 and 1953, minerals exports of Japan dropped from 4.2 to 0.8 per cent. On the import side, between 1913 and 1953, imports of textiles fell significantly; that of minerals rose rapidly. In Japan, imports of metals declined from 11.1 to 1.6 per cent during this period.

As computed in Tables A.4(a) - A.9(b) of Appendix A, for the period between 1955 and 1983, commodities were mainly grouped into primary products and manufactures. Non-ferrous metal was classified as manufactures in earlier issues of International

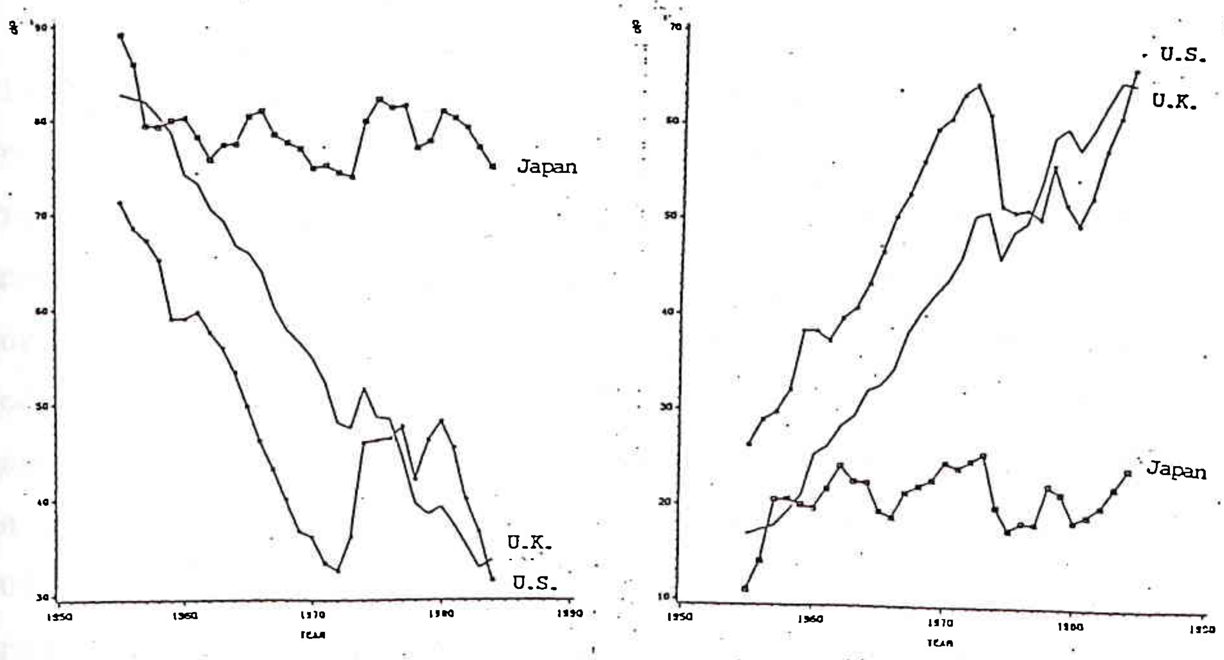
Table 1.8. Percentage Share of Trade in Value by Commodity Group in 1913 and 1953 : U. K., U. S. and Japan

Commodity Group	United Kingdom				United States				Japan			
	Exports		Imports		Exports		Imports		Exports		Imports	
	1913	1953	1913	1953	1913	1953	1913	1953	1913	1953	1913	1953
1. Food	7.8	6.9	43.5	40.6	24.1	14.1	25.9	32.7	10.8	11.3	15.6	26.8
2. Agricultural Material	2.6	3.4	27.1	24.0	28.4	6.1	30.6	16.7	29.4	5.4	37.3	35.6
3. Minerals	12.1	6.3	4.9	14.6	9.9	7.8	5.3	15.2	4.2	0.8	4.2	24.3
4. Metals	12.4	13.5	7.0	6.8	13.0	10.3	7.9	13.1	5.7	15.6	11.1	1.6
5. Chemicals	5.3	7.0	1.7	2.4	3.0	5.4	5.8	3.6	4.5	4.9	12.7	2.9
6. Machinery	13.9	37.0	2.7	5.4	11.1	36.3	1.9	3.3	0.8	14.9	7.6	6.7
7. Textiles	37.1	14.3	6.6	2.0	3.0	3.7	11.1	3.7	35.4	32.8	5.1	0.8
8. Other Manufactures	8.8	11.6	6.5	4.2	7.5	16.3	11.5	11.7	9.2	14.3	6.4	1.3

Source : P. L. Yates, Forty Years of Foreign Trade, London, 1959, Tables A 48 and A 49, pp. 250-251.

Trade studied by GATT, and it has been reclassified as primary product since 1973 data in later issues. Therefore, in my computation, non-ferrous metal was put into the group of primary products. Also, manufactures group has been reclassified since 1973 as in GATT.(1) Though completely accurate figures could not be available, commodities were grouped as unique as possible in terms of the Standard International Trade Classification (SITC) for the period studied.

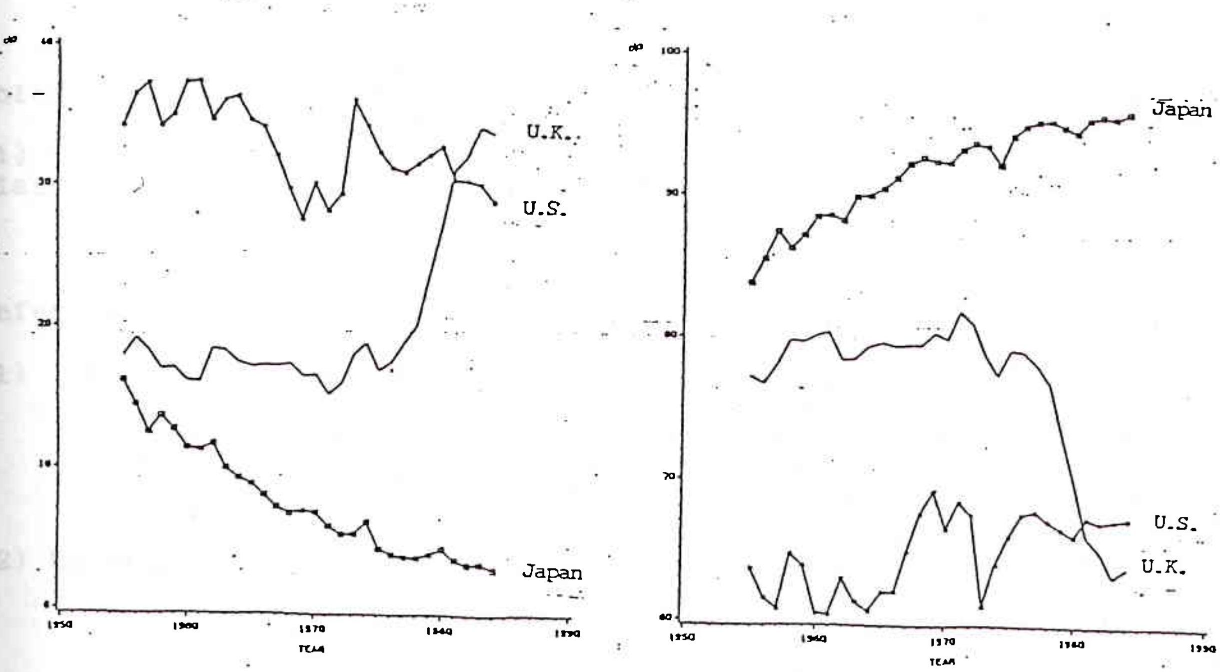
First, if we looked at the percentage shares in nominal value of primary products and manufactured imports between 1955 and 1983, it seemed that Japan showed stable and slightly cyclical nature of imports in both groups; the United Kingdom and the United States, on the other hand reveal downward trends in primary products and upward trends in manufactures. On the export side, Japan exhibited a slightly decreasing trend in percentage shares of primary products and a slightly increasing trend in manufactures. The United Kingdom depicted a tendency for rising percentages in exports of primary products and for declining percentages in manufactured exports. The United States, during the period 1955-1983, had maintained her position in terms of nominal value of exports such that one-third were primary products and two-thirds, manufactures. These patterns can be seen in Figures 1.4 and 1.5. According to these patterns, Japan enjoys a successful market share of manufactured exports while the United Kingdom and the United States have been leading to unpleasant patterns of trade.



(a) Primary Products

(b) Manufactures

Figure 1.4. Percentage Shares of Primary Products and Manufactures in Imports



(a) Primary Products

(b) Manufactures

Figure 1.5. Percentage Shares of Primary Products and Manufacture in Exports

Data Source : Appendix Tables A.4 - A.9

It will be difficult to give definite conclusions only from the point of view of nominal value since inflation, foreign exchange rate and other political situations greatly affect the foreign trade trends. Roughly, food was the most important item in the imports of primary products of the United Kingdom. It was also a major item in the U.S. imports of primary products from 1955 to 1973; after 1973, the nominal value of food imports dropped in importance and, it was replaced by fuel. Japan had imported the largest proportion of raw materials in the 1955-1967 period, but after 1967, fuel rose and nearly 45 per cent of Japanese imports has been spent on fuel since 1974. In the Japanese exports of manufactures, textiles and clothing had predominated until 1963, and was displaced by engineering products and motor vehicles after 1963.

Notes

(1) Started from the figures for 1973, GATT has published by new classifications in manufactures.

References

(1) Anjaria, S. J., Kirmani, N., and Petersen, A. B. (1980), **Trade Policy Issues and Development**, Occasional Paper 38, International Monetary Fund, Washington, D. C.

(2) Baldwin, R. E. (1958), "The Commodity Composition of Trade : Selected Industrial Countries, 1900-1954", **Review of Economics and Statistics**, 40(Supplement No. 1, Part 2, February),50-68.

(3) Bradford, C. I., Jr., and Branson, W. H. (1987), **Patterns of Trade and Structural Change**, in Trade and Structural Change in Pacific Asia, edited by the same authors, The University of Chicago Press.

(4) Condliffe, J. F. (1950) , **The Commerce of Nations**, W. W. Norton & Company Inc., New York, Chapter 1, pp. 11-26.

(5) Flux, A. W. (1899), "The Flag and Trade", **Journal of the Royal Statistical Society**, , 62.

(6) Foreman-Peck, J. (1983), **A History of the World Economy : International Economic Relations Since 1850**, Wheatsheaf Book Ltd., Great Britain, Chapter 4, pp. 94-122.

(7) Godfrey, L. G. and Wicken, M. R.(1981), "Testing Linear and Log-Linear Regressions for Functional Form", **Review of Economic Studies**, 48, 487-496.

(8) Hansan II, J. R. (1980), **Trade in Transition : Exports from the Third World, 1840-1900**, Academic Press, New York.

(9) Kakwani, N. C. (1972), "On the Bias in Estimates of Import Demand Parameters", **International Economic Review**, 13 (No. 2, June), 239-244.

(10) Kemp, M. C. (1962), "Errors of Measurement and Bias in Estimates of Import Demand Parameters", **The Economic Record**, 38(September), 369-372.

(11) Kenwood, A. G., and Lougheed, A. L. (1983), **The Growth of the International Economy 1820-1980 : An Introductory Text**, George Allen & Unwin, London.

(12) Kuznets, S. (1967), "Quantitative Aspects of the Economic Growth of Nations, X. Level and Structure of Foreign Trade : Long-Term Trends", **Economic Development and Cultural Change**, 15 (No. 2, Part II, January),1-140.

(13) Lewis, A. (1981), The Rate of Growth of World Trade, 1830-1973, in **The World Economic Order : Past and Prospects**, edited by Grassman, S., Landberg, E., The Macmillan Press Ltd., Hong Kong, 11-75.

(14) Rostow, W. W. (1978), **The World Economy : History & Prospect**, The Macmillan Press Ltd.

(15) Savin, N. E. and White, K. J. (1978), "Estimation and Testing for Functional Form and Autocorrelation : A Simultaneous Approach", **Journal of Econometrics**, 8, 1-12.

(16) Yates, P. L. (1959), **Forty Years of Foreign Trade**, George Allen & Unwin Ltd., London.

CHAPTER 2

POLAK'S PIONEER HYPOTHESIS ON INTERRELATIONSHIP BETWEEN IMPORTS, EXPORTS, AND INCOME

2.1 Introduction

In the context of world trade modelling, Polak, as one of the implications in his international economic system, provided a hypothetical causal inference on the interdependence between three 'macro' variables, namely exports, imports and income. His concern is that exports determines income and income determines imports. Polak's hypothesis contributes the 'income' channel between exports and imports, whereas imports are directly reviewed from exports in input-output system of trade flows. Polak looked into his framework by the prewar data of some countries over the world, and noted, " Of all the relationships used in this study, that between national income and imports is the most widely known and accepted".(1)

In this chapter, empirical efforts are, however, made to verify such relationships by cross-spectral approach and causality tests, covering both prewar and postwar periods for three industrialized countries, the United Kingdom (U.K.), the United States (U.S.), and Japan. Being concentrated on requirement of stationarity in data series, we ignore the possibility of structural changes during the periods analysed.

2.2 Polak's Model on International Economic System

In his international economic system, Polak suggested a transimission model by four major relationships; (i) variations in exports tend to fluctuate income ; (ii) fluctuations in income affects imports with or without time lag; **(iii)** each country's exports is a portion of world trade; **(iv)** adding up the imports of all countries amounts to the total volume of world trade .

Polak's international economic system can be described by a simple model consisting of the following four equations:

$$Y_i = \lambda_i X_i \tag{2.2.1}$$

$$M_i = \theta_i Y_i \tag{2.2.2}$$

$$X_i = \Omega_i W \tag{2.2.3}$$

$$W = \sum_{i=1}^{n} M_i \tag{2.2.4}$$

where subscript 'i' denotes for the i-th country and

Y = real national income

X = volume of exports

M = volume of imports

W = total volume of world trade

λ = foreign trade multiplier

θ = marginal propensity to import

Ω = marginal propensity of foreign countries to import from country i

In this model, Polak derived the foreign trade multiplier, λ_i, from national income identity, treated domestic investment and exports as exogeneous variables. According to his derivation, the foreign trade multiplier was obtained as '$1/(1-\beta_i + \theta_i)$' ; β_i, being the marginal propensity to consume. Then imports were linked with exports by a fraction, called 'international reflection ratio' which was resulted from equations (2.2.1) and (2.2.2) as '$\theta_i/(1-\beta_i + \theta_i)$' . Polak suggested that this ratio should be less than unity for the stability of an economy. Finally, world trade multiplier was derived from equation (2.2.4).

In dealing with statistical evidence, behavioural equations of this model were estimated on prewar annual data of 25 countries for 1924-38. Relative price variable was added in some equations. Since the computed international reflection ratios were observed as below unity for a plurality of countries, and additionally, world trade multiplier was computed as near to 0.5, it would seem to reveal a stable state of international economic system during the prewar years in the sense of global trade.

2.3 Empirical Evidence on Linkage of Exports, Imports, and Income: Cross-Spectral Approach and Causality Testing

2.3.1 Cross-Spectral Approach

In the field of time series analysis, cross-spectra are usually used to investigate relationship between two series by coherences and phases at different frequencies within the framework of frequency domain approach. Coherence measures the degree of relationship between the two series at each frequency and phase is a measure of time lag. The estimation procedure can be described as follows :

Given the data of a bivariate discrete stationary process, i. e. $(x_t, y_t, t=1,2,...,n)$, we compute the estimate of covariances as

$$c_{xx}(k) = \frac{1}{n} \sum_{t=1}^{n-k} (x_t - \bar{x})(x_{t+k} - \bar{x})$$

$$c_{yy}(k) = \frac{1}{n} \sum_{t=1}^{n-k} (y_t - \bar{y})(y_{t+k} - \bar{y})$$

$$c_{yx}(k) = \frac{1}{n} \sum_{t=1}^{n-k} (x_t - \bar{x})(y_{t+k} - \bar{y}) \qquad (2.3.1)$$

$$c_{xy}(k) = \frac{1}{n} \sum_{t=1}^{n-k} (y_t - \bar{y})(x_{t+k} - \bar{x})$$

where $\bar{x} = \frac{1}{n} \sum_{t=1}^{n} x_t$, $\bar{y} = \frac{1}{n} \sum_{t=1}^{n} y_t$, and k is time-lag.

The estimated power spectrum is

$$\hat{S}_{xx}(u) = \frac{c_{xx}(0)}{2\pi} + \frac{1}{\pi} \sum_{k=1}^{m} w_k \, c_{xx}(k) \cos(ku) \qquad (2.3.2)$$

where w_k's are computed by the Parzen weights with truncation point m as

$$w_k = 1 - \frac{6k^2}{m^2}\left(1 - \frac{k}{m}\right) \quad ; \quad 0 < k < m/2$$

$$= 2\left(1 - \frac{k}{m}\right)^3 \quad ; \quad m/2 < k < m \qquad (2.3.3)$$

$$= 0 \quad ; \quad k > m .$$

The smoothed co- and quadrature spectra are :

$$\hat{c}(u) = \frac{1}{4}\{c_{xy}(0) + c_{yx}(0)\} + \frac{1}{2}\sum_{k=1}^{m} w_k\{c_{xy}(k) + c_{yx}(k)\}\cos(ku) \quad (2.3.4)$$

$$\hat{q}(u) = \frac{1}{2}\sum_{k=1}^{m} w_k\{c_{xy}(k) - c_{yx}(k)\}\sin(ku) \quad (2.3.5)$$

where $u = \pi j/m$; $j=0,1,2,\ldots,m$.

The estimated cross-spectrum is

$$\hat{S}_{xy}(u) = \hat{c}(u) + i\,\hat{q}(u) \quad (2.3.6)$$

The estimated coherence and phase are

$$\hat{K}_{xy}(u) = \frac{\left|\hat{S}_{xy}(u)\right|^2}{\hat{S}_{xx}(u)\,.\,\hat{S}_{yy}(u)} \quad (2.3.7)$$

and

$$\hat{\Phi}(u) = \tan^{-1}\frac{\hat{q}(u)}{\hat{c}(u)} \quad (2.3.8)$$

The phases are in degree between -180° and 180°.

(a) **Prewar and Postwar**

Since analysis of short series has been supported by the work of Granger and Huge (1968), spectral measures are computed by the small number of observations, 53 observations for prewar and 37 observations for postwar. Despite of criticisms, annual data of gross national product, merchandise imports and exports are used for the three countries, since prewar years are included in this analysis. As all series seem to have trends, a second-order filter called Sims' filter $(1-0.75L)^2$ is computed on logarithmic values to eliminate trends and prewhiten the data.[2] Graphs of the series for prewar and postwar at current and constant prices are displayed in Appendix B. The number of lags used is 15 for each data set.

Results at current and constant prices are displayed in Tables 2.1(a)- 2.3(b).[3] As shown in those tables, there are many large coherences for the estimates at current prices. However, some of the coherences are considerably reduced by computing estimates at constant prices; some are still large.[4] Particularly, the majority of high coherence values at constant prices are observed in the relationships between imports and GNP of the postwar U.K., between imports and exports of the prewar U.K., and between the U.S. imports and GNP of both periods.

In Table 2.1(b), the highest coherence between the prewar U.K. exports and imports appears as 0.783 at 3.75 years with the phase 47° or about 6 months, exports leading. For the United States, imports with a maximum coherence leads GNP at 3.3 years with the phase 9° or one month during prewar, and this direction has seemed to change in postwar period 1947-1985 revealing a peak coherence 0.858 with the phase 14° or 2.3 months at 6 years, GNP leading as shown in Table 2.2(b). However, imports of the postwar U.K. leads its GNP at the highest coherence with the phase 16° or about 3 months at 5 years.

Table 2.1(a). Estimated Coherences and Phases between Imports and Exports - U.K., U.S., and Japan

(At Current Prices)

Years	Prewar, 1885-1939						Postwar, 1947-1985					
	U.K.		U.S.		Japan		U.K.		U.S.		Japan	
	K	φ	K	φ	K	φ	K	φ	K	φ	K	φ
30.00	0.760*	- 2°	0.823*	4°	0.932*	2°	0.987*	1°	0.963*	- 0.2°	0.901*	7°
15.00	0.645*	- 14°	0.762*	2°	0.740*	7°	0.946*	2°	0.869*	0.2°	0.803*	17°
10.00	0.660*	- 23°	0.748*	1°	0.536*	22°	0.770*	- 3°	0.482*	- 3°	0.619*	24°
7.50	0.656*	- 21°	0.730*	4°	0.559*	23°	0.602*	- 20°	0.558	- 23°	0.520	7°
6.00	0.712*	- 11°	0.630*	4°	0.632*	13°	0.699*	- 34°	0.782*	- 24°	0.532	- 6°
5.00	0.828*	- 9°	0.440*	- 10°	0.543*	- 3°	0.797*	- 36°	0.737*	- 30°	0.367	- 4°
4.28	0.902*	- 12°	0.376	- 25°	0.234	- 25°	0.729*	- 30°	0.566	- 43°	0.113	13°
3.75	0.884*	- 13°	0.436*	- 18°	0.086	- 35°	0.616*	- 16°	0.393	- 55°	0.031	9°
3.33	0.729*	- 11°	0.554*	- 7°	0.086	- 14°	0.607*	- 5°	0.280	- 68°	0.127	- 31°
3.00	0.414	- 1°	0.562*	4°	0.077	13°	0.623*	- 6°	0.294	- 76°	0.328	- 10°
2.73	0.319	23°	0.363	17°	0.028	65°	0.572*	- 6°	0.279	- 79°	0.571*	3°
2.50	0.489*	18°	0.096	30°	0.014	135°	0.320	- 14°	0.256	- 91°	0.690*	8°
2.31	0.668*	4°	0.061	13°	0.042	-163°	0.319	64°	0.319	- 102°	0.618*	4°
2.14	0.803*	- 4°	0.128	4°	0.112	-161°	0.310	63°	0.171	- 93°	0.500	- 3°
2.00	0.832*	- 0°	0.150	0°	0.132	-180°	0.109	0°	0.006	- 0°	0.462	0°

* Significant at 5 percent level

Table 2.1(b). Estimated Coherences and Phases between Imports and Exports - U.K., U.S., and Japan

(Prewar : At 1913 Prices; Postwar : At 1980 Prices)

Years	Prewar, 1885-1939						Postwar, 1947-1985					
	U.K.		U.S.		Japan		U.K.		U.S.		Japan	
	K	ϕ	K	ϕ	K	ϕ	K	ϕ	K	ϕ	K	ϕ
30.00	0.395	22	0.535*	1	0.791*	2	0.966*	3	0.662*	- 9	0.918*	6
15.00	0.681*	17	0.373	- 10	0.332	10	0.885*	8	0.342	- 26	0.835*	15
10.00	0.623*	4	0.298	- 19	0.123	61	0.568	16	0.240	- 79	0.685*	22
7.50	0.501*	- 8	0.195	- 14	0.271	72	0.294	- 3	0.380	- 76	0.462	8
6.00	0.529*	- 16	0.112	- 21	0.454*	54	0.459	- 30	0.449	- 69	0.260	- 14
5.00	0.610*	- 31	0.045	- 58	0.308	40	0.629*	- 39	0.453	- 69	0.133	- 37
4.28	0.750*	- 44	0.008	- 57	0.027	- 29	0.535	- 45	0.392	- 74	0.101	- 30
3.75	0.783*	- 47	0.049	22	0.102	- 80	0.252	- 43	0.343	- 88	0.077	- 17
3.33	0.723*	- 48	0.176	23	0.054	- 52	0.109	- 10	0.419	- 108	0.016	- 45
3.00	0.509*	- 55	0.204	22	0.001	103	0.118	- 7	0.439	- 118	0.038	- 58
2.73	0.167	- 64	0.016	60	0.104	176	0.097	- 8	0.302	- 127	0.203	- 36
2.50	0.051	- 43	0.094	153	0.239	-166	0.072	70	0.298	- 140	0.377	- 36
2.31	0.148	- 30	0.108	138	0.290	-156	0.422	106	0.384	- 139	0.294	- 46
2.14	0.320	- 26	0.038	84	0.338	-163	0.440	117	0.239	- 134	0.077	- 60
2.00	0.335	- 0	0.031	0	0.386	-180	0.113	180	0.056	- 180	0.022	0

* Significant at 5 percent level

Table 2.2(a). Estimated Coherences and Phases between Imports and GNP - U.K., U.S., and Japan

(At Current Prices)

Years	Prewar, 1885-1939						Postwar, 1947-1985					
	U.K.		U.S.		Japan		U.K.		U.S.		Japan	
	K	ϕ	K	ϕ	K	ϕ	K	ϕ	K	ϕ	K	ϕ
30.00	0.662*	- 1	0.840*	-0.3	0.958*	- 2	0.977*	1	0.980*	- 1	0.864*	8
15.00	0.650*	- 4	0.798*	- 4	0.803*	- 8	0.913*	2	0.943*	- 1	0.670*	20
10.00	0.678*	- 5	0.812*	- 8	0.633*	- 12	0.640*	4	0.780*	3	0.283	58
7.50	0.641*	- 1	0.816*	- 4	0.647*	- 5	0.194	- 19	0.660*	9	0.221	94
6.00	0.601*	- 3	0.818*	1	0.612*	- 0	0.294	- 83	0.659*	- 2	0.114	75
5.00	0.626*	- 20	0.694*	5	0.340	- 7	0.443	- 90	0.700*	- 15	0.151	49
4.28	0.681*	- 34	0.494*	15	0.143	- 28	0.368	- 82	0.751*	- 19	0.205	54
3.75	0.690*	- 44	0.640*	19	0.212	- 17	0.176	- 63	0.690*	- 20	0.117	60
3.33	0.607*	- 44	0.658*	14	0.437*	- 4	0.083	- 0	0.594*	- 26	0.102	46
3.00	0.459*	- 18	0.535*	2	0.325	- 2	0.219	42	0.528	- 21	0.274	50
2.73	0.672*	- 5	0.510*	- 7	0.081	4	0.232	66	0.519	- 3	0.500	62
2.50	0.818*	- 10	0.562*	-0.2	0.048	41	0.180	88	0.562	4	0.601*	74
2.31	0.787*	- 12	0.652*	8	0.094	64	0.083	96	0.484	- 8	0.506	78
2.14	0.572*	- 8	0.691*	5	0.050	91	0.028	138	0.258	- 23	0.256	57
2.00	0.371	0	0.701*	0	0.010	180	0.054	180	0.086	- 0	0.147	0

* Significant at 5 percent level

Table 2.2(b). Estimated Coherences and Phases between Imports and GNP - U.K., U.S., and Japan

(Prewar : At 1913 Prices; Postwar : At 1980 Prices)

Years	Prewar, 1885-1939 U.K.		Prewar U.S.		Prewar Japan		Postwar, 1947-1985 U.K.		Postwar U.S.		Postwar Japan	
	K	ϕ	K	ϕ	K	ϕ	K	ϕ	K	ϕ	K	ϕ
30.00	0.372	- 38	0.958*	0.4	0.857*	- 1	0.969*	3	0.956*	0.01	0.932*	0.1
15.00	0.357	- 59	0.859*	- 1	0.471*	6	0.880*	7	0.821*	0.20	0.803*	2
10.00	0.048	- 56	0.579*	- 8	0.238	51	0.683*	15	0.669*	- 6	0.546	12
7.50	0.192	88	0.451*	- 12	0.316	76	0.744*	19	0.804*	- 14	0.423	35
6.00	0.450*	77	0.471*	- 9	0.099	106	0.854*	16	0.858*	- 14	0.355	53
5.00	0.335	50	0.495*	- 4	0.173	-178	0.850*	11	0.831*	- 13	0.413	52
4.28	0.225	27	0.553*	2	0.288	-170	0.780*	4	0.796*	- 12	0.465	49
3.75	0.151	24	0.706*	8	0.119	-170	0.756*	6	0.681*	- 12	0.442	52
3.33	0.173	25	0.728*	9	0.001	152	0.836*	18	0.619*	- 19	0.330	43
3.00	0.177	25	0.581*	2	0.011	53	0.795*	25	0.654*	- 21	0.195	- 9
2.73	0.149	1	0.413	- 4	0.014	143	0.617*	35	0.670*	- 13	0.263	- 75
2.50	0.319	- 29	0.390	6	0.079	159	0.440	60	0.719*	- 11	0.434	-116
2.31	0.418*	- 35	0.494*	9	0.183	141	0.388	82	0.657*	- 22	0.504	-146
2.14	0.315	- 32	0.610*	4	0.286	143	0.264	94	0.360	- 33	0.599*	-169
2.00	0.146	- 0	0.660*	0	0.260	180	0.012	180	0.087	- 0	0.675*	180

* Significant at 5 percent level

Table 2.3(a). Estimated Coherences and Phases between GNP and Exports - U.K., U.S., and Japan

(At Current Prices)

Years	Prewar, 1885-1939						Postwar, 1947-1985					
	U.K.		U.S.		Japan		U.K.		U.S.		Japan	
	K	ϕ	K	ϕ	K	ϕ	K	ϕ	K	ϕ	K	ϕ
30.00	0.321	- 4°	0.643*	6°	0.932*	2°	0.996*	0.4°	0.919*	1°	0.988*	- 2°
15.00	0.281	- 21°	0.695*	11°	0.740*	7°	0.979*	0.3°	0.794*	4°	0.909*	- 5°
10.00	0.361	- 33°	0.842*	13°	0.536*	22°	0.862*	- 2°	0.302	- 2°	0.568	- 24°
7.50	0.467*	- 34°	0.866*	13°	0.559*	23°	0.565	0.1°	0.225	- 43°	0.379	- 70°
6.00	0.508*	- 9°	0.704*	10°	0.632*	13°	0.415	25°	0.414	- 28°	0.126	- 93°
5.00	0.680*	17°	0.340	4°	0.543*	- 3°	0.404	37°	0.507	- 22°	0.005	49°
4.28	0.748*	26°	0.149	- 13°	0.234	- 25°	0.234	34°	0.512	- 32°	0.139	49°
3.75	0.730*	33°	0.270	- 20°	0.086	- 35°	0.053	32°	0.466	- 48°	0.220	24°
3.33	0.640*	43°	0.415	- 12°	0.086	- 14°	0.007	- 6°	0.442	- 61°	0.179	- 8°
3.00	0.414	52°	0.316	4°	0.077	13°	0.045	- 48°	0.583*	- 63°	0.198	- 31°
2.73	0.457*	45°	0.198	31°	0.028	65°	0.072	- 42°	0.658*	- 83°	0.290	- 45°
2.50	0.647*	32°	0.136	48°	0.014	135°	0.092	- 8°	0.622*	- 89°	0.394	- 61°
2.31	0.659*	18°	0.105	42°	0.042	-163°	0.191	26°	0.621	- 82°	0.377	- 75°
2.14	0.481*	1°	0.047	41°	0.112	-161°	0.152	51°	0.384	- 0°	0.184	- 63°
2.00	0.292	- 0°	0.009	0°	0.132	-180°	0.001	0°	0.020	- 0°	0.076	- 0°

* Significant at 5 percent level

Table 2.3(b). Estimated Coherences and Phases between GNP and Exports - U.K., U.S., and Japan

(Prewar : At 1913 Prices ; Postwar : At 1980 Prices)

Years	Prewar, 1885-1939						Postwar, 1947-1985					
	U.K.		U.S.		Japan		U.K.		U.S.		Japan	
	K	ϕ	K	ϕ	K	ϕ	K	ϕ	K	ϕ	K.	ϕ
30.00	0.250	114	0.612*	0.2	0.883*	6	0.984*	-0.5	0.745*	- 6	0.962*	4
15.00	0.337	111	0.565*	- 4	0.713*	18	0.935*	- 1	0.557	- 14	0.858*	9
10.00	0.198	128	0.564*	-0.2	0.529*	33	0.715*	- 6	0.321	- 39	0.528	13
7.50	0.072	-177	0.406	17	0.384	18	0.515	- 27	0.433	- 52	0.187	- 3
6.00	0.084	- 79	0.154	30	0.200	- 25	0.589*	- 44	0.524	- 47	0.031	- 27
5.00	0.196	- 43	0.001	- 79	0.198	- 73	0.665*	- 44	0.586*	- 44	0.008	10
4.28	0.143	- 46	0.078	-129	0.192	- 75	0.615*	- 38	0.561	- 48	0.052	- 5
3.75	0.104	- 66	0.036	- 77	0.107	- 51	0.436	- 33	0.487	- 61	0.112	- 34
3.33	0.179	- 77	0.154	- 9	0.074	- 11	0.331	- 32	0.521	- 76	0.053	- 91
3.00	0.104	- 65	0.328	4	0.125	1	0.406	- 40	0.572*	- 79	0.045	-171
2.73	0.069	19	0.132	27	0.212	- 15	0.501	- 41	0.435	- 82	0.047	128
2.50	0.199	39	0.188	108	0.247	- 26	0.445	- 25	0.355	- 94	0.070	98
2.31	0.214	30	0.401	113	0.179	- 7	0.425	6	0.432	- 95	0.073	105
2.14	0.166	2	0.212	104	0.287	12	0.498	22	0.328	- 84	0.074	140
2.00	0.151	- 0	0.0002	180	0.389	0	0.436	0	0.023	- 0	0.085	180

* Significant at 5 percent level

The results at constant prices cannot give a complete information on the linkage of imports, exports and GNP of each country because of statistically insignificant coherences in some cases. Anyhow, if we consider the statistically significant high coherences at current prices, we can summarize the relationships as shown in Table 2.4.

Table 2.4. Patterns on the Linkage of Imports, Exports, and GNP at Current Prices
U.K., U.S., and Japan : 1885-1985

	Prewar (1885-1939)	Postwar (1947-1985)
U.K.	GNP ⟶ Exports ---> Imports	GNP ⟶ Imports
U.S.	Imports ⟶ GNP ---> Exports	Exports ⟶ GNP ⟶ Imports
Japan	GNP ⟶ Imports ---> Exports	Imports ⟶ Exports ⟶ GNP

Based on these patterns, postwar data of the U.K. and Japan verifies the Polak's emphasis that income determines imports, with the evidence that GNP is leading imports with about one month each at 2.5 years and 6 years respectively. A complete validation appears in the postwar U.S. data with less than one year of lead-lag periods.

(b) Postwar Quarterly Data

To investigate the relationships with longer data series, spectral measures are computed by quarterly data for the three variables over the postwar period, 1955 Q.1-1983 Q.4. As the graphs of the original quarterly data are showing upward trends logarithmic values of the series are prewhitened by Sims' filter. The resulting series are observed as random series without trend which will be allied to stochastic processes. Graphs are shown in Appendix B.

The same procedure used for annual data is also employed in postwar quarterly data. The estimated coherences associated with statistical significance and phases at current and constant prices are shown in Tables 2.5(a) - 2.5(c) covering period from the first quarter of 1955 to the fourth quarter of 1983. Spectral measures are estimated with 30 lags, a sufficient number at which the cross correlation functions damp out. Except the relationship between imports and exports of Japan at constant prices, we observe plausible coherency estimates at both current and constant prices and a summary of relationships is given in Table 2.6.

Table 2.6. Patterns on the Linkage of Imports, Exports, and GNP U.K., U.S., and Japan : 1955 Q.1-1983 Q.4

	At Current Prices	At Constant Prices (1980= 100)
U.K.	Exports ⟶ Imports ⟶ GNP	Exports ⟶ Imports ⟶ GNP
U.S.	Exports ⟶ GNP ⟶ Imports	Exports ⟶ Imports ⟶ GNP
Japan	Exports ⟶ Imports	GNP ⟶ Imports ⟶ Exports

Table [illegible] : Estimated Coherences and Phases between Imports and Exports : U.K., U.S., and Japan

1955 Q.1 - 1983 Q.4

Years	At Current Prices						At Constant Prices (1980=100)					
	U.K.		U.S.		Japan		U.K.		U.S.		Japan	
	K	φ	K	φ	K	φ	K	φ	K	φ	K	φ
60.00	0.9963*	- 0.675	0.9942*	- 0.706	0.9933*	- 0.200	0.9729*	- 2.452	0.9551*	- 2.536	0.9737*	- 1.988
30.00	0.9859*	- 1.572	0.9707*	- 2.098	0.9635*	- 0.718	0.9357*	- 5.767	0.8314*	- 8.838	0.9092*	- 3.455
20.00	0.9252*	- 4.069	0.7908*	- 9.893	0.7555*	- 3.097	0.8029*	- 12.532	0.4896*	- 42.964	0.5486*	0.072
15.00	0.8127*	-10.204	0.4465*	-25.502	0.4072*	- 21.573	0.6733*	- 20.261	0.4060*	- 76.695	0.0464	6.358
12.00	0.7460*	-14.591	0.2869	-18.218	0.4062*	- 41.271	0.6146*	- 20.740	0.1593*	- 69.908	0.0320	-111.135
10.00	0.7108*	-12.157	0.2987	-10.487	0.4210*	- 40.065	0.5273*	- 10.681	0.0643	- 39.428	0.1150	- 89.827
8.57	0.6015*	- 9.263	0.1971	-23.476	0.4371*	- 33.786	0.3316	0.636	0.0290	- 56.091	0.0958	- 73.923
7.50	0.4225*	-10.145	0.1112	-42.206	0.4919*	- 30.348	0.1788	15.145	0.0159	- 62.978	0.0217	- 46.117
6.67	0.3178	- 5.047	0.1568	-18.695	0.4614*	- 31.396	0.1914	30.806	0.0903	3.599	0.0003	- 99.990
6.00	0.4159*	3.046	0.4233*	- 4.504	0.2369	- 26.124	0.3140	24.775	0.4069	4.868	0.0394	171.910
5.45	0.6056*	1.980	0.4997*	-10.956	0.0702	0.265	0.4628*	3.804	0.5149*	- 4.846	0.1134	163.779
5.00	0.6837*	- 3.959	0.2266	-20.556	0.0047	- 14.598	0.6175*	- 11.105	0.2109*	- 9.866	0.1603	171.678
4.62	0.6461*	- 2.735	0.0071	- 0.710	0.1420	-146.965	0.6038*	- 8.505	0.0015	123.956	0.1675	-164.277
4.28	0.6327*	8.311	0.0336	42.735	0.4035*	-161.156	0.5562*	6.650	0.0142	161.065	0.2528	-165.337
4.00	0.6470*	17.741	0.1222	14.084	0.5312*	-169.892	0.5613*	19.068	0.0278	- 8.801	0.3307	-174.437
3.75	0.5830*	23.503	0.1997	0.897	0.5505*	-177.989	0.5096*	25.362	0.1353	- 9.456	0.3591	175.705
3.53	0.3406	4.707	0.1813	- 4.805	0.4427*	169.300	0.3429	7.455	0.1576	- 6.675	0.2879	163.037
3.33	0.4035*	-21.727	0.0556	8.012	0.2626	134.579	0.3074	- 18.062	0.0661	8.852	0.1701	152.035
3.16	0.4041*	-14.805	0.0463	45.920	0.1820	119.733	0.3092	- 13.375	0.0600	27.847	0.1430	160.970
3.00	0.3925*	-10.462	0.1418	19.526	0.0420	152.010	0.3863	- 6.418	0.2057	8.710	0.0660	-175.131
2.86	0.4625*	- 8.681	0.3489	- 1.720	0.0549	- 94.720	0.4507*	- 2.712	0.4574*	- 1.732	0.0559	-110.004
2.73	0.5019*	- 6.415	0.4974*	- 7.789	0.1633	- 67.793	0.4970*	- 2.422	0.5909*	- 4.304	0.1070	- 94.590
2.61	0.3666	-13.169	0.4982*	- 6.380	0.2287	- 51.790	0.4019*	- 10.896	0.5652*	- 4.693	0.2059	- 79.967
2.50	0.2726	-29.659	0.4423*	- 5.513	0.2866	- 29.506	0.3402	- 25.045	0.4503*	- 7.976	0.2662	- 50.990
2.40	0.2030	-29.394	0.5107*	- 7.606	0.2950	- 14.176	0.3126	- 23.156	0.4661*	- 11.014	0.1709	- 34.926
2.31	0.1718	7.728	0.6012*	- 7.866	0.2288	- 2.526	0.2601	0.256	0.5622*	- 10.121	0.1207	1.143
2.22	0.4167*	29.184	0.5283*	- 9.706	0.1589	0.138	0.3674*	20.325	0.5245*	- 11.737	0.1842	4.015
2.14	0.6309*	9.508	0.5511*	- 5.670	0.4473*	- 3.312	0.5689*	6.327	0.5552*	- 6.407	0.5262*	- 6.024
2.07	0.7884*	0.455	0.7209*	- 1.361	0.7475*	- 1.447	0.7336*	- 0.168	0.7130*	- 1.470	0.8010*	2.713
2.00	0.8270*	- 0.000	0.7649*	- 0.000	0.8369*	- 0.000	0.7770*	- 0.000	0.7561*	- 0.000	0.8746*	- 0.000

* Significant at 5 percent level

Table 2.5(b). Estimated Coherences and Phases between Imports and GNP - U.K., U.S., and Japan

1955 Q.1 - 1983 Q.4

Years	At Current Prices						At Constant Prices (1980=100)					
	U.K.		U.S.		Japan		U.K.		U.S.		Japan	
	K	φ	K	φ	K	φ	K	φ	K	φ	K	φ
60.00	0.9876	- 0.247	0.9858	- 0.364	0.9870	0.306	0.9868	1.247	0.9784	0.020	0.9828	- 1.345
30.00	0.9658	0.164	0.9725	- 0.472	0.9437	0.505	0.9654	3.414	0.9630	- 0.241	0.9546	- 2.237
20.00	0.8304	3.282	0.9102	2.401	0.6784	1.503	0.8832	7.024	0.9104	- 1.708	0.7489	0.912
15.00	0.4929	5.877	0.7293	7.767	0.2106	- 5.057	0.7135	12.134	0.7869	- 0.356	0.2938	6.641
12.00	0.2469	7.041	0.5534	4.942	0.1166	- 34.561	0.5606	27.885	0.6408	4.644	0.1094	- 12.867
10.00	0.2406	7.926	0.4591	4.843	0.2461	- 34.830	0.4740	30.654	0.5548	7.752	0.2154	- 40.947
8.57	0.2923	- 3.030	0.3253	11.453	0.4719	- 32.546	0.2417	10.910	0.3959	14.380	0.4544	- 47.290
7.50	0.2116	- 19.980	0.1764	23.750	0.4743	- 30.414	0.0618	7.814	0.2311	33.761	0.5180	- 43.014
6.67	0.0201	- 22.633	0.1536	29.634	0.2606	- 18.314	0.0506	77.171	0.2236	42.510	0.2414	- 20.738
6.00	0.0426	91.679	0.2864	14.457	0.1919	- 0.470	0.1191	70.493	0.3173	25.386	0.0659	21.035
5.45	0.1063	59.717	0.4025	- 1.080	0.0709	- 25.694	0.2396	17.374	0.3911	6.342	0.0483	118.549
5.00	0.0842	19.424	0.2380	- 8.356	0.1251	-117.100	0.2319	- 2.276	0.1899	1.116	0.0865	-165.262
4.62	0.1402	147.617	0.0183	- 29.686	0.2950	-170.005	0.1292	140.636	0.0320	- 2.420	0.1637	-172.924
4.28	0.5823	152.828	0.0129	-130.371	0.5095	167.415	0.5812	148.238	0.0250	- 5.942	0.2989	167.700
4.00	0.7176	152.239	0.0109	-161.164	0.5907	158.310	0.6919	140.383	0.0213	18.480	0.3978	157.308
3.75	0.6129	151.422	0.0063	115.426	0.5648	154.095	0.5444	150.762	0.0347	46.015	0.4347	152.073
3.53	0.2233	153.172	0.0730	63.715	0.3770	154.290	0.1976	171.637	0.1004	53.345	0.3178	151.550
3.33	0.0027	118.056	0.2709	62.307	0.0342	162.375	0.0366	-104.306	0.2436	58.580	0.0311	154.542
3.16	0.0303	21.628	0.1963	86.817	0.0182	17.530	0.0860	6.523	0.1732	70.348	0.0144	10.401
3.00	0.0594	- 10.664	0.0683	127.743	0.0514	10.540	0.1956	11.454	0.0312	123.359	0.0398	- 0.805
2.86	0.1622	- 40.353	0.0457	175.334	0.0950	13.292	0.2722	- 4.437	0.0291	-164.065	0.0820	11.336
2.73	0.2865	- 40.692	0.0504	-144.925	0.1368	29.253	0.3201	- 16.465	0.0487	-134.649	0.0786	30.241
2.61	0.2321	- 48.818	0.0319	- 93.927	0.0714	28.630	0.1990	- 38.140	0.0336	-105.594	0.0170	- 22.576
2.50	0.0622	- 31.474	0.0337	- 37.823	0.1005	- 3.410	0.1078	- 52.686	0.0138	- 49.708	0.0908	- 45.514
2.40	0.0187	44.056	0.0384	- 28.891	0.1604	6.472	0.0406	- 36.181	0.0090	- 30.061	0.1131	- 19.264
2.31	0.0225	28.547	0.0311	- 56.924	0.1972	33.129	0.0476	- 6.883	0.0006	- 75.461	0.1638	28.209
2.22	0.1788	- 21.483	0.0264	- 41.960	0.2965	30.190	0.1687	- 20.158	0.0162	- 31.294	0.2626	42.080
2.14	0.3309	- 10.873	0.3147	1.013	0.4494	11.432	0.3167	- 21.246	0.3124	1.780	0.3620	10.605
2.07	0.3802	- 9.249	0.6390	1.833	0.6518	2.070	0.3727	- 11.060	0.6281	1.378	0.5703	0.767
2.00	0.3914	- 0.000	0.7025	0.000	0.7192	0.000	0.3827	- 0.000	0.6944	0.000	0.6399	0.000

* Significant at 5 percent level

Table 2.b(c) . Estimated Coherences and Phases between GNP and Exports - U.K., U.S., and Japan

1955 Q.1 - 1983 Q.4

Years	At Current Prices						At Constant Prices (1980=100)					
	U.K.		U.S.		Japan		U.K.		U.S.		Japan	
	K	ϕ	K	ϕ	K	ϕ	K	ϕ	K	ϕ	K	ϕ
60.00	0.9913	- 0.335	0.9786	- 0.245	0.9945	- 0.412	0.9480	- 3.463	0.9560	- 2.060	0.9908	- 0.384
30.00	0.9803	- 1.362	0.9266	- 1.261	0.9775	- 0.402	0.9106	- 8.465	0.8686	- 7.146	0.9722	- 0.366
20.00	0.9192	- 6.108	0.6640	- 10.626	0.8831	0.670	0.7927	- 18.422	0.5787	- 31.956	0.8705	0.984
15.00	0.7326	- 14.432	0.4152	- 36.010	0.6223	0.225	0.6316	- 31.170	0.4282	- 59.088	0.5737	3.318
12.00	0.5522	- 17.510	0.3923	- 29.533	0.4220	2.854	0.5739	- 46.356	0.2665	- 46.859	0.3442	12.108
10.00	0.5622	- 17.467	0.4525	- 17.947	0.4328	3.603	0.6232	- 45.677	0.2096	- 26.458	0.3200	17.062
8.57	0.6384	- 15.107	0.3278	- 11.724	0.4211	6.329	0.5556	- 37.001	0.1193	- 13.155	0.2864	17.379
7.50	0.4937	- 8.374	0.2749	0.813	0.2785	12.497	0.3945	- 24.544	0.1430	7.737	0.1812	23.355
6.67	0.2230	- 7.977	0.3479	1.117	0.1848	18.552	0.2674	- 11.662	0.2588	8.985	0.1235	31.104
6.00	0.1679	- 25.923	0.3877	- 5.322	0.1917	25.951	0.2542	- 10.096	0.3697	1.237	0.1096	30.477
5.45	0.2538	- 33.062	0.2046	0.436	0.3167	34.069	0.3271	- 13.777	0.2466	7.358	0.1402	23.468
5.00	0.2056	- 16.920	0.0194	27.100	0.3601	37.303	0.3006	- 8.442	0.0523	38.384	0.2424	25.325
4.62	0.0372	- 69.345	0.2315	-161.340	0.6915	40.783	0.0330	- 76.908	0.1331	-174.386	0.6995	34.358
4.29	0.2085	-128.530	0.5948	-163.010	0.8560	39.733	0.2163	-125.196	0.4572	-172.738	0.8817	34.770
4.00	0.4072	-130.645	0.5710	-165.595	0.9025	38.256	0.3775	-124.857	0.4438	-176.673	0.9149	34.027
3.75	0.4861	-128.913	0.3265	-164.852	0.8812	36.302	0.3740	-122.195	0.2334	179.833	0.8651	32.890
3.53	0.2021	-125.460	0.0574	-140.310	0.7340	33.001	0.0646	-119.383	0.0295	-179.517	0.6587	32.407
3.33	0.1322	- 0.559	0.0497	- 52.821	0.3110	27.300	0.1446	17.432	0.0049	- 25.502	0.2277	45.095
3.16	0.4096	1.681	0.0281	- 92.601	0.1671	10.122	0.3738	- 0.162	0.0025	-142.005	0.0057	41.656
3.00	0.5385	13.442	0.0448	-133.256	0.1510	- 29.472	0.4578	4.455	0.0110	-157.403	0.0340	- 26.220
2.86	0.5438	26.505	0.0301	-175.336	0.0509	- 62.814	0.4577	15.598	0.0197	173.672	0.0151	- 84.189
2.73	0.4652	32.676	0.0209	116.450	0.0029	- 75.081	0.4317	19.784	0.0146	152.712	0.0011	112.528
2.61	0.3165	23.204	0.0325	12.802	0.1219	31.214	0.3170	18.787	0.0070	- 16.009	0.1208	42.843
2.50	0.2902	14.694	0.2057	- 12.865	0.4126	19.929	0.3339	24.585	0.1592	- 15.441	0.3680	27.896
2.40	0.2767	27.216	0.2692	- 13.239	0.3801	6.901	0.4370	31.184	0.2603	- 10.104	0.3639	17.399
2.31	0.3442	42.771	0.2365	- 0.368	0.1885	- 21.585	0.5649	32.832	0.2469	5.051	0.1266	- 12.018
2.22	0.5027	35.923	0.3041	6.778	0.2072	- 10.460	0.6826	28.900	0.3278	8.422	0.1025	- 9.926
2.14	0.6464	14.814	0.7552	1.212	0.6802	5.972	0.7160	14.487	0.7843	1.514	0.5472	8.141
2.07	0.7325	5.405	0.9237	0.254	0.8304	3.232	0.7774	5.369	0.9422	0.388	0.7520	4.262
2.00	0.7539	0.000	0.9498	0.000	0.8573	0.000	0.7974	0.000	0.9645	0.000	0.7894	0.000

* Significant at 5 percent level

From Table 2.6, the United Kingdom suggests a similar pattern between nominal and real values, differing the lengths of lead-lag period. At current prices, the U.S. data series confirm Polak's hypothesis, in agreement with the pattern of annual data. Japan fails to show a particular pattern on the linkage of three variables significantly, but a causation from income to exports is clear at nominal and real values and that from income to imports can be seen at real value.

2.3.2 Causality Tests

Next to cross-spectral measures, the causality test is performed to explore the causal direction of the three interrelated variables in Polak's hypothesis. The causal model is established based on two considerations : **(a)** the Granger's Axiom A (1980) that the past and the present may cause the future but the future cannot cause the past; **(b)** priority in time in the cause before the effect is at most two years as shown by the frequency domain approach. By these considerations, the causal models can be expressed as

(1) Unidirectional Causality

$$Y_t = a + \sum_{i=1}^{2} \beta_i Y_{t-i} + \sum_{j=1}^{2} \alpha_j X_{t-j} + \gamma t + u_t \qquad (2.3.7a)$$

$$X_t = b + \sum_{j=1}^{2} \alpha'_j X_{t-j} + \sum_{i=1}^{2} \beta'_i Y_{t-i} + \gamma' t + v_t \qquad (2.3.7b)$$

(2) Bidirectional Causality (Feedback)

$$Y_t = c + \alpha_0 X_t + \sum_{i=1}^{2} \beta_i Y_{t-i} + \sum_{j=1}^{2} \alpha_j X_{t-j} + \gamma t + u_t \qquad (2.3.8a)$$

$$X_t = d + \beta_0 Y_t + \sum_{j=1}^{2} \alpha'_j X_{t-j} + \sum_{i=1}^{2} \beta'_i Y_{t-i} + \gamma' t + v_t \qquad (2.3.8b)$$

where X_t and Y_t are transformed variables, t, time trend, u_t and v_t are mutually uncorrelated white noise series. X_t and Y_t are transformed by Sim's filter in order to remove serial correlation in the two-sided regression residuals. To test for causality we performed F-tests under the null hypothesis :

Model(1)

$H_0 : \alpha_j = 0$ (X causes Y : $X \longrightarrow Y$)

$H_0 : \beta'_i = 0$ (Y causes X : $X \longleftarrow Y$)

Model(2)

$H_0 : \alpha_0 = 0$ (X causes Y : $X \longleftrightarrow Y$)

$H_0 : \beta_0 = 0$ (Y causes X : $Y \longleftrightarrow X$)

Models are tested in linear and log-linear forms and the results are given in Tables 2.7(a) - 2.8(b). At current prices, it is clear from those tables that there exists a bidirectional causal relationship in all cases of three countries for the prewar period; also shown by high coherences in cross-spectral methods. When we compute for real values, simple causal

Table 2.7(a). Statistics for Causality Test - U.K., U.S., and Japan, Prewar(1885-1939) at Current Prices

X	Y	Form	Time lag	U.K. F(X→Y)	U.K. F(X↔Y)	U.K. F(X←Y)	U.K. F(X↔Y)	U.S. F(X→Y)	U.S. F(X↔Y)	U.S. F(X←Y)	U.S. F(X↔Y)	Japan F(X→Y)	Japan F(X↔Y)	Japan F(X←Y)	Japan F(X↔Y)
Imports	Exports	Linear	1	3.0853	163.6801*	6.9585*	163.6786*	7.3276*	71.6596*	11.7504*	71.6586*	1.3678	104.7946*	4.9429*	104.7948*
			2	13.9305*	89.5122*	15.0578*	89.5125*	6.1501*	55.1705*	9.7342*	55.1703*	0.4528	101.7201*	2.2730	101.7193*
		Log-Linear	1	1.4562	75.1547*	0.3174	75.2306*	0.0236	39.1062*	2.5338	39.1063*	1.4382	14.3830*	8.2323*	14.3031*
			2	6.7293*	50.3842*	4.9109*	50.3842*	0.0188	39.3683*	2.0185	39.3685*	2.1030	12.1601*	4.4191*	12.1601*
Imports	GNP	Linear	1	4.5018*	92.1527*	7.6629*	92.1535*	5.7638*	117.8818*	2.1189	117.8812*	0.7030	50.2484*	2.0246	50.2488*
			2	4.0535*	86.8735*	4.6456*	86.8738*	6.1795*	120.4292*	7.2768*	120.4293*	0.7017	40.1976*	0.2943	40.1974*
		Log-Linear	1	2.5900	60.6556*	2.9889	60.6555*	1.5391	70.9622*	2.8633	70.9616*	1.4368	40.5031*	3.0233	40.5030*
			2	2.4083	59.6353*	2.7344	59.6353*	1.0997	90.6273*	4.8391*	90.6268*	3.4732*	25.2053*	10.7310*	25.2054*
Exports	GNP	Linear	1	0.8104	59.1828*	6.2484*	59.1030*	0.5843	39.6054*	0.0185	39.6055*	4.7273	66.8954*	0.0052	66.8954*
			2	9.3011*	28.0518*	13.7711*	28.0509*	0.7651	46.3324*	2.8217	46.3325*	0.4822	60.5527*	1.0084	60.5542*
		Log-Linear	1	2.4890	22.7138*	2.9397	22.7140*	3.3272	26.7305*	0.5117	26.7307*	7.5224	42.2347*	0.0778	42.2347*
			2	8.1333*	8.8240*	7.4578*	8.8242*	1.8228	30.8672*	1.3998	30.8674*	1.1962	31.7445*	2.3747	31.7444*

* The null hypothesis of no causal relation can be rejected at 5 percent significance level.

Table 2.7(b). Statistics for Causality Test - U.K., U.S., and Japan, Prewar(1885-1939) at Constant Prices, 1913=100

X	Y	Form	Time lag	U.K. F(X⟶Y)	U.K. F(X⟷Y)	U.K. F(X⟵Y)	U.K. F(X⟷Y)	U.S. F(X⟶Y)	U.S. F(X⟷Y)	U.S. F(X⟵Y)	U.S. F(X⟷Y)	Japan F(X⟶Y)	Japan F(X⟷Y)	Japan F(X⟵Y)	Japan F(X⟷Y)
Imports	Exports	Linear	1	11.2105*	17.6656*	4.9309*	17.6658*	0.4324	5.9318*	0.7585	5.9319*	0.0349	2.9988	6.6757*	2.9998
			2	3.5551*	21.0050*	1.7688	21.0049*	1.4681	6.7281*	0.4081	6.7281*	0.2782	4.2662*	4.1460*	4.2659*
		Log-Linear	1	18.2377*	17.1547*	5.5383*	17.1547*	0.0656	1.9510	1.9430	1.9510	0.0282	0.4336	0.3946	0.4335
			2	7.2569*	16.0218*	1.6454	16.0220*	0.5956	2.0050	1.0176	2.0951	1.4610	0.5326	0.3764	0.5326
Imports	GNP	Linear	1	0.7398	2.0946	0.1813	2.0947	2.5999	49.3308*	4.5274*	49.3258*	0.0276	2.2829	12.4430*	2.2832
			2	3.0592	0.7921	1.0738	0.7910	1.3369	44.2683*	2.7054	44.2685*	0.0863	1.4426	1.9682	1.4430
		Log-Linear	1	1.0064	4.6407*	0.1108	4.6409*	1.6477	48.0026*	1.5940	48.0024*	1.7343	2.0733	2.4585	2.0732
			2	3.2217*	1.9651	1.4098	1.9649	1.1044	45.6421*	1.2754	45.6424*	6.6313*	1.9187	1.3791	1.9189
Exports	GNP	Linear	1	1.9635	1.2389	0.4911	1.2387	0.0415	2.9119	0.6350	2.9119	5.1534*	7.9689*	1.7479	7.9611*
			2	1.0967	0.0208	1.0571	0.0200	0.0001	3.9117	0.0459	3.9118	3.0921	12.9058*	2.1063	12.9059*
		Log-Linear	1	1.0601	0.0339	28.5479*	0.0339	1.1387	1.0591	0.2254	1.0591	0.1106	4.4798*	2.5480	4.4798*
			2	1.1051	0.0714	0.5387	0.0714	0.7384	1.5526	1.0366	1.5528	0.0821	5.5779*	3.3274*	5.5717*

* The null hypothesis of no causal relation can be rejected at 5 percent significance level.

Table 2.8(a). Statistics for Causality Test - U.K., U.S., and Japan, Postwar(1947-1985) at Current Prices

X	Y	Form	Time lag	U.K. F(X⟶Y)	U.K. F(X⟷Y)	U.K. F(X⟵Y)	U.K. F(X⟷Y)	U.S. F(X⟶Y)	U.S. F(X⟷Y)	U.S. F(X⟵Y)	U.S. F(X⟷Y)	Japan F(X⟶Y)	Japan F(X⟷Y)	Japan F(X⟵Y)	Japan F(X⟷Y)
Imports	Exports	Linear	1	7.4584	76.4827*	0.4972	76.4830*	0.8554	52.4634*	0.00002	52.4633*	8.1482*	99.3960*	0.0001	99.3962*
			2	8.5117*	45.6553*	4.0177*	45.6556*	4.5117*	20.1116*	7.3125*	20.1117*	10.7037*	70.3063*	6.1492*	70.3068*
		Log-Linear	1	1.2296	36.5732*	0.0020	36.5736*	9.8838*	13.4691*	0.7147	13.4690*	0.0208	16.0991*	1.0102	16.0988*
			2	0.6804	33.7839*	1.6752	33.7837*	4.0199*	26.8861*	0.4850	26.8861*	0.1693	24.7651*	1.3110*	24.7649*
Imports	GNP	Linear	1	11.5613*	0.4823	12.2742*	0.4822	0.0045	34.2385*	1.5832	34.2385*	5.4359*	3.1048	18.1044*	3.1048
			2	5.5810*	0.0137	7.7043*	0.0136	1.2533	36.0499*	2.2424	36.0502*	3.4570*	1.7343	13.5665*	1.7344
		Log-Linear	1	0.7514	1.1292	0.6293	0.0555	1.0954	32.3865*	0.0290	32.3866*	9.5120*	23.4988*	0.5007	23.4989*
			2	2.7749	4.0234*	1.2795	4.0233*	0.4765	22.1226*	0.6737	22.1228*	1.6607	22.1321*	0.5008	22.1310*
Exports	GNP	Linear	1	11.0793*	0.7629	20.1100*	0.7629	0.2406	13.9581*	0.3476	13.9584*	8.0477*	1.2790	26.9688*	1.2789
			2	3.5972	1.1091	11.4111*	1.1091	1.5720	13.5710*	0.8552	13.5718*	3.0138*	2.5122	10.4483*	2.5128
		Log-Linear	1	0.8347	2.9429	2.4153	2.9429	3.7037	16.2166*	11.8963*	16.2165*	1.4350	4.6813*	0.2323	4.6812*
			2	2.1190	6.7746*	2.4170	6.7745*	1.8261	10.9482*	3.9222*	8.7141*	0.3455	9.6015*	1.0034	9.6017*

* The null hypothesis of no causal relation can be rejected at 5 percent significance level.

Table 2.8(b). Statistics for Causality Test - U.K., U.S., and Japan, Postwar(1947-1985) at Constant Prices, 1980=100

X	Y	Form	Time lag	U.K. F(X→Y)	U.K. F(X↔Y)	U.K. F(X←Y)	U.K. F(X↔Y)	U.S. F(X→Y)	U.S. F(X↔Y)	U.S. F(X←Y)	U.S. F(X↔Y)	Japan F(X→Y)	Japan F(X↔Y)	Japan F(X←Y)	Japan F(X↔Y)
Imports	Exports	Linear	1	8.1262*	6.6597*	3.3357	6.6597*	1.8143	23.4515*	0.2638	23.4515*	2.5612	0.5641	0.0070	0.5641
			2	2.6754	4.8741*	1.1984	4.8740*	1.6895	22.7662*	2.9990	22.7660*	1.6209	0.1967	2.0560	0.1967
		Log-Linear	1	1.8696	6.1530*	0.1726	6.1531*	1.1086	4.1154	0.8955	4.1152	2.2965	2.3146	1.7960	2.3147
			2	1.7288	3.8592	2.3186	3.8591	0.0183	3.8123	1.0960	3.8124	5.2730*	3.3891	3.8063*	3.3893
Imports	GNP	Linear	1	0.5966	88.4857*	9.2300*	88.4051*	0.5741	10.0129*	4.9786*	10.0129*	9.8179*	5.4179*	11.9150*	5.4180*
			2	0.3097	65.8439*	4.6035*	65.8436*	0.8354	5.5981*	4.2772*	5.5980*	4.1951*	5.3238*	7.6158*	5.3238*
		Log-Linear	1	0.5458	57.8197*	13.3391*	57.8199*	0.0268	12.4355*	0.9135	12.4355*	0.3632	2.3358	19.6729*	2.3357*
			2	0.8245	42.3969*	7.8121*	42.3966*	0.2636	7.2364*	1.3655	7.2364*	0.2635	2.8296	6.9758	2.8297
Exports	GNP	Linear	1	9.5191*	8.7008*	13.5553*	8.7000*	4.4280*	13.8932*	9.5292*	13.8931*	0.0005	0.0154	8.3164*	0.0152
			2	1.7308	8.3775*	3.4218*	8.3775*	3.7781*	11.3060*	2.8134	11.3062*	0.0325	0.0002	2.8744	0.0002
		Log-Linear	1	6.5673*	9.8996*	6.8842*	9.8999*	4.3935*	10.2396*	10.8328*	10.2396*	1.3398	2.1076	11.0027*	2.1076
			2	1.7848	11.6449*	2.9037	11.6449*	4.4756*	8.7141*	8.1725*	8.7141*	2.5651	2.6893	21.5943*	2.6893

* The null hypothesis of no causal relation can be rejected at 5 percent significance level.

relations become weaker and feedback, too, as shown in Tables 2.7(a) and 2.8(b). At constant prices, there exists a bidirectional causal relation between imports and exports for the U.K., between imports and GNP for the U.S., and between exports and GNP for Japan, in the prewar data; those between imports and GNP, also, between exports and GNP, for the U.K. and U.S. in the postwar period. Particularly, if we look at the results in constant prices, the most pronounced evidence is the causal relation from GNP to imports which can be seen in linear form for all countries studied in the postwar period.

2.4 Conclusion

Polak had postulated a causal model of international trade and national income on the basis of multipliers. In his empirical econometric work, the single-equation framework was employed by using prewar data of selected 25 countries. He recognized that the most significant fit had been in the causal relation between imports and income.

In the present study, as an attempt to verify Polak's pioneer hypothesis, causal variables are analysed by cross-spectral methods and the Granger framework by dividing the data into two periods, prewar (1885-1939) and postwar (1947-1985) for the United Kingdom, the United States and Japan. In addition, cross-spectral measures are computed for quarterly data by the availability of information in postwar period. The present empirical study provides the following findings :

(i) Both cross-spectral and causality measures support significant linkage between imports and exports at current and constant prices for the United Kingdom during prewar and postwar years and spectral procedure gives certain causality from exports to imports with lags ranging between 20 days and 6.5 months. The very association is apparent in postwar period for the United States with a small length of lag between 12 and 18 days. This observation seems to be supported by the fact that the United States aggregate imports are not a linear function of aggregate exports.

(ii) Prewar cross-spectral results at current prices for the United Kingdom and Japan show a causal relation from income to imports, but results for quarterly data demonstrate differently. However, if we view on the results of causality results, this causality is observed for the prewar United Kingdom results at current price and the most obvious verification of this pattern is discerned at constant prices for all three countries.

(iii) Although the spectral results of prewar years at current prices appear to be inconsistent with the underlying causation process, those of the postwar U.K. and U.S. at current and constant prices significantly support that exports lead income.

(iv) In the case of the United States, spectral measures at current prices for the postwar period agree with the Polak's pioneer hypothesis while causality tests perform a perfect linkage of three variables for prewar and postwar periods.

These methods of analysis will be of interest at the conceptual level, especially, by statistical reasoning, that the power spectrum examines how the variance of the stochastic process is distributed with frequency, providing the property that the spectrum estimates at neighbouring frequencies are approximately independent. Nevertheless, there would be due to some critisms in this method. Though we need a more pronounced information in tracing Polak's causal pattern of imports, exports and GNP, the above-mentioned empirical implications, entirely, perform the causal relation from exports to imports, given by input-output system and partially, reinforces our theoretical foundation that 'income variable' should not be neglected in determination of imports.

Notes

(1) Polak(1954) p.161.

(2) According to Sim, this filter approximately flattens the spectral density of most economic time-series.

(3) A test for non-zero coherency is employed for coherences by computing the F ratios as

$$F_{(2,d-2)} = \frac{(d-2)\,\hat{K}_{xy}}{2\,(1-\hat{K}_{xy})}$$

where d is degree of freedom and d for Parzen lag window is assessed as 3.71(m/n).

(4) In econometric applications of regression analysis, deflation may increase or decrease the resulting correlations. [See in G. S. Maddala(1977)]

References

(1) Cargill, T. F. (1969), An Empirical Investigation of the Wage-Lag Hypothesis, **American Economic Review**, 59(December), 806-816.

(2) Granger, C. W. J. (1969), Investigation Causal Relations by Econometric Relations by Econometric Models and Cross-Spectral Methods, **Econometrica**, 37(No.3, July), 424-438.

(3) Granger, C. W. J. (1980), Testing for Causality : A Personal Viewpoint, **Journal of Economic Dynamics and Control**, 2(No.4, November), 329-352.

(4) Granger, C. W. J. and Hatanaka, M. (1964), **Spectral Analysis of Economic Time Series**, Princeton University Press.

(5) Granger, C. W. J. and Huges, A. O. (1968), Spectral Analysis of Short Series - A Simulation Study, **Journal of the Royal Statistical Society, A**, 131(Part 1), 83-99.

(6) Gudmudsson, G. (1971), Time-Series Analysis of Imports, Exports, and Other Economic Variables, **Journal of the Royal Statistical Society, A,**, 134(Part 3), 385-412.

(7) Jenkins, G. M. and Watts, D. G. (1968), **Spectral Analysis and Its Applications**, Holden-Day, Inc., California.

(8) Kirchgassner, G. and Wolters, J. (1987), U. S. - European Interest Rate Linkage : A Time Series Analysis for West Germany, Switzerland, and the United States, **Review of Economics and Statistics**, 69(No.4, November) 675-685.

(9) Maddala, G. S.(1977), **Econometrics**, McGraw-Hill Inc., New York.

(10) Pindyck, R. S. (1981), **Econometric Models and Economic Forecasts**, International Student Edition, McGraw-Hill.

(11) Polak, J. J. (1954), **An International Economic System**, Georage Allen & Unwin Ltd., London.

(12) Sargent, T. J. (1973), Interest Rates and Prices in the Long Run : A Study of the Gibson Paradox, **Journal of Money, Credit and Banking**, 5(No.1, Part 2, February), 385-449.

(13) Singh, B. and Sahni, B. S. (1984), Causality between Public Expenditure and National Income, **Review of Economics and Statistics**, 66(No.4, November), 630-644.

CHAPTER 3

TRADITIONAL AGGREGATE IMPORT DEMAND FUNCTION AND ITS ECONOMETRIC APPLICATIONS

3.1. Introduction

The role of imports in econometric studies of international trade had been highlighted by pioneering works of Metzler (1950) and Polak (1954). In the Metzler model, the whole pattern of world trade was expressed by import functions, treating total exports of a country as the sum of imports of its trade partners. Polak adopted a system that the sum of the volume of imports of all countries equal total volume of world trade. Estimation of aggregate import demand function is one of the major interests for adjustment of trade balances and exchange rate stability.

A significant number of empirical studies has been made to estimate price and income elasticities of aggregate import demand model since the end of World War II. Econometric issues on aggregate import demand model have been reviewed by Cheng (1959), Prais (1962), Magee (1975), Stern et al.(1976) and Goldstein and Khan (1985).

3.2. Earlier Arguments on Statistical Estimates of Aggregate Import Demand Function

There has been a number of empirical econometric studies of aggregate import demand function analyzed with prewar data, using ordinary least-squares technique; especially multi-country estimates were seen in Chang (1945), Neisser and Modigliani (1953) and Polak (1954).

The investigations of the problems in estimating aggregate import demand function by prewar data were framed by Orcutt (1950) and Harberger (1957, 1958). To his argument that estimated price elasticity of demand had been lower than the true price elasticity in international trade studies based on time-series data, Orcutt provided five sources of 'error and bias' : (i) omission of some other factors that might affect demand and simultaneous shifts in demand and supply schedules; (ii) errors of observations (1) ; (iii) aggregation; (iv) neglect of lagged terms or short-run and long-run effects; and (v) quantum effect. Machlup (1950), supporting Orcutt's argument, also mentioned that historical circumstances had led the elasticities of demand for imports and exports underestimated.

Neisser and Modigliani (1953) and Harberger (1957, 1958) were on the same criticism of inapplicability of classical regression method in measuring inter-war quantitative estimates of trade elasticities. Harberger gave a rule-of-thumb judgment for short-run elasticity of import demand to lie in or above the range -0.5 to -1.0.

Prais, in his review paper, noted that " Orcutt's arguments seem to be over-stated in my opinion; . . . it is not clear that they would always necessarily arise in a quantitatively important way ". He pointed out that the bias due to simultaneous shifts in demand and supply schedules would vanish when supply was infinitely elastic and the shifts were independent. Liu (1954) also substantiated this hypothesis and defended for the least-squares method in estimating the import demand function. Also, the assumption of the well-known Marshall-Learner condition that the supply elasticities of imports and exports are perfectly elastic, supports their suggestion.

Statistical properties of the bias due to errors of observations in import demand formulation were re-examined by Kemp (1962) and Kakwani (1972).[2]

3.3. A Simple Model for Aggregate Import Demand

Systematic empirical studies on import demand model have been elaborated for various countries or commodity groups in the postwar period. Many research workers discussed the issues on specification of functional form, choice of variables, and data selection from both theoretical and empirical backgrounds. On the theoretical level, imports can be modelled by perfect- and imperfect-substitutability approaches. Under the perfect-substitutes model, imports of a country are considered as the difference between domestic demand and domestic supply. By this approach, price and income elasticities of demand for imports, δ^{d}_{mp} and δ^{d}_{my}, can be considered as

$$\delta^{d}_{mp} = \frac{D}{M} \eta_{dp} - \frac{S}{M} e_{sp} \qquad (3.3.1)$$

$$\delta^{d}_{my} = \frac{D}{M} \eta_{dy} - \frac{S}{M} e_{sy} \qquad (3.3.2)$$

where D, S, and M are demand, supply, and imports respectively; η_{dp} and e_{sp} represent the domestic demand and supply-price elasticities; η_{dy} and e_{sy} are the elasticities of domestic demand and supply with respect to income.

The price elasticity of demand for imports, δ^{d}_{mp}, will be negative since the domestic demand elasticity, η_{dp}, is negative and the domestic supply elasticity, e_{sp}, is positive. However, the income elasticity of imports,[3] δ^{d}_{mp}, could be either positive or negative as Magee (1975) asserted.

In accordance with the imperfect-substitutability approach, demand function for imports can be derived from maximizing utility subject to a budget constraint when imports are considered as consumer goods, or by minimizing cost subject to the production function when imports are intermediate goods. If an aggregate import demand function is approximately derived from constrained utility maximization, then this function will be homogeneous of degree zero in prices and income and be of the form

$$M^{d} = M^{d}(P_{m} / P_{d} \, , \, Y/ P_{d}) \qquad (3.3.3)$$

or

$$M^{d} = M^{d}(P \, , \, y) \; ; \quad P = P_{m}/P_{d} \, , \; y = Y/P_{m}$$

where M^{d} is the quantity of imports demanded, P_{m} is the price of imports, P_{d} is the domestic price variable, and Y is the domestic gross output or other domestic activity variable. Within this framework, it is expected that

$$\frac{\partial M^d}{\partial P} < 0 \quad \text{and} \quad \frac{\partial M^d}{\partial y} \gtrless 0 \qquad (3.3.4)$$

If imports are treated as intermediate goods, a simple model for import demand can be derived by minimizing cost given a non-negative, monotonically increasing, and strictly concave aggregate production function

$$q_Y = f(q_d, M) \qquad (3.3.5)$$

with the assumption of cost minimization, the cost function can be expressed as

$$C(P_M, P_d, q_Y) = \min_{M, q_d} \{ M . P_M + q_d . P_d : f(q_d, M) \geqslant q_Y ; M, q_Y \geqslant 0\}$$

$$\text{for } P_M, P_d > 0, q_Y \geqslant 0. \qquad (3.3.6)$$

Here, q_Y, q_d and M are the domestic gross output, domestic composite factor and imports, P_M and P_d, the price of imports and the rental price of the domestic composite factor, respectively.[4] Given the assumptions that $f(q_d, M)$ is linear homogeneous with at least twice continuously differentiable and it exhibits decreasing marginal returns, $C(p_M, p_d, q_Y)$ is non-decreasing, linearly homogeneous and concave in prices and it is monotonically increasing in the quantity of gross output.

3.4. Empirical Issues

3.4.1 Some Implications

Most of the researchers agreed the fact that the theory could provide little guidence on the specification of import demand, for it would be difficult to assume that the import demand function is strictly a demand relation. Goldstein and Khan (1976), Khan and Ross (1977), J. Thursby and M. Thursby (1984) believed that an appropriate specification of import demand function would greatly rely upon the empirical work. Nevertheless, we should make a way to have some solutions by regarding earlier works on aggregate import demand models of multi-country data.(5)

In the postwar empirical econometric studies of multi-country trade models, Houthakker and Magee (1969) focused on the relationship between income elasticities of demand for exports and those for imports for 15 industrial countries. The aggregate import demand model in their study was of the logarithmic form and was estimated by annual data from 1951 to 1966, using ordinary least-squares method. Many of the estimated relative unexpected price coefficients were observed as insignificant or with positive signs. Houthakker and Magee reestimated the equations in two aspects : (i) omitting the price variable which showed insignificance or wrong sign; (ii) adjusting serially correlated residuals. As Leamer (1975) pointed out there had been no changes in signs of the revised income elasticity estimates when insignificant price variables were dropped from the equations. After correcting the presence of serial correlation in the errors by the Cochrane-Orcutt technique, some of the positive signs in price elasticity estimates changed to be negative or became significant. This evidence seems to reveal that application of the appropriate procedures may narrow the gap between the theoretical and empirical concepts. Nevertheless, we should take into account of a certain degree of inaccuracy in the elasticity estimates associated with errors of observations in data manipulating process, also as Goldstein (1973) remarked.

Murray and Ginman (1976) gave some interesting outlines in the formulation of the traditional aggregate import demand model, based on the quarterly data of Canada and the United States. They mentioned the need of infinite supply elasticity assumption, consistent with the Prais argument, and that of homogeneity of degree zero in money income and prices. With U.S. data, Murray and Ginman also, considering the separability between traded and non-traded items, had observed that the traded items showed larger impact on price elasticity of demand for imports than the non-traded items. Also later, the deficiency of the price of nontradable goods as a determinant of import demand function can be found in the empirical work of Goldstein et al. (1980) with multi-country data, covering the period from 1951 to 1973.

Khan and Ross (1975) introduced trend or potential import and income variables into the traditional aggregate import demand model of log-linear form,for the determination of separate effects of the secular and cyclical factors. Most of the secular income elasticity estimates were observed as negative values; some of these were not statistically significant. This empirical evidence supported the Magee's (1975) assertion of duality of signs in secular income elasticity of demand for imports.

Statistical examination of quantum effect on aggregate demand for imports, one of the Orcutt's arguments, was made by Liu (1954), using U.S. data and by Goldstein and Khan (1976), using multi-country data. Liu's implication with a very limited information was that the price elasticity of demand for imports was changing in direct proportion with the size of the change in relative prices. However, the multi-country study of Goldstein and Khan did not give any empirical support for this quantum hypothesis.

3.4.2 Static and Dynamic Framework

In empirical econometric problems, the aggregate import demand can be evaluated within the static and dynamic framework. The static model, which is assumed to be in a state of equilibrium and has no lags in the system, is simply specified in linear or log-linear form as

$$M^d_t = b_0 + b_1 P_t + b_2 y_t + e_t \quad ; \; t=1,2,...,n \qquad (3.4.1)$$

or

$$\ln M^d_t = a_0 + a_1 \ln P_t + a_2 \ln y_t + e'_t \quad ; \; t=1,2,...,n \qquad (3.4.2)$$

Dynamic system which expects time lags in the variables and is supposed to be in disequilibrium state, can be also expressed in linear or log-linear form, by imposing a partial-adjustment mechanism to (3.4.1) and (3.4.2), as

$$M_t = \alpha b_0 + \alpha b_1 P_t + \alpha b_2 y_t + (1-\alpha) M_{t-1} + \alpha e_t ; \quad t=1,2,...,n \qquad (3.4.3)$$

or

$$\ln M_t = w a_0 + w a_1 \ln P_t + w a_2 \ln y_t + (1-w) \ln M_{t-1} + w e'_t ; \quad t=1,2,...,n \qquad (3.4.4)$$

where $0 \leqslant \alpha, w \leqslant 1$ are the coefficients of adjustment for linear and non-linear forms respectively.

Long-run and short-run elasticities can be distinguished by these static and dynamic models. Empirical studies of such models by multi-country data can be specifically seen in Goldstein and Khan (1976), Khan and Ross (1977), and J. Thursby and M. Thursby (1984). Goldstein and Khan observed the average time lag to be in the range of one to three quarters in their quarterly dynamic model. In addition to their observation, they claimed a possible evidence that adjustment rate of aggregate imports to real income changes was faster than that to relative price changes for industrial countries. Within static and dynamic framework, the choice between the linear or log-linear specifications was made by Khan and Ross, using the Box-Cox procedure. This empirical investigation showed that the log-linear specification was suggested as an appropriate functional form for aggregate import demand of the three sample countries, the United States, Canada and Japan, covering the sample period 1960 to 1972. The work of J. Thursby and M. Thursby was an informative one, concerning problems with model selection, variable choice and structural shift. A variety of single-equation models was tested by the regression specification error test (RESET), as also suggested by Goldstein and Khan (1985).

3.4.3 Some Comparative Empirical Results

In, this subsection, I shall try to concentrate on some empirical studies made for the United Kingdom, Japan, and the Unites States.(6)

Prewar Data

Most of the prewar statistical estimates of demand for total imports were rarely found together with their corresponding significance statistics (t-statistics) in available published studies. Nevertheless, some of the estimates will be presented here for historical interest.

Chang (1945, 1946, 1950) stated a connection between the marginal propensity to import and the concept of the marginal propensity to consume of a society by the reason that, in open economies, imports would be affected by any change in consumer expenditure which varied with national income. In his statistical formulation of import demand, he used 'export' variable together with relative price and income variables as independent variables since imported materials were used to produce exports.

Available estimates of import demand function for the United Kingdom are summarized in Table 3.1, based on the findings of Chang (1945) and Thackeray (1950). As shown in Table 3.1, Thackery's estimates showed a poor performance, when he

Table 3.1. Estimation of Aggregate Import Demand Function : Prewar Data of The United Kingdom

Researcher	Sample Period	Specification	Estimation Method	Dependent Variable	Independent Variables: Price Variable	Independent Variables: Activity Variable	Independent Variables: Other Variable	Relative Price Elasticity	Income Elasticity	R
1. Chang (1945, 1950)	1924-38	Log-Linear	Ordinary Least-Square	Quantity of Imports	Import Price Index / Cost-of-Living Index	Index of Home Employment	Quantity of Exports	- 0.28	+ 1.10	0.94
2. Chang (1946, 1950)	1924-38	Log-Linear	Ordinary Least-Square	Quantity of Imports	Import Price Index / Cost-of-Living Index	Index of Home Employment	-	- 0.64	+ 1.43	0.75
3. Chang (1946, 1950)	1924-38 (except 1926& 1931)	Log-Linear	Ordinary Least-Square	Quantity of Imports	Import Price Index / Cost-of-Living Index	Index of Home Employment	-	- 0.46	+ 1.41	0.85
4. Thackeray (1950)	1924-38	Log-Linear	Ordinary Least-Square	Quantity of Imports	Import Price Index / Cost-of-Living Index	Real National Income	Quantity of Exports	- 0.40	- 0.40	-
5. Thackeray (1950)	1924-38	Log-Linear	Ordinary Least-Square	Quantity of Imports	Import Price Index / Cost-of-Living Index	Real National Income	-	+ 0.10	+ 0.70	-
6. Thackeray (1950)	1932 IV-1936 I	Log-Linear	Ordinary Least-Square	Quantity of Imports	Import Price Index / Price Index of Goods Produced & Consumed	Index of Home Employment	-	+ 0.22	+ 0.79	-
7. Thackeray (1950)	1932 IV-1936 I	Log-Linear	Ordinary Least-Square	Quantity of Imports	Import Price Index / Price Index of Goods Produced & Consumed	Real National Income	-	+ 0.23	+ 1.20	-

Table 3.2. Estimation of Aggregate Import Demand Function : Prewar Data of the United States

Researcher	Sample Period	Specification	Estimation Method	Dependent Variable	Independent Variables: Price Variable	Independent Variables: Activity Variable	Independent Variables: Other Variable	Relative Price Elasticity	Income Elasticity	R
1. Adlers (1945)	1922-37	Linear	Ordinary Least-Squares	Quantity of Imports	Import Price Index / Wholesale Price Index	National Income at Constant-of-Living	-	- 0.09	+ 1.01	0.946
2. Adlers (1945)	1922-29	Linear	Ordinary Least-Squares	Quantity of Imports	Import Price Index / Wholesale Price Index	National Income at Constant-of-Living	-	- 0.52	+ 1.16	0.947
3. Chang (1946, 1950)	1924-38	Log-Linear	Ordinary Least-Squares	Quantity of Imports	Import Price Index / Cost-of-Living Index	National Income at Constant-of-Living	-	- 0.97	+ 1.27	0.928

substituted 'real income' variable in place of 'home employment' variable that Chang had used. This poor performance can be argued by Chang's observation and then, statistical reason. Chang (1945, 1951), in his 'The British Demand for Imports in the Inter-War Period', believed that the total British demand for imports would be fluctuated by changes in national income. However, the data did not show a high correlation between fluctuations of domestic national income and of total imports. His reasoning for this low correlation coefficient was that home employment conditions during the period 1924-38 did reflect short-term waves of imports and the index of home employment had been a stable function of the national income. Apart from Chang's observation, on the other hand, we can also consider the rarely availability of accurate data for prewar period, since Levi (1977) mentioned that measurement errors in one variable would cause all the coefficients of the regression to be biased.

Hinshaw (1945) suggested to relate volume of U.S. imports to its real national income and relative price level of imports to domestic price level by demonstrating the correlations between variables based on the data for the period 1922-40. However, 'a primitive problem' in estimating aggregate import demand equation can easily be seen in Table 3.2, compared to the prewar estimates of Adler (1945) and Chang (1946, 1951) for the United States. Adler's 'linear' form yielded varying elasticity estimates while Chang's 'log-linear' specification gave constant elasticity estimates. These two different investigations provided slightly distinct income elasticity estimates, but relative price elasticity estimates were in large gap. Since sample periods were nearly similar, we might throw our attention upon 'linear' or or 'log-linear' specification and choice of variables, apart from 'errors-in-variables' problem. Variability of relative price elasticity estimates over different samples seemed to rely largely upon statistical grounds such as estimation methods and structural parameter stability.

Some studies on prewar data of Japan are shown in Table 3.3. If we had to choose the statistically significant estimates, Shinohara and Fujino's (1967) estimates for the period 1897-1913 would be favorable. My conjecture on the statistically insignificant price elasticity estimate for the period 1873-1896 in their estimation is concerned with the correlation among ratio variables or stability of structural parameters. Kinoshita's (1969) estimates were also statistically significant. Nevertheless, his study had mainly emphasized on trade and industrialization and mostly analyzed disaggregated data.

Postwar Data

Since the World War II, the broader statistical framework for the determination of import demand has been gradually pursued in a precise or an efficient way with the rising tide of contributions in advanced statistical methodology. Also, later developments in import demand function have been in

Table 3.3. Estimation of Aggregate Import Demand Function - Prewar Data of Japan

Researcher	Sample Period	Specification	Estimation Method	Dependent Variable	Independent Variables: Price Variable	Independent Variables: Activity Variable	Independent Variables: Other Variable	Relative Price Elasticity	Income Elasticity	R^2
1. Shinohara & Fujino (1967)	1873-96	Log-Linear	Ordinary Least-Squares	Quantity of Imports	Import Price Index / Domestic Price Index	Real GNP	-	- 0.59	+ 1.85	0.91
2. Shinohara & Fujino (1967)	1897-1913	Log-Linear	Ordinary Least-Squares	Quantity of Imports	Import Price Index / Domestic Price Index	Real GNP Business Activity Index	-	- 1.14	+ 0.98	0.82
3. Kinoshita (1969)	1918-36	Log-Linear	Ordinary Least-Squares	Quantity of Imports	Import Price Index / Price Index of Manufacturing Products	Industrial Production	-	- 1.12	+ 0.88	0.98
4. Tatemoto (1960)	1924-37	Log-Linear	Ordinary Least-Squares	Quantity of Imports	Import Price Index	Real National Income	Export Price Index	- 0.28	+ 0.74	0.94
5. Chang (1945, 1950)	1924-38	Log-Linear	Ordinary Least-Squares	Quantity of Imports	Import Price Index / Cost-of-Living Index	Real National Income	Quantity of Exports	- 0.47	+ 1.35	0.84

Table 3.4. Estimation of Aggregate Import Demand Function - Static Model : Postwar Data of the United Kingdom

Researcher	Sample Period	Specification	Estimation Method	Dependent Variable	Independent Variables: Price Variable	Independent Variables: Activity Variable	Independent Variables: Other Variable	Relative Price Elasticity	Income Elasticity	R^2
1. Houthakker & Magee (1969)	1951-66	Log-Linear (Annual Data)	Ordinary Least-Squares (Cochrane-Orcutt)	Value of Imports / Import Price Index	Import Price Index / Wholesale Price Index	Real GNP Index	-	- 0.21**	+ 1.45	0.986
2. Khan & Ross (1975)	1960-72	Log-Linear (Semiannual)	Ordinary Least-Squares	Value of Imports	Unit Value Index of Imports / Wholesale Price Index	Real GDP	Potential Income	+ 0.48*	+ 0.94	0.980
3. Goldstein & Khan (1976)	1955 III-1973 IV	Log-Linear (Quarterly)	Two-Step Search	Volume of Imports	Unit Value Index of Imports / GNP Deflator	Real GNP Index	-	+ 0.18*	+ 1.78	0.980

* Significant at 10 per cent level
** Insignificant

the establishment of models, derived from production function, in which imports are viewed as intermediate goods. Though there has been a number of empirical investigations concentrated on disaggregated imports, especially for the United Kingdom, I shall mention some important econometric work, mostly from multi-country studies at aggregate level. Models of postwar data will be mainly divided into static and dynamic models.

Three empirical studies of aggregate import demand function by postwar U.K. data are shown in Tables 3.4 and 3.7. Meaningful judgement cannot be made from those tables because of the different types of data used. Houthakkar and Magee gave an insignificant negative sign for the relative price coefficient. Nevertheless, several researchers observed a noteworthy empirical evidence that price responsiveness in U.K. imports showed to be opposed to economic theory. J. Thursby and M. Thursby (1984) suggested that this positive price elasticity estimate should be assumed as an attenuated estimate of the supply function, for Leamer (1981) demonstrated the possibility of a positive estimate for price elasticity when the demand was more variable than the supply. However, if the premise that the appropriate specification of aggregate import demand function is an empirical issue, had to be accepted, I have a serious doubt in this prominent feature of relative price elasticity estimate for total U.K. imports, by the consideration of influence of simple or partial correlations among those specified ratio variables in the formulation.[(7)]

Table 3.5. Estimation of Aggregate Import Demand Function - Static Model : Postwar Data of The United States

Researcher	Sample Period	Specification	Estimation Method	Dependent Variable	Independent Variables: Price Variable	Independent Variables: Activity Variable	Independent Variables: Other Variable	Relative Price Elasticity	Income Elasticity	$\bar{R}^2$
1. Houthakker & Magee (1969)	1951-66	Log-Linear (Annual Data)	Ordinary Least-Squares (Cochrane-Orcutt)	Value of Imports / Import Price Index	Import Price Index / Wholesale Price Index	Real GNP Index	-	- 1.03	+ 1.45	0.986
2. Khan & Ross (1975)	1960-72	Log-Linear (Semiannual)	Ordinary Least-Squares (Cochrane-Orcutt)	Value of Imports	Unit Value Index of Imports / Wholesale Price Index	Real GDP	Potential Income	- 0.995*	+ 0.55	0.991
3. Goldstein & Khan (1976)	1955 III-1973 IV	Log-Linear (Quarterly)	Two-Step Search	Volume of Imports	Unit Value Index of Imports / GNP Deflator	Real GNP Index	-	- 0.45*	+ 1.84	0.987
4. Murray & Ginman (1977)	1961-68	Log-Linear (Quarterly)	Ordinary Least-Squares	Value of Imports in Constant Dollars	Unit Value Index of Imports / Wholesale Price Index	Real GNP	-	- 1.23*	+ 1.94	0.950
5. Khan & Ross (1977)	1960-72	Linear (Quarterly)	Ordinary Least-Squares	Value of Imports	Unit Value Index of Imports / Wholesale Price Index	Real GNP	-	-	-	0.966
6. Khan & Ross (1977)	1960-72	Log-Linear (Quarterly)	Ordinary Least-Squares	Value of Imports	Unit Value Index of Imports / Wholesale Price Index	Real GNP	-	- 1.88	+ 1.39	0.968

* Significant at 10 per cent level

Table 3.6. Estimation of Aggregate Import Demand Function - Static Model : Postwar Data of Japan

Researcher	Sample Period	Specification	Estimation Method	Dependent Variable	Independent Variables: Price Variable	Independent Variables: Activity Variable	Independent Variables: Other Variable	Relative Price Elasticity	Income Elasticity	$\bar{R}^2$
1. Houthakker & Magee (1969)	1951-66	Log-Linear (Annual Data)	Ordinary Least-Squares (Cochrane-Orcutt)	Value of Imports / Import Price Index	Import Price Index / Wholesale Price Index	Real GNP Index	-	- 0.72	+ 1.23	0.985
2. Khan & Ross (1975)	1960-72	Log-Linear (Semiannual)	Ordinary Least-Squares	Value of Imports	Unit Value Index of Imports / Wholesale Price Index	Real GNP	Potential Income	+ 0.15**	+ 1.94	0.994
3. Goldstein & Khan (1976)	1955 III-1973 IV	Log-Linear (Quarterly)	Two-Step Search	Volume of Imports	Unit Value Index of Imports / GNP Deflator	Real GNP Index	-	+ 0.003**	+ 1.30	0.995
4. Khan & Ross (1977)	1960-72	Linear (Quarterly)	Ordinary Least-Squares	Value of Imports	Unit Value Index of Imports / Wholesale Price Index	Real GNP	-	-	-	0.942
5. Khan & Ross (1977)	1960-72	Log-Linear (Quarterly)	Ordinary Least-Squares	Value of Imports	Unit Value Index of Imports / Wholesale Price Index	Real GNP	-	- 0.78	+ 0.75	0.945

* Significant at 10 per cent level

Table 3.7. Estimation of Aggregate Import Demand Function : Dynamic Models of Postwar Data - U.K., U.S., and Japan

Researcher	Sample Period	Specification	Short-Run Elasticities		Long-Run Elasticities		$\bar{R}^2$
			Price	Income	Price	Income	
I. The United Kingdom							
1. Goldstein & Khan (1976)	1955 III- 1973 IV (Quarterly)	$\log M_t = \gamma a_0 + \gamma a_1 \log P_t + \gamma a_2 \log Y_t + (1-\gamma) \log M_{t-1} + \gamma u_t$	+ 0.18*	+ 1.85	-	-	0.980
II. The United States							
1. Houthakkar & Magee (1969)	1947-66 (Quarterly)	$\log M_t = D_0 + D_1 \log M_{t-1} + D_2 (\log Y_{t-1} + \log Y_t) + D_3 (\log P_{1t-1} + \log P_{1t}) + e_t$	- 0.20	+ 0.33	- 0.88	+ 1.42	0.981
2. Goldstein & Khan (1976)	1955 III- 1973 IV (Quarterly)	$\log M_t = \gamma a_0 + \gamma a_1 \log P_t + \gamma a_2 \log Y_t + (1-\gamma) \log M_{t-1} + \gamma u_t$	- 0.17	+ 0.66	- 0.48	+ 1.84	0.988
3. Khan & Ross (1977)	1960-72 (Quarterly)	$\log M_t = \phi\beta_0 + \phi\beta_1 \log P_t + \phi\beta_2 \log Y_t + (1-\phi) \log M_{t-1} + \phi w_t$	- 1.64	+ 1.08*	- 2.15	+ 1.42	0.971
III. Japan							
1. Goldstein & Khan (1976)	1955 III- 1973 IV (Quarterly)	$\log M_t = \gamma a_0 + \gamma a_1 \log P_t + \gamma a_2 \log Y_t + (1-\gamma) \log M_{t-1} + \gamma u_t$	+ 0.004**	+ 0.81	-	-	0.995
2. Khan & Ross (1977)	1960-72 (Quarterly)	$\log M_t = \phi\beta_0 + \phi\beta_1 \log P_t + \phi\beta_2 \log Y_t + (1-\phi) \log M_{t-1} + \phi w_t$	- 0.64	+ 0.13	- 3.37	+ 0.68	0.988

* Significant at 10 per cent level
** Insignificant

Tables 3.5 and 3.7 display some empirical investigations on aggregate import demand model for the United States. Most are in log-linear specification and signs in coefficients of relative price and income variables are consistent with conventional demand theory. Quarterly models signify the importance of appropriate economic measure for total imports, but we have to notice the method of estimation used and the significance of the statistic. J. Thursby and M. Thursby (1984) suggested to use quantity index for the U.S. models, provided by their empirical work.

Some of the estimates for Japan are included in Tables 3.6 and 3.7. Khan and Ross' (1975) study on cyclical and secular behaviour in import-income elasticity observed a negative estimate of potential real income elasticity which seemed to support Magee's (1975) hypothesis. There, however, seemed to be a methodological problem, for relative price elasticity estimate was statistically insignificant and had a positive sign.

Imports as Intermediate Goods

We had observed that in the earlier econometric studies, 'exports' variable was put into the formulation of import demand, assuming that some of the imports were used to produce exports. This consideration had appeared in the approach which assumed imports as intermediate goods in later development of postwar studies.

Kohli (1982) derived import demand price and quantity elasticities for various specifications under constant returns to scale and variable returns to scale technologies. Under constant returns to scale technology, the aggregate production function is assumed to be given by equation (3.3.5) associated with a cost function represented by equation (3.3.6). Kohli gave seven possible specifications of the aggregate import demand and derived the import price and quantity elasticities. These elasticities are also considered by the variable profit function under variable returns to scale technology.

3.5. Conclusion

It becomes visible that empirical evidence on elasticity estimate of traditional aggregate import demand model has been a long-existing problem and challenging for necessary and sufficient approach to researchers and policy makers. In fact, we adopted the economic theory of consumer behaviour into our aggregate import demand specification. We assumed that the appropriate functional form should be provided by empirical work, since we have been in hunger of quantitative elasticity estimates for our international economy. Also, the famous Marshall-Learner condition formulates that the absolute sum of demand elasticities for imports and exports must be greater than unity to improve the trade balance caused by devaluation of the foreign exchange rate.

Yet, among the critisms made by the researchers , I shall handle two problems of estimation of traditional aggregate import demand function in the following chapters. As a primary step,I do accept that there exist biases in elasticity estimates and the choice of appropriate functional form should be investigated empirically. Due to the availability of the most accurate data, the three industrialized countries, the United Kingdom, the United States and Japan are selected as sample regions for my empirical work.

My research work would be mostly influenced by statistical sense within the framework of economic reasoning. In any way, there still has been remaining enormous future researches to determine aggregate import demand from both standpoints of eminent Economics and Statistics sciences.

Notes

(1) Because of the errors of observations, we can have a biased estimate of income elasticity. [See in Orcutt (1950)]

(2) This is one of the central issues in my dissertation.

(3) Magee (1975) gave a condition for minus sign in income elasticity of demand for imports that

$$\frac{D}{S} < (e_{sy} / \eta_{dy})$$

(4) A detailed discussion for this issue can be seen in Kohli (1982, 1983).

(5) A focus on estimates for the industrial countries will only be made here.

(6) Those countries are major locations of my study.

(7) See in K. Pearson (1897), Oksanen (1987) and Visco (1988).

References

(1) Adler, J. H. (1945), "United States Import Demand During the Interwar Period", **American Economic Review**, 35(No. 3, June), 418-430.

(2) Baba, M. and Tatemoto, M. (1967), "Nippon ni Okeru Gaikoku Boeki to Keizai Seichio" (Foreign Trade and Economic Growth of Japan) in M. Shinohara and M. Fujino, **Nippon Keizai Seicho (Economic Growth of Japan)**, Nippon Keizai Shinbunsha, Chap. 10, 250-271.

(3) Chang, T. C. (1945), "International Comparison of Demand for Imports", **Review of Economic Studies**, 13, 53-67.

(4) Chang, T. C. (1946), "The British Demand for Imports in the Inter-War Period", **Economic Journal**, 56(June), 188-207.

(5) Chang, T. C. (1950), **Cyclical Movements in the Balance of Payments**, Cambridge University Press, London.

(6) Cheng, H. S.(1959), "Statistical Estimates of Elasticities and Propensities in International Trade : A Survey of Published Studies", **International Monetary Fund, Staff Papers**, 7(No. 1, April), 107-158.

(7) Goldstein, H. N. (1973), "Alternative Explanations of Contrasting Export Performance - Another Look at the Houthakker and Magee Findings", in R. M. Stern et al., **Price Elasticities in International Trade : An Annotated Bibliography**, Macmillan, London, 1976, p.213.

(8) Goldstein, M. and Khan, M. S. (1976), "Large Versus Small Price Changes and the Demand for Imports", **IMF Staff Papers**, 3(No. 2, October), 200-225.

(9) Goldstein, M. , Khan, M. S.(1985), "Income and Price Effects in Foreign Trade", in Jones R. W. and Kenen, P. B. (ed.), **Handbook of International Economics Vol. II**, Elsevier Science Publishers B. V.

(10) Goldstein, M. , Khan, M. S. and Officer, L. H. (1980), "Prices of Tradable and Nontradable Goods in the Demand for Total Imports", **Review of Economics and Statistics**, 62(No. 2, May), 190-199.

(11) Harberger, A. C. (1957), "Some Evidence on the International Price Mechanism", **Journal of Political Economy**, 65 (No. 6, December), 506-521.

(12) Harberger, A. C. (1958), "Some Evidence on the International Price Mechanism", **Review of Economics and Statistics, 40(No. 2, May)**, 123-132.

(13) Hinshaw, R. (1945), "American Prosperity and the British Balance-of-Payments Problem", **Review of Economic Statistics**, 27(No. 1, February), 1-9.

(14) Houthakker, H. S. and Magee, S. P. (1969), "Income and Price Elasticities in World Trade", **Review of Economics and Statistics**,51(No. 2, May), 111-125.

(15) Kakwani, N. C. (1972), "On the Bias in Estimates of Import Demand Parameters" , **International Economic Review**, 13(No. 2, June), 239-244.

(16) Kemp, M. C. (1962), "Errors of Measurement and Bias in Estimates of Import Demand Parameters" , **The Economic Record**, 38(September), 369-372.

(17) Khan, M. S. and Ross, K. Z. (1975), "Cyclical and Secular Income Elasticities of the Demand for Imports ", **Review of Economics and Statistics**, 57(No. 3. August), 357-361.

(18) Khan, M. S. and Ross, K. Z. (1977), "The Functional Form of the Aggregate Import Equation, **Journal of International Economics**, 7(No. 2, May), 149-160.

(19) Kinoshita, S. (1969), "Choki Model ni Okeru Gaikoku Boeki Sector : 1920-1946" (Trade Sector in Long-Term Model : 1920-1946) in M. Tatemoto, **Kokusai Boeki no Keiro Bunseki(Econometric Analysis of International Trade)**, Nippon Keizai Shinbunsha, Chap. 2, 63-87.

(20) Kohli, U. R. (1982), "Relative Price Effects and the Demand for Imports", **Canadian Journal of Economics**, 15(No. 2, May) 205-219.

(21) Kohli, U. R. (1983), "Technology and the Demand for Imports, **Sourthen Economic Journal**, 50(No. 1, July), 137-150.

(22) Leamer, E. E. (1975), "A Result on the Sign of Restricted Least-Squares Estimates", **Journal of Econometrics**, 3 (No. 4, November), 387-390.

(23) Leamer, E. E. (1981), "Is It a Demand Curve or Is It a Supply Curve ? Partial Identification Through Inequality Constraints", **Review of Economics and Statistics**, 63 (No. 3, August), 319-327.

(24) Levi, M. D. (1977), 'Measurement Errors and Bounded OLS Estimates', **Journal of Econometrics**, 6 (No.2, September), 165-171.

(25) Liu, T. C. (1954), "The Elasticity of U.S. Import Demand : A Theoretical and Empirical Reappraisal" , **IMF Staff Papers**, 3(No. 3, February), 416-441.

(26) Machlup, F. (1950), "Elasticity Pessimism in International Trade" , **Economia Internazionale**, 3(Part 1), 118-137.

(27) Magee, S. P. (1975), "Prices, Incomes, and Foreign Trade", in Kenen, P. B. (ed.) **International Trade and Finance: Frontiers for Research**, Cambridge: Cambridge University Press.

(28) Murray, T. and Ginman, P. J. (1976), "An Empirical Examination of the Traditional Aggregate Import Demand Model", **Review of Economics and Statistics**, 58(No. 1, February), 75-80.

(29)Metzler, L. A. (1950), "A Multiple-Region Theory of Income and Trade" , **Econometrica**, 18(No. 4, October), 329-354.

(30) Neisser, H. and Modigliani, F. (1953), **National Income and International Trade**, Urbana.

(31) Orcutt, G. H. (1950), "Measurement of Price Elasticities in International Trade" , **Review of Economics and Statistics**, 32(No. 2, May), 117-132.

(32) Pearson, K. (1897), "Mathematical Contribution to the Theory of Evolution - On a Form of Spurious Correlation Which May Arise When Indices are Set in the Measurement of Organs", **Proceedings of the Royal Society of London**, 60, 489-498.

(33) Polak, J. J. (1954), **An International Economic System**, London.

(34) Prais, S. J. (1962), "Econometric Research in International Trade" , **Kyklos**, 15(Fasc. 3), 560-579.

(35) Stern, R. M. , Francis, J. and Schumacher, B. (ed.) (1976), **Price Elasticities in International Trade : An Annotated Bibliography**, Macmillan, London.

(36) Tatemoto, M. (1960), "Yunyujuyo Kansu no Sokutei" (Determination of Import Demand Function) in "**Boeki no Keiryoteki Bunseiki(Econometric Analysis of Trade)**, Osaka University, Japan.

(37) Thackeray, F. G. (1950), "Elasticity of Demand for U.K. Imports", **Bulletin of the Oxford University Institute of Statistics**, 12, 109-114.

(38)Thursby, J. and Thursby, M. (1984), "How Reliable Are Simple Equation Specification of Import Demand", **Review of Economics and Statistics**, 66(No. 1, February), 120-128.

CHAPTER 4

On The Bias in Estimates of The Traditional Aggregate Import Demand Model in The Presence of Errors of Measurement - A Reexamination -

4.1. Introduction

An important aspect of bias in statistical estimates of price and income elasticities of demand for imports was widely discussed by Orcutt (1950). A source of bias is the presence of errors of measurement in the variables. Orcutt demonstrated that "any combination of errors of the type assumed in the price and income series will bias the estimated price and income elasticities towards zero, whether or not such errors are present in the quantities series".(1)

Kemp (1962) and Kakwani (1972) had later tried to verify by the relationship between quantity and price variables, in the presence of errors of measurement in the variables, omitting the income variable, that the price elasticity estimate would be biased towards minus one. Also, Liu (1954) expounded on Orcutt's view that errors of observations involved in price and income series will be in greater degree than those in quantity series of import demand formulation. We would expect a spurious or biased estimates of elasticity from such a relationship with the absence of an income term if the price variable is correlated with the income variable. On the other hand, the specification given by Kemp and Kakwani was not in an exact form of the import demand relationship.(2)

Visco (1978, 1988) and Oksanen (1987) demonstrated that there may be changes in signs of the least-square coefficient estimates under certain conditions, when one of the intercorrelated regressors is dropped. Therefore, this chapter reexamines the bias in estimates of the traditional aggregate import demand model, connected with the errors of measurement.

4.2. Previous Studies on the Bias in Price and Income Elasticity Estimates of Import Demand

Three previous studies will be reviewed on the bias in the elasticity estimates in the errors-in-variable model.

(i) Orcutt (1950)

One of the Orcutt's (1950) arguments on statistical estimates of price elasticities of imports and exports which seemed to have been underestimated in pre-war studies, was errors and bias due to errors of measurement. Orcutt provided a mathematical treatment, and showed a bias towards zero in the estimated price and income elasticities, assuming errors in the measurement of quantities, prices and income be uncorrelated with each other and with the true values of these variables. In his mathematical treatment, he considered three cases, all of which assumed no errors of measurement in the quantity variable.

(ii) Kemp (1962)

Kemp (1962) made a number of arguments on Orcutt's (1950) demonstration, that **(i)** the quantity variable could have errors, **(ii)** the error in the quantity variable might have a correlation with the error in the price variable, and (iii) not only linear but also non-linear relations should be considered. Kemp's reason for the existence of the error in the quantity variable was that the quantity variable is of ratio type, and the deflator, which is an index variable, is likely to have errors. His study was, therefore, based upon the formulation of the type

$$\frac{\text{Nominal Value (V)}}{\text{Price Index (p)}} = f(p) \qquad (4.2.1)$$

where the measurement error was considered only to be in the price variable, p, and there was no other error term in the equation. With this model, he considered non-linear and linear relations and showed that the price elasticity estimate was asymptotically biased towards minus one. However, his formulation ignored the inclusion of income variable; also, he did not give any evaluation for the argument (ii) mentioned above.

(iii) Kakwani (1972)

Kakwani (1972), adding a disturbance term to Kemp's (1960) formulation in non-linear form, derived the bias and the exact distribution of the price elasticity estimate. In the case where the true price was independent of the measurement error and the disturbance term of the equation, the bias of the price elasticity estimate was the same as Kemp's result. When the true price variable was considered as a non-stochastic variable, a unitary price elasticity removed the estimation bias; otherwise the bias tended towards minus one.

Though Kakwani's results are interesting by statistical implications, there still left a question of the lack of income variable in import demand function.

4.3. The Traditional Aggregate Import Demand Model

A typical functional form of aggregate import demand relationship which has been considerably used in the trade literature, is a linear or log-linear single equation form under the assumption that the supply elasticity of imports is infinitely elastic, as

$$M_t = b_0 + b_1 P_t + b_2 y_t + e_t \; ; \; t=1,2,\ldots,n \qquad (4.3.1)$$

or

$$\ln M_t = a_0 + a_1 \ln P_t + a_2 \ln y_t + e_t \; ; \quad t = 1, 2, \ldots, n \qquad (4.3.2)$$

where M_t is the quantity of imports demanded, P_t is the relative price of imports to domestic price, y_t is the real income or other activity variable, e_t is the stochastic variable with zero mean and constant variance σ^2. Log-linear equation, with constant-elasticity property, produces the price and income elasticities of demand, a_1 and a_2, respectively. The parameters in (4.3.1) and (4.3.2) are expected to be

$$b_1, a_1 < 0 , \quad b_2, a_2 \gtrless 0 .$$

In most empirical works, the quantity variable, M_t, enters into this formulation as a ratio variable, the money value of total imports deflated by an appropriate price index. The price and income variables, P_t and y_t, are also of ratio types since P_t itself is by definition and the y_t is measured in real terms.

4.4. Errors of Measurement

'Errors of measurement' is one of the challenging problems to the applied econometricians. A well-known feature of economic data is that the errors in data series cannot be framed within the classical errors-in-variable model in which error variables are assumed to be independent of each other.

In errors-in-variable models, it is well known that the presence of measurement errors in one variable will bias all the parameters of the equation. Levi (1973, 1977) studied this problem and gave bounds on the estimated coefficients of the variables. This section involves a particular problem for the traditional aggregate import demand model, compared with Levi's solutions. Also, we will obtain some bounds on the bias of the estimates. A consideration in which errors are correlated with true values of the variables is also included in this study.

4.4.1 Statement of Problem

Let M_t, P_t, and y_t be the true values of observed variables Q_t, R_t, and S_t respectively. Suppose that

$$Q_t = M_t + f_t \tag{4.4.1}$$

$$R_t = P_t + g_t \tag{4.4.2}$$

$$S_t = y_t + h_t \tag{4.4.3}$$

where f_t, g_t, and h_t are the corresponding errors of measurement to the true values M_t, P_t, and y_t.

Assumption 1

The measurement errors, f_t, g_t, and h_t $(t=1,2,...,n)$ are treated as the random variables with zero means and finite variances, each having no serial correlation, i.e. ,

(i) $E(f_t) = E(g_t) = E(h_t) = 0, \quad \forall\ t$

(ii) $cov(f_t\ f_{t'}) = 0 \quad \forall\ t \neq t'$

$= \sigma_f^2 < \infty \quad \forall\ t = t'$

(iii) $cov(g_t\ g_{t'}) = 0 \quad \forall\ t \neq t'$

$= \sigma_g^2 < \infty \quad \forall\ t = t'$

(iv) $cov(h_t\ h_{t'}) = 0 \quad \forall\ t \neq t'$

$= \sigma_h^2 < \infty \quad \forall\ t = t'$

Assumption 2

The measurement errors f_t, g_t and h_t $(t=1,2,...,n)$ are uncorrelated with the true values of the corresponding observed variables, i.e.,

(i) $cov(M_t\ f_{t'}) = 0 \quad \forall\ t, t'$

(ii) $cov(P_t\ g_{t'}) = 0 \quad \forall\ t, t'$

(iii) $cov(y_t\ h_{t'}) = 0 \quad \forall\ t, t'$

Assumption 3

Measurement error of the three variables is uncorrelated with each other, i.e.,

(i) $cov(f_t \; g_t) = 0 \quad \forall t$

(ii) $cov(f_t \; h_t) = 0 \quad \forall t$

(iii) $cov(g_t \; h_t) = 0 \quad \forall t$

Assumption 4

Measurement errors and disturbance term of the equation are independently distributed.

Assumption 5

The true values M_t, P_t, and g_t (t=1,2,...,n) are contemporeneously correlated with the associated measurement errors as

(i) $cov(M_t \; f_{t'}) = 0 \quad \forall t \neq t'$

$= C_{Mf} \quad \forall t = t'$

(ii) $cov(P_t \; g_{t'}) = 0 \quad \forall t \neq t'$

$= C_{Pg} \quad \forall t = t'$

(iii) $cov(y_t \; h_{t'}) = 0 \quad \forall t \neq t'$

$= C_{yh} \quad \forall t = t'$

Cases

Case I : It is assumed that the dependent variable and the price variable in the import demand equation are measured with errors.

Case II : It is assumed that the dependent variable and the income variable in the import demand equation are measured with errors.

Case III : It is assumed that the dependent variable and all the independent variables (price and income) are measured with errors.

4.4.2 Propositions

Proposition 1

Let the assumptions 1 to 4 hold for cases I and II. Then, for large sample,

(i) the coefficient of the error-containing independent variable is attenuated.

(ii) the coefficient of the error-free independent variable is also biased and the bias is a linear function of the coefficient of the error-containing independent variable if the true values of the underlying independent variables (price and income) are correlated.

Proof

(i) Under the assumptions 1 to 4

Case I : $$\text{plim}\ \hat{b}_1 = b_1 - \frac{b_1 V(y_t)\sigma_g^2}{V(y_t)[V(P_t) + \sigma_g^2] - [\text{cov}(P_t, y_t)]^2} \qquad (4.4.4)$$

$$= b_1 \cdot \frac{V(P_t)(1 - r_{Py}^2)}{V(P_t).(1 - r_{Py}^2) + \sigma_g^2} \qquad (4.4.5)$$

Case II : $$\operatorname{plim} \hat{b}_2 = b_2 - \frac{b_2 V(P_t) \sigma_h^2}{V(P_t)[V(y_t) + \sigma_h^2] - [\operatorname{cov}(P_t, y_t)]^2} \qquad (4.4.6)$$

$$= b_2 \cdot \frac{V(y_t)(1 - r_{Py}^2)}{V(y_t)(1 - r_{Py}^2) + \sigma_h^2} \qquad (4.4.7)$$

(ii) Under the assumptions 1 to 4

Case I : $$\operatorname{plim} \hat{b}_2 = b_2 + \frac{b_1 \operatorname{cov}(P_t, y_t) \sigma_g^2}{V(y_t)[V(P_t) + \sigma_g^2] - [\operatorname{cov}(P_t, y_t)]^2} \qquad (4.4.8)$$

$$= b_2 + \frac{b_1 \operatorname{cov}(P_t, y_t) \sigma_g^2}{V(y_t)[V(P_t)(1 - r_{Py}^2) + \sigma_g^2]} \qquad (4.4.9)$$

Case II : $$\operatorname{plim} \hat{b}_1 = b_1 + \frac{b_2 \operatorname{cov}(P_t, y_t) \sigma_h^2}{V(P_t)[V(y_t) + \sigma_h^2] - [\operatorname{cov}(P_t, y_t)]^2} \qquad (4.4.10)$$

$$= b_1 + \frac{b_2 \operatorname{cov}(P_t, y_t) \sigma_h^2}{V(P_t)[V(y_t)(1 - r_{Py}^2) + \sigma_h^2]} \qquad (4.4.11)$$

Results (4.4.4), (4.4.6), (4.4.8) and (4.4.10) are obtained as the same as Levi's result (8)[Levi(1977), p.167].[3]

Propositon 2

Let the assumptions 1 to 4 hold for case III. Then, for large sample, the bias in each least-squares estimator is the linear function of both estimators and the bias moves towards the opposite direction of its own parameter.

Proof

Under the assumptions 1 to 4, for Case III,

(i)

$$\text{plim}\ \hat{b}_1 = \frac{b_1[\ V(P_t)V(y_t) + V(P_t)\sigma_h^2 - \{cov(P_t, y_t)\}^2\ ] + b_2\ cov(P_t, y_t)\sigma_h^2}{[\ V(P_t) + \sigma_g^2\ ][\ V(y_t) + \sigma_h^2\ ] - [\ cov(P_t, y_t)]^2}$$

$$= \frac{b_1[(\ 1 - r_{Py}^2\ )V(P_t)V(y_t) + V(P_t)\sigma_h^2\ ] + b_2\ cov(P_t, y_t)\sigma_h^2}{(\ 1 - r_{Py}^2\ )V(P_t)V(y_t) + V(y_t)\sigma_g^2 + V(P_t)\sigma_h^2 + \sigma_g^2\sigma_h^2}$$

Let $D = (1 - r_{Py}^2)V(P_t)V(y_t) + V(y_t)\sigma_g^2 + V(P_t)\sigma_h^2 + \sigma_g^2\sigma_h^2$.

$$\text{plim}\ \hat{b}_1 = b_1 - \frac{b_1[\ V(y_t)\sigma_g^2 + \sigma_g^2\sigma_h^2\ ]}{D} + \frac{b_2\ cov(P_t, y_t)\sigma_h^2}{D} \qquad (4.4.12)$$

(ii)

$$\operatorname{plim} \hat{b}_2 = \frac{b_1 \operatorname{cov}(P_t, y_t)\sigma_g^2 + b_2[V(y_t)\{V(P_t) + \sigma_g^2\} - \{\operatorname{cov}(P_t, y_t)\}^2]}{[V(P_t) + \sigma_g^2][V(y_t) + \sigma_h^2] - [\operatorname{cov}(P_t, y_t)]^2}$$

$$\operatorname{plim} \hat{b}_2 = \frac{b_1 \operatorname{cov}(P_t, y_t)\sigma_g^2 + b_2 V(y_t)[(1 - r_{Py}^2)V(P_t) + \sigma_g^2]}{D}$$

$$= b_2 - \frac{b_2[V(P_t)\sigma_h^2 + \sigma_g^2 \sigma_h^2]}{D} + \frac{b_1 \operatorname{cov}(P_t, y_t)\sigma_g^2}{D}$$

(4.4.13)

The possible directions of biases are shown in tables 4.1, 4.2 and 4.3 for the above-mentioned propositions.

Proposition 3

Let the assumptions 1 to 3 and 5 hold for cases I and II. Then, for large sample, the least-squares coefficient of each independent variable with measurement error reduces in its coefficient in absolute term if and only if each true variable is positively correlated with its measurement error.

Proof

$$\text{(i) } \operatorname{plim} \hat{b}_1 = \frac{b_1(1 - r_{Py}^2)V(P_t)V(y_t) + b_1 C_{Pg} V(y_t)}{(1 - r_{Py}^2)V(P_t)V(y_t) + (\sigma_g^2 + 2 C_{Pg})V(y_t)}$$

$$= b_1 - b_1 . \frac{1}{1 + [\{(1- r^2_{Py})V(P_t) + C_{Pg}\}/(\sigma^2_g + C_{Pg})]} \quad (4.4.14)$$

$$\text{(ii) plim } \hat{b}_2 = \frac{b_2(1- r^2_{Py})V(P_t)V(y_t) + b_2 C_{yh} V(P_t)}{(1- r^2_{Py})V(P_t)V(y_t) + V(P_t)(\sigma^2_h + 2 C_{yh})}$$

$$\text{plim } \hat{b}_2 = b_2 - \frac{1}{1 + [\{(1- r^2_{Py})V(y_t) + C_{yh}\}/(\sigma^2_h + 2 C_{yh})]} \quad (4.4.15)$$

4.4.3 Transformed Variables

We can also apply our proposed results to cases in which variables are in ratio or logarithmic forms. Those results, however, will concern with the cases when we define the variables such that

$$Q'_t = (M_t / P_{Mt}) + f_t = M'_t + f_t$$

$$R'_t = (P_t / P_{Pt}) + g_t = P'_t + g_t$$

$$S'_t = (y_t / P_{yt}) + h_t = y'_t + h_t$$

or

$$Q'_t = \log M_t + f_t = M'_t + f_t$$

$$R'_t = \log P_t + g_t = P'_t + g_t$$

$$S'_t = \log y_t + h_t = y_t + h_t$$

Table 4.1. Possible Results with Measurement Errors in Import and Price Variables

	$cov(P_t, y_t) < 0$	$cov(P_t, y_t) > 0$
$b_1 < 0$	(I) $\hat{b}_1$ will be biased away from zero (II) $\hat{b}_2$ will be biased away from zero	(I) $\hat{b}_1$ will be biased away from zero (II) $\hat{b}_2$ will be biased towards zero
$b_1 > 0$	(I) $\hat{b}_1$ will be biased towards zero (II) $\hat{b}_2$ will be biased towards zero	(I) $\hat{b}_1$ will be biased towards zero (II) $\hat{b}_2$ will be biased away from zero

Table 4.2. Possible Results with Measurement Errors in Import and Income Variables

	$cov(P_t, y_t) < 0$	$cov(P_t, y_t) > 0$
$b_2 < 0$	(I) $\hat{b}_1$ will be biased towards zero (II) $\hat{b}_2$ will be biased away from zero	(I) $\hat{b}_1$ will be biased towards zero (II) $\hat{b}_2$ will be biased away from zero
$b_2 > 0$	(I) $\hat{b}_1$ will be biased towards zero (II) $\hat{b}_2$ will be biased towards zero	(I) $\hat{b}_1$ will be biased away from zero (II) $\hat{b}_2$ will be biased towards zero

Table 4.3. Possible Results with Measurement Errors in Import, Price and Income Variables

	$cov(P_t, y_t) < 0$	$cov(P_t, y_t) > 0$
$b_1 < 0$ $b_2 < 0$	(I) $\hat{b}_1$ will be biased away from zero (II) $\hat{b}_2$ will be biased away from zero	(I) $\hat{b}_1$ will be biased away from zero (II) $\hat{b}_2$ will be biased towards zero
$b_1 > 0$ $b_2 > 0$	(I) $\hat{b}_1$ will be biased towards zero (II) $\hat{b}_2$ will be biased towards zero	(I) $\hat{b}_1$ will be biased towards zero (II) $\hat{b}_2$ will be biased away from zero

4.5. Monte Carlo Experiments

Monte Carlo experiments are conducted to investigate the probable bias for each case in small samples. We consider the sampling model

$$y = X\beta + e$$

$$= \beta_0 + \beta_1 x_1 + \beta_2 x_2 + e .$$

Our errors-in-variable model is as follows :

$$y' = \beta_0 + \beta_1 x'_1 + \beta_2 x'_2 + e$$

where

$$y' = y + f$$

$$x'_1 = x_1 + g$$

$$x'_2 = x_2 + h$$

and assume that each vector of measurement errors, **f**, **g**, **h**, is independent with **e**, the vector of error in equation. A multiplicative congruential number generator with modulus $2^{31} - 1$ is used to produce four sets of error values, each with 1500 random numbers.

Since the vectors, **f**, **g**, and **h** are uncorrelated with each other, the 1500 random numbers for each vector are generated from bivariate normal distributions with mean zero and the covariance matrices

$$\Sigma_1 = \begin{bmatrix} 0.25^2 & 0 \\ 0 & 0.5^2 \end{bmatrix}$$

and

$$\Sigma_2 = \begin{bmatrix} 0.25^2 & 0 \\ 0 & 0.75^2 \end{bmatrix} .$$

The e_i are random numbers generated from the standard normal distribution. The variables x_1 and x_2 take the values of ratio variables, i.e., relative price and income respectively, obtained from actual data series as shown in Appendix I. Constant term and coefficient values are derived from estimation of linear import demand models for annual data of the United Kingdom, Japan, and the United States.

The models considered are :

Model I. $\beta_1 < 0$, $\beta_2 > 0$, $cov(x_1, x_2) < 0$.

$y = 231.547 - 0.9513\,x_1 + 0.2468\,x_2 + e$

$e \sim N(0, 1)$

Model II. $\beta_1 < 0$, $\beta_2 > 0$, $cov(x_1, x_2) > 0$.

$y = -\,187.8489 - 0.5014\,x_1 + 0.1857\,x_2 + e$

$e \sim N(0, 1)$

Model III. $\beta_1 > 0$, $\beta_2 > 0$, $cov(x_1, x_2) < 0$.

$y = -\,136.4301 + 0.4933\,x_1 + 0.1798\,x_2 + e$

$e \sim N(0, 1)$

Model IV. $\beta_1 > 0$, $\beta_2 > 0$, $cov(x_1, x_2) > 0$.

$y = -\,187.8489 + 0.5014\,x_1 + 0.1857\,x_2 + e$

$e \sim N(0, 1)$

Model V . $\beta_1 > 0$, $\beta_2 < 0$, $cov(x_1, x_2) < 0$.

$y = -\,136.4301 + 0.4933\,x_1 - 0.1798\,x_2 + e$

$e \sim N(0, 1)$

Model VI. $\beta_1 > 0$, $\beta_2 < 0$, $cov(x_1, x_2) > 0$.

$y = -\,187.8489 + 0.5014\,x_1 - 0.1857\,x_2 + e$

$e \sim N(0, 1)$

Model VII. $\beta_1 < 0$, $\beta_2 < 0$, $cov(x_1, x_2) < 0$.

$$y = -136.4301 - 0.4933\, x_1 - 0.1798\, x_2 + e$$

$$e \sim N(0,\ 1)$$

Model VIII. $\beta_1 < 0$, $\beta_2 < 0$, $cov(x_1, x_2) > 0$.

$$y = -187.8489 - 0.5014\, x_1 - 0.1857\, x_2 + e$$

$$e \sim N(0,\ 1)$$

In each model, the Monte Carlo sample mean values are calculated for the least-squares coefficients, the standard errors of the estimated coefficients, the adjusted R-squared values, and the standard error of the regression, over the 75 samples of size 20. The results are shown in Appendix I.

We observe that most of the results agree with the possible results in large sample case as presented in tables 1 to 3. When there exists measurement errors in imports and income variables, some models give inconsistent results with those in large sample case. (See in models I - V)

4.6. Conclusion

This chapter tries to examine the effects of measurement errors on the ordinary least squares estimates of the traditional aggregate import demand model, recognizing the correlation between the price and income variables. The main findings of this study can be summarized as follows :

(1) The correlation between dependent variables and the signs of the coefficients of true variables give major effects to the direction of the asymptotic biases of the least-squares

coefficient estimates in an errors-in-variable model. This indicates that deletion of a variable from a linear regression with measurement errors would mislead the direction of bias.

(2) The usual case in an aggregate import demand model is $b_1 < 0$ and $b_2 > 0$. In this case, when the price variable is measured with errors, OLS yields smaller price coefficient estimate. Also, when the income variable is measured with errors, smaller income coefficient estimate is obtained.

However, this study leaves several interesting future researches. Some of them are as follows:

(a) Theoretical attempts should be made on the transformation of variables, for instance, ratio and logarithmic transformations, since theoretical derivations yield exact expressions in the parameters.

(b) Exact sample distribution is important for sample moments of the parameter estimates for the theoretial statistical measures which would be helpful for obtaining more complete inference on statistical estimates of price and income elasticities of demand for imports.

(c) We should investigate the effects of error variables in Monte Carlo study, departured from the normal distribution assumption in order to study distributional effects.

Appendix I

The Monte Carlo results for each model are presented in this appendix. The figures in parentheses below the estimated coefficients are mean values of the standard errors of corresponding coefficients.

Model I

$$y' = \underset{(5.785)}{230.0140} - \underset{(0.035)}{0.9402}\, x'_1 + \underset{(0.001)}{0.2470}\, x_2 \qquad \bar{R}^2 = 0.9998,\quad S = 0.3668$$

$$y' = \underset{(4.930)}{231.6106} - \underset{(0.030)}{0.9504}\, x_1 + \underset{(0.001)}{0.2467}\, x'_2 \qquad \bar{R}^2 = 0.9999,\quad S = 1.1588$$

Model II

$$y' = -\underset{(1.604)}{187.6727} - \underset{(0.041)}{0.4986}\, x'_1 + \underset{(0.002)}{0.1855}\, x_2 \qquad \bar{R}^2 = 0.9996,\quad S = 1.2010$$

$$y' = -\underset{(1.542)}{187.6526} - \underset{(0.039)}{0.5046}\, x_1 + \underset{(0.001)}{0.1857}\, x'_2 \qquad \bar{R}^2 = 0.9997,\quad S = 1.1549$$

$$y' = -\underset{(1.619)}{187.6534} - \underset{(0.041)}{0.4983}\, x'_1 + \underset{(0.002)}{0.1855}\, x'_2 \qquad \bar{R}^2 = 0.9996,\quad S = 1.2127$$

Model III

$$y' = -\underset{(4.343)}{135.7413} + \underset{(0.038)}{0.4876}\, x'_1 + \underset{(0.0004)}{0.1797}\, x_2 \qquad \bar{R}^2 = 0.99996,\quad S = 1.2214$$

$$y' = -\underset{(4.108)}{136.5755} + \underset{(0.036)}{0.4951}\, x_1 + \underset{(0.0004)}{0.1798}\, x'_2 \qquad \bar{R}^2 = 0.99997,\quad S = 1.1464$$

$$y' = -\underset{(4.378)}{135.7071} + \underset{(0.038)}{0.4874}\, x'_1 + \underset{(0.0004)}{0.1797}\, x'_2 \qquad \bar{R}^2 = 0.99996,\quad S = 1.2311$$

Model IV

$$y' = -\underset{(1.647)}{187.6692} + \underset{(0.042)}{0.4902}\, x'_1 + \underset{(0.002)}{0.1860}\, x_2 \qquad \bar{R}^2 = 0.9997,\quad S = 1.2337$$

$$y' = -\underset{(1.542)}{187.6525} + \underset{(0.039)}{0.4982}\, x_1 + \underset{(0.001)}{0.1857}\, x'_2 \qquad \bar{R}^2 = 0.9998,\quad S = 1.1549$$

Model V

$$y' = -\underset{(4.343)}{135.7401} + \underset{(0.038)}{0.4876}\,x'_1 - \underset{(0.0004)}{0.1799}\,x_2 \qquad \bar{R}^2 = 0.99996,\quad S = 1.2214$$

$$y' = -\underset{(4.082)}{136.6403} + \underset{(0.036)}{0.4956}\,x_1 - \underset{(0.0004)}{0.1798}\,x'_2 \qquad \bar{R}^2 = 0.99997,\quad S = 1.1390$$

Model VI

$$y' = -\underset{(1.647)}{187.6694} + \underset{(0.042)}{0.4902}\,x'_1 - \underset{(0.002)}{0.1854}\,x_2 \qquad \bar{R}^2 = 0.9996,\quad S = 0.0015$$

$$y' = -\underset{(1.534)}{187.6915} + \underset{(0.039)}{0.4976}\,x_1 - \underset{(0.001)}{0.1856}\,x'_2 \qquad \bar{R}^2 = 0.9997,\quad S = 1.1492$$

$$y' = -\underset{(1.655)}{187.6886} + \underset{(0.042)}{0.4898}\,x'_1 - \underset{(0.002)}{0.1854}\,x'_2 \qquad \bar{R}^2 = 0.9996,\quad S = 1.2396$$

Model VII

$$y' = -\underset{(4.238)}{137.3733} - \underset{(0.037)}{0.4845}\,x'_1 - \underset{(0.0004)}{0.1798}\,x_2 \qquad \bar{R}^2 = 0.99996,\quad S = 1.1919$$

$$y' = -\underset{(4.082)}{136.6415} - \underset{(0.036)}{0.4910}\,x_1 - \underset{(0.0004)}{0.1798}\,x'_2 \qquad \bar{R}^2 = 0.99997,\quad S = 1.139$$

$$y' = -\underset{(4.248)}{137.4068} - \underset{(0.037)}{0.4842}\,x'_1 - \underset{(0.0004)}{0.1798}\,x'_2 \qquad \bar{R}^2 = 0.9996,\quad S = 1.1946$$

Model VIII

$$y' = -\underset{(1.604)}{187.6731} - \underset{(0.041)}{0.4986}\,x'_1 - \underset{(0.002)}{0.1859}\,x_2 \qquad \bar{R}^2 = 0.9998,\quad S = 1.2010$$

$$y' = -\underset{(1.534)}{187.6918} - \underset{(0.039)}{0.5052}\,x_1 - \underset{(0.001)}{0.1856}\,x'_2 \qquad \bar{R}^2 = 0.9998,\quad S = 1.1492$$

Appendix II

The variables y, x_1 and x_2 are calculated as

$$y = \frac{\text{value of imports}}{\text{unit value index}} - f_1$$

$$x_1 = \frac{\text{unit value index}}{\text{wholesale price index}} - g_1$$

$$x_2 = \frac{\text{gross national (or) domestic product}}{\text{deflator}} - h_1$$

where f_1 = the first 20 random numbers generated from N(0, 0.0625)
g_1 = the first 20 random numbers generated from N(0, 0.25)
h_1 = the first 20 random numbers generated from N(0, 0.5625)

Using the data from the yearbooks of International Financial Statistics, aggregate import demand models in linear form are estimated as

UK (1951-1970)

$$\underset{}{y} = -\underset{(-0.619)}{68.3734} - \underset{(-1.414)}{0.9513}\, x_1 + \underset{(12.616)}{0.2468}\, x_2 \; ; \; cov(x_1, x_2) = -0.7083$$

Japan (1952-1971)

$$y = -\underset{(-3.078)}{136.4301} + \underset{(1.263)}{0.4933}\, x_1 + \underset{(47.418)}{0.1798}\, x_2 \; ; \; cov(x_1, x_2) = -0.7451$$

US (1962-81)

$$y = -\underset{(-11.548)}{187.8489} - \underset{(-1.211)}{0.5014}\, x_1 + \underset{(12.136)}{0.1857}\, x_2 \; ; \; cov(x_1, x_2) = 0.8790$$

The figures below the coefficients are t-values.

Notes

(1) See Orcutt (1950) p. 125 and p.129.

(2) In recent works of Kemp (1962) and Kakwani (1972), the import demand equation was of the form

$$M_t = b_0 + b_1 P_t + e_t$$

and

$$\log M_t = a_0 + a_1 \log P_t + e_t$$

where P_t was expressed as the price index while M_t was a ratio variable. Leamer (1975) showed that there would be no change in sign of any other variables if we dropped a variable which would be less significant. In most empirical econometric studies of import demand function, the income variable has been more significant than the price variable.

(3) Levi(1977) gave a result for a multiple linear regression model as

$$\text{plim } \hat{\beta}_j = \beta_j - \frac{\beta_1 \sigma^2_{\varepsilon_1} \Sigma_{1j}}{|\Sigma| + \sigma^2_{\varepsilon_1} \Sigma_{11}}$$

where β_1 is the coefficient of the mismeasured variable, β_j, the coefficient of the correctly measured variable, Σ = plim(x' x/T), Σ_{1j} and Σ_{11} are co-factors of Σ.

References

(1) Cochran, W. G. (1968), "Errors of Measurement in Statistics", **Technometrics**, 10(No. 4, November), 637-666.

(2) Griliches, Z. (1986), "Economic Data Issues", in Z. Griliches and M. D. Intriligator (ed.), **Handbook of**

Econometrics, Vol. III, Klsevier Science Publishers BV, Chap. 25, 1465-1514.

(3) Haitovsky, Y. (1972), "On Errors of Measurements in Regression Analysis in Economics", **Review of the International Statistical Institute**, 40, 23-35.

(4) Hall, B. H. (1986), **TSP Manual, Version 4.1**, TSP International, California.

(5) Judge, G. G., Hill, R. C., Griffiths, W., Lutkepohl, H., and Lee, T-C. (1981), **Introduction to the Theory and Practice of Econometrics**, John Wiley, New York.

(6) Kakwani, N. C. (1972), "On the Bias in Estimates of Import Demand Parameters", **International Economic Review**, 13 (No. 2, June), 239-244.

(7) Kemp, M. C. (1962), "Errors of Measurement and Bias in Estimates of Import Demand Parameters", **The Economic Record**, 38(September), 369-372.

(8) Leamer, E. E. (1975), A Result on the Sign of Restricted Least-Squares Estimates, **Journal of Econometrics**, 3 (No. 4, November), 387-390.

(9) Levi, M. D. (1973), "Errors in the Variables Bias in the Presence of Correctly Measured Variables", **Econometrica**, 41(No. 5, September), 985-986.

(10) Levi, M. D. (1977), "Measurement Errors and Bounded OLS Estimates", **Journal of Econometrics**, 6(No. 2, September), 165-171.

(11) Liu, T. C. (1954), "The Elasticity of U.S. Import Demand : A

Theoretical and Empirical Reapprasial", **IMF Staff Papers,** 3(No. 3, February), 416-441.

(12) Oksanen, E. H. (1987), "On Sign Changes Upon Deletion of a Variable in Linear Regression Analysis", **Oxford Bulletin of Economics and Statistics**, 49 (No. 2, May), 227-229.

(13) Orcutt, G. H. (1950), "Measurement of Price Elasticities in International Trade", **Review of Economics and Statistics**, 32(No. 2 May), 117-132.

(14) Visco, I. (1978), "On Obtaining the Right Sign of a Coefficient by Omitting A Variable from the Regression", **Journal of Econometrics**, 7(No.1, February), 115-117.

(15) Visco, I. (1988), "Again on Sign Changes Upon Deletion of a Variable from a Linear Regression", **Oxford Bulletin of Economics and Statistics**, 50(No. 2, May), 225-227.

CHAPTER 5

TESTS FOR DISCRIMINATION BETWEEN LINEAR AND LOG-LINEAR SPECIFICATIONS OF AGGREGATE IMPORT DEMAND

5.1. Introduction

The discrimination between a linear and log-linear specification should be made by using the theories of statistical decisions, in the case where economic theory cannot provide significant information for the choice of an appropriate functional form of economic relationship. In empirical studies, the demand for imports is principally specified by either linear or log-linear formulation . An appropriate functional form is important for both economic and statistical implications; especially, a linear specification suggests a variable price elasticity of import demand, while a log-linear formulation implies constant elasticities with respect to price and income. This chapter is primarily concerned with the choice of the optimal functional form of quarterly aggregate import demand equations for the three industrial countries - the United Kingdom, the United States, and Japan.

5.2. Alternative Tests of Functional Form : Aggregate Import Demand Model

The models considered are as follows:

Static Model

H_0 : The model is linear, that is,

$$M_t = b_0 + b_1 P_t + b_2 y_t + e_t \quad ; \; t=1,2,...,n. \qquad (5.2.1)$$

H_1 : The model is log-linear, that is,

$$\ln M_t = a_0 + a_1 \ln P_t + a_2 \ln y_t + e'_t \; ; \; t=1,2,\ldots,n. \qquad (5.2.2)$$

Dynamic Model

H_0 : The model is linear, that is,

$$M_t = \alpha b_0 + \alpha b_1 P_t + \alpha b_2 y_t + (1-\alpha) M_{t-1} + \alpha e_t$$

$$0 \leqslant \alpha \leqslant 1, \; t=1,2,\ldots,n.$$

or (5.2.3)

$$M_t = b'_0 + b'_1 P_t + b'_2 y_t + b'_3 M_{t-1} + v_t$$

where $b'_0 = \alpha b_0$, $b'_1 = \alpha b_1$, $b'_2 = \alpha b_2$, $b'_3 = (1-\alpha)$, and $v_t = \alpha e_t$.

H_1 : The model is log-linear, that is,

$$\ln M_t = w a_0 + w a_1 \ln P_t + w a_2 \ln y_t + (1-w) \ln M_{t-1} + w e'_t ;$$

$$0 \leqslant w \leqslant 1, \; t=1,2,\ldots,n.$$

or (5.2.4)

$$\log M_t = a'_0 + a'_1 \log P_t + a'_2 \log y_t + a'_3 \log M_{t-1} + v'_t$$

where $a'_0 = w a_0$, $a'_1 = w a_1$, $a'_2 = w a_2$, $a'_3 = (1-w)$, and $v'_t = w e'_t$.

(i) Sargan's Likelihood Ratio Test

Sargan (1964) suggested a likelihood ratio criterion for the choice between linear and log-linear forms in his econometric study of wages and prices in the United Kingdom. Under the assumption that random variables for the linear and log-linear models are independently distributed normal variables with zero means and constant variances σ_L^2 and σ_{LL}^2 respectively, the maximum likelihood functions for linear and log-linear models hypothesized, will be obtained respectively as,

$$\Omega_0 = (2 \hat{\sigma}_L^2)^{-n/2} e^{-n/2} \tag{5.2.5}$$

and

$$\Omega_1 = (2 \hat{\sigma}_{LL}^2)^{-n/2} e^{-n/2} \prod_{t=1}^{n} \frac{1}{M_t} \tag{5.2.6}$$

Then the Sargan's test criterion is

$$SG = \frac{\Omega_1}{\Omega_0} \tag{5.2.7}$$

$$= \left[\frac{\hat{\sigma}_L}{g_M \hat{\sigma}_{LL}} \right]^n \tag{5.2.8}$$

where SG = Sargen's test statistic

σ_L^2 = sum of squared residuals of linear form

σ_{LL}^2 = sum of squared residuals of log-linear form

g_M = geometric mean of dependent variable, M_t

n = number of observations

If SG < 1, then the linear form is to be preferred, and if SG > 1, the log-linear form is to be chosen.

(ii) Box-Cox Extended Procedure

The well-known Box-Cox transformation can be employed not only on dependent variable but also on independent variables as

$$Y^{(\lambda)} = X^{(\lambda)}\beta + u \qquad (5.2.10)$$

where $Y^{(\lambda)}$ is the nx1 vector of transformed y values, $X^{(\lambda)}$, the (nxk) matrix of transformed x values, and u, a (nx1) vector of independent and normally distributed disturbance terms with zero mean and constant variance σ_u^2. The transformed values of y and X are defined by Box and Cox (1964) as

$$Y^{(\lambda)} = \frac{Y^{(\lambda)} - 1}{\lambda} \qquad \text{for} \quad \lambda \neq 0$$

$$= \log Y \qquad \text{for} \quad \lambda = 0$$

and

$$X^{(\lambda)} = \frac{X^{(\lambda)} - 1}{\lambda} \qquad \text{for} \quad \lambda \neq 0$$

$$= \log X \qquad \text{for} \quad \lambda = 0 .$$

The concentrated log-likelihood function is computed as

$$L(\lambda ;X,Y) = -\frac{n}{2}\left[\ln (2\pi) + \ln \hat{\sigma}^2(\lambda) + 1 \right] + (\lambda - 1)\sum_{i=1}^{n} \ln Y_t \qquad (5.2.11)$$

where

$$\hat{\sigma}^2(\lambda) = \frac{1}{n} (Y^{(\lambda)} - X^{(\lambda)}\hat{\beta})' (Y^{(\lambda)} - X^{(\lambda)}\hat{\beta}) \qquad (5.2.12)$$

and

$$\hat{\beta}(\lambda) = [\{ X^{(\lambda)}\}' X^{(\lambda)}]^{-1} \{ X^{(\lambda)}\}' Y^{(\lambda)} . \qquad (5.2.13)$$

Then the maximum likelihood estimates are searched over a grid of different values of λ . Approximate α per cent confidence region for λ can be obtained by the likelihood ratio method. This region is computed from

$$2 [L_{max}(\lambda) - L_{max}(\lambda)] < \chi^2_{\alpha}(1)$$

$$\text{or,} \quad [L_{max}(\lambda) - L_{max}(\lambda)] < \frac{1}{2}\chi^2_{\alpha}(1) \qquad (5.2.14)$$

Savin and White(1978) generalized the Box-Cox extended model for the first-order autoregressive disturbances. Under the Box-Cox autoregressive procedure, an assumption that the disturbances, u_t's, follow a stationary first-order auto-regressive process as

$$u_t = \rho u_{t-1} + e_t ; \qquad \rho < 1, \qquad (5.2.15)$$

where the e_t's are independently and normally distributed random variables with zero means and constant variances, is added to the model expressed by Equation (5.2.7). It can be shown that mean and variance of the disturbance vector u is

$$E (u) = 0$$
$$E (uu') = \sigma^2 V \qquad (5.2.16)$$

where

$$V = \frac{1}{(1-\rho^2)} \begin{bmatrix} 1 & \rho & \rho^2 & \cdots & \rho^{n-1} \\ \rho & 1 & \rho & \cdots & \rho^{n-2} \\ \rho^2 & \rho & 1 & \cdots & \rho^{n-3} \\ \cdot & \cdot & \cdot & \cdots & \cdot \\ \rho^{n-1} & \rho^{n-2} & \rho^{n-3} & \cdots & 1 \end{bmatrix} \qquad (5.2.17)$$

Then the concentrated log-likelihood function is obtained as

$$L(\lambda, \rho; X, Y) = -\frac{n}{2}\left[\ln(2\pi) + \ln \hat{\sigma}^2(\lambda,\rho) + 1\right] + (\lambda - 1)\sum_{i=1}^{n} \ln Y_t + \frac{1}{2}\ln(1-\rho^2) \qquad (5.2.18)$$

where

$$\hat{\sigma}^2(\lambda,\rho) = \frac{1}{n}\left[Y^{(\lambda)} - X\hat{\beta}(\lambda,\rho)\right]' V^{-1}\left[Y^{(\lambda)} - X\hat{\beta}(\lambda,\rho)\right]$$

$$\hat{\beta}(\lambda,\rho) = (\{X^{(\lambda)}\}' V^{-1} X^{(\lambda)})^{-1} \{X^{(\lambda)}\}' V^{-1} Y^{(\lambda)} \qquad (5.2.19)$$

and

$$V^{-1} = \begin{bmatrix} 1 & -\rho & 0 & \cdots\cdots & 0 & 0 \\ -\rho & (1+\rho^2) & & \cdots\cdots & 0 & 0 \\ 0 & -\rho & (1+\rho^2) & \cdots\cdots & 0 & 0 \\ \cdot & \cdot & \cdot & \cdots\cdots & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdots\cdots & \cdot & \cdot \\ 0 & 0 & 0 & \cdots\cdots & (1+\rho^2) & -\rho \\ 0 & 0 & 0 & \cdots\cdots & -\rho & 1 \end{bmatrix}. \qquad (5.2.20)$$

The maximum likelihood estimates of $\hat{\beta}(\lambda,\rho)$ can be computed by applying the Beach-MacKinnon maximum likelihood estimation to the transformation of the variables and the maximum value of the concentrated log-likelihood functions can be searched over a grid of different values of λ and ρ. Then we test a group of hypotheses as

(a) $H_0 : \lambda = 1$
$H_1 : \lambda \neq 1$

(b) $H_0 : \rho = 0$ **given** $\lambda = 1$
$H_1 : \rho \neq 0$ **given** $\lambda = 1$

(c) $H_0 : \rho = 0$
$H_1 : \rho \neq 0$

(d) $H_0 : \lambda = 1$ and $\rho = 0$
$H_1 : \lambda \neq 1$ and $\rho \neq 0$.

The corresponding test statistics are :

$$BC(\lambda) = 2[\, L(\hat{\lambda}, \hat{\rho}) - L(\lambda = 1, \hat{\rho})] \sim \chi^2(1)$$

$$BC(\rho|\lambda) = 2[\, L(\lambda = 1, \hat{\rho}) - L(\lambda = 1, \rho = 0)] \sim \chi^2(1)$$

$$BC(\rho) = 2[\, L(\hat{\lambda}, \hat{\rho}) - L(\hat{\lambda}, \rho = 0)] \sim \chi^2(1) \qquad (5.2.21)$$

$$BC(\lambda, \rho) = 2[\, L(\hat{\lambda}, \hat{\rho}) - L(\lambda = 1, \rho = 0)] \sim \chi^2(2)$$

respectively.

(iii) Lagrange Multiplier Test

In connection with the Box-Cox extended procedure, the Lagrange multiplier tests developed by Godfrey and Wicken

(1981), can be considered for the choice of an appropriate functional form. Their approach provides an asymptotic test statistic which is distributed as $\chi^2(1)$, for our case of the aggregate import demand formulation.

Godfrey and Wicken(1981) formed the Lagrange multiplier test statistic as

$$LM = -\left[\frac{\partial L(\theta_R)}{\partial \theta}\right]' \left[\frac{\partial^2 L(\theta_R)}{\partial \theta \partial \theta'}\right]^{-1} \left[\frac{\partial L(\theta_R)}{\partial \theta}\right] \qquad (5.2.22)$$

where $L(\theta_R)$ is the restricted log-likelihood function and θ, k-dimensional parameter vector. If $l_t(\theta)$ is the log-likelihood function for the t-th observation, we shall have

$$L(\theta) = \sum_{i=1}^{n} l_t(\theta) \qquad (5.2.23)$$

Therefore, Godfrey and Wicken gave an alternative formulation which is asymptotically equivalent with (5.2.22) as

$$LM^* = \left[\sum_{t=1}^{n} \frac{\partial l_t(\theta)}{\partial \theta}\right]' \left[\sum_{t=1}^{n} \left(\frac{\partial l_t(\theta)}{\partial \theta}\right)\left(\frac{\partial l_t(\theta)}{\partial \theta}\right)'\right]^{-1} \left[\sum_{t=1}^{n} \frac{\partial l_t(\theta)}{\partial \theta}\right] \qquad (5.2.24)$$

LM^* has a limiting $\chi^2(k\ )$ distribution under the null hypothesis, where k is the number of restricted parameters.

In the case of Box-Cox extended model for the aggregate import demand, the log-likelihood function for a single observation, t, will be observed as

$$l_t(\theta) = -\frac{1}{2}\ln 2\pi - \frac{1}{2}\ln\sigma^2 + (\lambda - 1)\ln M_t - \frac{1}{2\sigma^2}\varepsilon_t^2 \qquad (5.2.25)$$

At $\lambda = 1$, the relevant restricted maximum likelihood estimate of the linear specification for static model under H_0, is

$$\hat{\theta}_{Rs1} = [b_0, b_1, b_2, \sigma_s^2, 1]'.$$

and

$$\frac{\partial l_t(\theta)}{\partial b_0} = \frac{\hat{e}_t}{\hat{\sigma}_s^2}$$

$$\frac{\partial l_t(\theta)}{\partial b_1} = \frac{\hat{e}_t}{\hat{\sigma}_s^2}(P_t - 1)$$

$$\frac{\partial l_t(\theta)}{\partial b_2} = \frac{\hat{e}_t}{\hat{\sigma}_s^2}(y_t - 1) \qquad (5.2.26)$$

$$\frac{\partial l_t(\theta)}{\partial \sigma_s^2} = \frac{(\hat{e}_t^2 - \hat{\sigma}_s^2)}{2\hat{\sigma}_s^4}$$

$$\frac{\partial l_t(\theta)}{\partial \lambda} = \ln M_t - \frac{\hat{e}_t}{\hat{\sigma}_s^2}[(M_t \ln M_t - M_t + 1) - \hat{b}_1 (P_t \ln P_t - P_t + 1) - \hat{b}_2 (y_t \ln y_t - y_t + 1)]$$

At $\lambda = 0$, the relevant restricted maximum likelihood estimate of the log-linear specification for static model under H_1, is

$$\hat{\theta}_{Rs0} = [a_0 , a_1 , a_2 , \hat{\sigma}'^2_s , 0]'$$

and

$$\frac{\partial l_t(\theta)}{\partial a_0} = \frac{\hat{e}'_t}{\hat{\sigma}'^2_s}$$

$$\frac{\partial l_t(\theta)}{\partial a_1} = \frac{\hat{e}'_t}{\hat{\sigma}'^2_s} \ln P_t$$

$$\frac{\partial l_t(\theta)}{\partial a_2} = \frac{\hat{e}'_t}{\hat{\sigma}'^2_s} \ln y_t \tag{5.2.27}$$

$$\frac{\partial l_t(\theta)}{\partial \sigma'^2_s} = \frac{(\hat{e}'^2_t - \hat{\sigma}'^2_s)}{2\hat{\sigma}'^4_s}$$

$$\frac{\partial l_t(\theta)}{\partial \lambda} = \ln M_t - \frac{\hat{e}'_t}{\hat{\sigma}'^2_s} \cdot \frac{1}{2} [(\ln M_t)^2 - \hat{a}_1 (\ln P_t)^2 - \hat{a}_2 (\ln y_t)^2]$$

In similar manner, we can compute the corresponding estimates for dynamic model. At $\lambda = 1$,

$$\hat{\theta}_{Rd1} = [\hat{b}'_0, \hat{b}'_1, \hat{b}'_2, \hat{b}'_3, \hat{\sigma}^2_d, 1]'.$$

and

$$\frac{\partial l_t(\theta)}{\partial b'_0} = \frac{\hat{v}_t}{\hat{\sigma}^2_d}$$

$$\frac{\partial l_t(\theta)}{\partial b'_1} = \frac{\hat{v}_t}{\hat{\sigma}^2_d} (P_t - 1)$$

$$\frac{\partial l_t(\theta)}{\partial b'_2} = \frac{\hat{v}_t}{\hat{\sigma}^2_d} (y_t - 1) \qquad (5.2.28)$$

$$\frac{\partial l_t(\theta)}{\partial b'_3} = \frac{\hat{v}_t}{\hat{\sigma}^2_d} (M_{t-1} - 1)$$

$$\frac{\partial l_t(\theta)}{\partial \sigma^2_d} = \frac{(\hat{v}^2_t - \hat{\sigma}^2_d)}{2\hat{\sigma}^4_d}$$

$$\frac{\partial l_t(\theta)}{\partial \lambda} = \ln M_t - \frac{\hat{v}_t}{\hat{\sigma}_d^2} [(M_t \ln M_t - M_t + 1) - \hat{b}'_1(P_t \ln P_t - P_t + 1)$$

$$- \hat{b}'_2(y_t \ln y_t - y_t + 1) - \hat{b}'_3(M_{t-1} \ln M_{t-1} - M_{t-1} + 1)].$$

At $\lambda = 0$,

$$\hat{\theta}_{Rd0} = [\hat{a}'_0, \hat{a}'_1, \hat{a}'_2, \hat{a}'_3, \hat{\sigma}'^2_d, 0]'$$

and

$$\frac{\partial l_t(\theta)}{\partial a'_0} = \frac{\hat{v}'_t}{\hat{\sigma}'^2_d}$$

$$\frac{\partial l_t(\theta)}{\partial a'_1} = \frac{\hat{v}'_t}{\hat{\sigma}'^2_d} \ln P_t$$

$$\frac{\partial l_t(\theta)}{\partial a'_2} = \frac{\hat{v}'_t}{\hat{\sigma}'^2_d} \ln y_t \qquad (5.2.29)$$

$$\frac{\partial l_t(\theta)}{\partial a'_3} = \frac{\hat{v}'_t}{\hat{\sigma}'^2_d} \ln M_{t-1}$$

$$\frac{\partial l_t(\theta)}{\partial \sigma'^2_d} = \frac{(\hat{v}'^2_t - \hat{\sigma}'^2_d)}{2\hat{\sigma}'^4_d}$$

$$\frac{\partial l_t(\theta)}{\partial \lambda} = \ln M_t - \frac{\hat{v}'_t}{\hat{\sigma}'^2_d} \cdot \frac{1}{2} \left[(\ln M_t)^2 - \hat{a}'_1(\ln P_t)^2 - \hat{a}'_2(\ln y_t)^2 - \hat{a}'_3(\ln M_{t-1})^2 \right].$$

Then the Lagrange multiplier test statistics for the linear and log-linear specifications can be computed accordingly as (5.2.24).The test statistic will be asymptotically distributed with $\chi^2_\alpha(1)$ since we are testing only one restriction, λ. If neither linear nor log-linear specification is rejected at the α per cent significance level, then the underlying procedure cannot provide any guideline for the optimal functional form. If both linear and log-linear specifications are rejected, neither model should be used.

(iv) Andrews' Test

Andrews(1971) derived an exact test statistic by taking advantage of independence between residuals and fitted values of a regression computed for transformed data. His modified model is constructed by a first-order Taylor series expansion as

$$Y^{(\lambda_o)} = X^{(\lambda_o)}\beta + Z(\lambda_0 - \lambda) + u \qquad (5.2.30)$$

where

$$z_{ij} = \left[\frac{\partial \{y_i^{(\lambda)}\}}{\partial y_j} \right]_{\lambda = \lambda_0}$$

Then an exact test statistic which has a standard F distribution is obtained for the null hypothesis $\lambda = \lambda_0$. The acquistion of test statistic resulted from the regression of the least squares residuals $(y^{(\lambda)} - X\hat{\beta})$ on $[I-X(X'X)^{-1}X']\hat{Z}$ where $\hat{Z}$ is calculated by fitted values as

$$\hat{z}_{ij} = \left[\frac{\partial y_i^{(\lambda)}}{\partial \lambda_j} \right]_{\lambda = \lambda_0,\ y = \hat{y}} \qquad (5.2.31)$$

By applying Andrews' procedure, we add one additional variable to each of our models as :

Static models

$$M'_t = b_0 + b_1 P_t + b_2 y_t + k_1 \hat{z}_{t1} + e_t \qquad (5.2.32)$$

$$\ln M'_t = a_0 + a_1 \ln P_t + a_2 \ln y_t + k'_1 \hat{z}'_{t1} + e'_t \qquad (5.2.33)$$

Dynamic models

$$M'_t = b'_0 + b'_1 P_t + b'_2 y_t + b'_3 M_{t-1} + k'_2 \hat{z}'_{t2} + v_t \qquad (5.2.34)$$

$$\ln M'_t = a'_0 + a'_1 \ln P_t + a'_2 \ln y_t + a'_3 \ln M_{t-1} + k'_2 \hat{z}'_{t2} + v'_t \qquad (5.2.35)$$

where $\hat{z}_{tj}$ and $\hat{z}'_{tj}$ (j=1,2) are derived from Taylor series approximations of the Box-Cox extended model and

$$\hat{z}_{t1} = (\hat{M}_t \ln \hat{M}_t - \hat{M}_t + 1) - \hat{b}_1 (P_t \ln P_t - P_t + 1) - \hat{b}_2 (y_t \ln y_t - y_t + 1)$$

$$\hat{z}'_{t1} = \frac{1}{2} [(\ln M_t)^2 - \hat{a}_1 (\ln P_t)^2 - \hat{a}_2 (\ln y_t)^2]$$

$$\hat{z}_{t2} = (\hat{M}_t \ln \hat{M}_t - \hat{M}_t + 1) - \hat{b}'_1(P_t \ln P_t - P_t + 1)$$
$$- \hat{b}'_2(y_t \ln y_t - y_t + 1) - \hat{b}'_3(M_{t-1} \ln M_{t-1} - M_{t-1} + 1)$$

$$\hat{z}'_{t2} = \frac{1}{2} [(\ln M_t)^2 - \hat{a}'_1(\ln P_t)^2 - \hat{a}'_2(\ln y_t)^2 - \hat{a}'_3(\ln M_{t-1})^2]$$

Then we draw conclusions from the significance of the estimated coefficients of $\hat{z}_{tj}$ and $\hat{z}'_{tj}$ (j=1,2).

5.3. Results

Quarterly series of domestic prices, import prices, real income and aggregate imports are taken from the available sources for the period 1955 I-1983 IV. Data sources are given in Appendix C. Wholesale price index is used for the measure of domestic prices and unit value index of imports, for that of import prices. Real value of imports are computed by deflating nominal values by the unit value index of imports. Quantity index of imports is used as an alternative measure of dependent variable for the United States, based on the finding by J.Thursby and M. Thursby (1984) that the quantity index is engaged in 91% of the accepted models for the United States. All the data are valued at 1980 prices. Both linear and log-linear specifications are tested by the Sargan's likelihood ratio criterion, the extended Box-Cox procedure, the Lagrange multiplier test and Andrews' test mentioned in the previous section.

(i) Sargan's Criterion

The results of the Sargan's likelihood ratio criterion are summarized in Tables 5.1 and 5.2 by country and specification. The ordinary least-squares estimates for the static model of the United Kingdom reveal the presence of positively serially correlated errors and therefore, both equations are reestimated by the maximum likelihood method. (1) The dynamic models are estimated by using the Hildreth-Lu transformation since the Durbin-h statistic of linear specification of the estimated model suggests a serial correlated errors. For the United States, as solving for auto-correlation of the disturbances, static models are estimated by Durbin two-step method for both cases of dependent variables, total import value and quantity index of imports. For the case of total import value as the dependent variable, the equations are estimated by the ordinary least-squares procedure while the Cochrane-Orcutt procedure is used for the case of quantity index of imports in the first step ; but the maximum likelihood method is used in the second step for both cases. Also, the Cochrane-Orcutt procedure is used for dynamic models of the United States. Estimates of the underlying aggregate import demand models of Japan are also provided by the same process as the United States. (2)

Interestingly, the Sargan's likelihood ratio criterion indicates that the log-linear specification of aggregate import demand equation is acceptable in favour of the linear form in all cases for the United Kingdom, the United

Table 5.1. Sargan's Test Statistic for Static Model - Quarterly Data : 1955 Q.1 - 1983 Q.4

Country	Specification	Estimation Method	Constant	Relative Price	Income	$\bar{R}^2$	S.E.	D.W.	ρ	Test Statistic
The United Kingdom	Linear	Max. Likelihood	- 7.1068 (-8.500)	1.8909 (2.371)	0.2991 (31.742)	0.8977	0.3600	1.8690	0.6282 (8.673)	$\left[\frac{0.3554}{0.2922}\right]^{116} > 1$
	Log-Linear	Max. Likelihood	- 4.2619 (-34.872)	0.1355 (2.104)	1.6666 (52.126)	0.9600	0.0366	1.9607	0.4941 (6.065)	
The United States	Linear (1)	Durbin Two-Step	-12.0151 (-12.499)	10.6953** (1.499)	0.1445 (18.633)	0.8910	2.3917	1.9455	- 0.2301 (-2.513)	$\left[\frac{2.3603}{1.7261}\right]^{115} > 1$
	Log-Linear(1)	Durbin Two-Step	- 2.7565 (-19.448)	- 0.0150¤ (-0.135)	2.1766 (27.786)	0.9348	0.0528	1.9169	- 0.2581 (-2.835)	
	Linear (2)	Durbin Two-Step	- 3.8427 (-4.055)	-21.8120** (-1.409)	0.2736 (10.313)	0.4970	3.2083	2.0334	- 0.3156 (-3.529)	$\left[\frac{3.1662}{3.0059}\right]^{115} > 1$
	Log-Linear(2)	Durbin Two-Step	- 0.4730 (-5.698)	- 0.2992** (-1.446)	2.2409 (8.186)	0.3752	0.0533	1.9759	- 0.3233 (-3.628)	
Japan	Linear	Durbin Two-Step	162.6553 (2.257)	-2656.429 (3.526)	0.1203 (7.036)	0.3143	199.049	2.1543	0.3695 (4.205)	$\left[\frac{196.4358}{158.7767}\right]^{115} > 1$
	Log-Linear	Durbin Two-Step	- 0.3260 (-3.031)	- 0.3756 (-2.662)	1.0948 (10.819)	0.4864	0.0476	2.0838	0.3457 (3.914)	

t-values in parentheses below coefficients
** : significant at 20 percent
¤ : not significant
(1): estimates computed by import value
(2): estimates computed by quantity index of imports

Table 5.2. Sargan's Test Static for Dynamic Model - Quarterly Data : 1955 Q.2 - 1983 Q.4

Country	Specification	Estimation Method	Constant	Relative Price	Income	Lagged Dependent Variable	$\bar{R}^2$	S.E.	D.W.	ρ	Test Statistic
The United Kingdom	Linear	Hildreth-Lu	- 4.0089 (-4.752)	0.7678** (1.358)	0.1802 (7.608)	0.4116 (5.188)	0.9700	0.3507	1.9700	0.3000 (25.071)	$\left[\frac{0.3444}{0.2846}\right]^{114} > 1$
	Log-Linear	Hildreth-Lu	- 2.5047 (-7.353)	0.0511# (1.048)	0.9757 (7.610)	0.4206 (5.627)	0.9873	0.0355	1.9118	0.1000 (9.406)	
The United States	Linear (1)	Cochrane-Orcutt	- 7.4688 (-2.265)	- 1.1656# (-0.416)	0.0324 (3.348)	0.7983 (11.611)	0.9883	2.5080	1.9756	- 0.1789 (-1.651)	$\left[\frac{2.4636}{1.7654}\right]^{114} > 1$
	Log-Linear (1)	Cochrane-Orcutt	- 2.2832 (-3.870)	- 0.0604* (-1.719)	0.4872 (3.858)	0.7869 (13.771)	0.9940	0.0537	1.9621	- 0.2141 (-2.081)	
	Linear (2)	Cochrane-Orcutt	- 7.3451 (-1.843)	- 2.6592# (-0.590)	0.0398 (3.261)	0.8368 (13.843)	0.9854	3.6126	2.0060	- 0.0451 (-0.409)	$\left[\frac{3.5487}{3.3107}\right]^{114} > 1$
	Log-Linear (2)	Cochrane-Orcutt	- 0.9494 (-3.032)	- 0.0322# (-0.731)	0.2285 (3.003)	0.8843 (20.004)	0.9885	0.0586	1.9961	- 0.1404 (-1.384)	
Japan	Linear	Hildreth-Lu	847.8100 (3.911)	-1271.307 (-4.806)	0.0179 (3.839)	0.9002 (27.105)	0.9945	180.492	2.0015	0.1000 (12.750)	$\left[\frac{177.2970}{153.9919}\right]^{114} > 1$
	Log-Linear	Hildreth-Lu	- 0.8110 (-2.846)	- 0.1828 (-3.595)	0.2215 (3.072)	0.8154 (14.497)	0.9938	0.0459	2.1253	0.3000 (75.695)	

t-values in parentheses below coefficients
* : significant at 10 percent
** : significant at 20 percent
# : not significant
(1) : estimates computed by import value
(2) : estimates computed by quantity index of imports

States and Japan as shown in Tables 5.1 and 5.2. Because of estimation problems and parameter estimates, further exploration in the log-linear form will be considered in next chapter.

(ii) Box-Cox Procedure

The Box-Cox transformation is performed on the data of each country for values of λ over a range from -2.0 to +1.9, at intervals of 0.1. And the estimates of β and ρ are computed for each λ, estimating the equations by the maximum likelihood method.(3) The maximized concentrated log likelihood function according to Equation(5.2.15) and the optimal values of λ and ρ are selected over a grid of different values of λ and ρ . The maximum likelihood estimates of λ , ρ and the associated likelihood values for each model of three countries are presented in Tables 5.3 and 5.4. These tables demonstrate that all the hypotheses adopted are strongly rejected for all models by the likelihood ratio tests. Thus, the log-linear specification for the conventional aggregate import demand model is preferable to linear one. The evidence of autocorrelation indicated by the tests, however, exist.

(iii) Lagrange Multiplier Test

All models are estimated by ordinary least squares method for the United Kingdom, the United States and Japan. The sample values of the asymptotic Lagrange multiplier test statistics are calculated for linear and log-linear specifications of both static and dynamic models according to

Table 5.3. Box - Cox Autoregressive Procedure for Static Model - Quarterly Data : 1955 Q.1 - 1983 Q.4

Country	Hypothesis	$\hat{\lambda}$	$\hat{\rho}$	$L(\lambda=1,\rho=0)$	$L(\lambda=1,\hat{\rho})$	$L(\hat{\lambda},\rho=0)$	$L(\hat{\lambda},\hat{\rho})$	Test Statistic
The United Kingdom	(a) $H_0 : \lambda = 1$	- 0.4	0.4470				- 19.6109	50.4524
	$H_1 : \lambda \neq 1$	1.0	0.6202		- 44.8371			
	(b) $H_0 : \rho = 0$ given $\lambda = 1$	1.0	0.6202		- 44.8371			57.2256
	$H_1 : \rho \neq 0$ given $\lambda = 1$	1.0	0.0000	- 73.4499				
	(c) $H_0 : \rho = 0$	- 0.4	0.4470				- 19.6109	24.4974
	$H_1 : \rho \neq 0$	- 0.6	0.0000			- 31.8596		
	(d) $H_0 : \lambda = 1$ and $\rho = 0$	- 0.4	0.4470				- 19.6109	107.6780
	$H_1 : \lambda \neq 1$ and $\rho \neq 0$	1.0	0.0000	- 73.4499				
The United States	(1) (a) $H_0 : \lambda = 1$	- 0.4	0.7416				-225.3856	81.8010
	$H_1 : \lambda \neq 1$	1.0	0.7160		-266.2861			
	(b) $H_0 : \rho = 0$ given $\lambda = 1$	1.0	0.7160		-266.2861			86.8978
	$H_1 : \rho \neq 0$ given $\lambda = 1$	1.0	0.0000	-309.7350				
	(c) $H_0 : \rho = 0$	- 0.4	0.7416				-225.3856	93.5452
	$H_1 : \rho \neq 0$	- 0.6	0.0000			-272.1582		
	(d) $H_0 : \lambda = 1$ and $\rho = 0$	- 0.4	0.7416				-225.3856	168.6988
	$H_1 : \lambda \neq 1$ and $\rho \neq 0$	1.0	0.0000	-309.7350				
	(2) (a) $H_0 : \lambda = 1$	0.3	0.8864				-295.2742	15.8642
	$H_1 : \lambda \neq 1$	1.0	0.8660		-303.2063			
	(b) $H_0 : \rho = 0$ given $\lambda = 1$	1.0	0.8660		-303.2063			146.4654
	$H_1 : \rho \neq 0$ given $\lambda = 1$	1.0	0.0000	-376.4390				
	(c) $H_0 : \rho = 0$	0.3	0.8864				-295.2742	159.1592
	$H_1 : \rho \neq 0$	0.7	0.0000			-374.8538		
	(d) $H_0 : \lambda = 1$ and $\rho = 0$	0.3	0.8864				-295.2742	
	$H_1 : \lambda \neq 1$ and $\rho \neq 0$	1.0	0.0000	-376.4390				
Japan	(a) $H_0 : \lambda = 1$	0.2	0.9213				-754.2183	62.6986
	$H_1 : \lambda \neq 1$	1.0	0.9470		-785.5676			
	(b) $H_0 : \rho = 0$ given $\lambda = 1$	1.0	0.9470		-785.5676			236.5448
	$H_1 : \rho \neq 0$ given $\lambda = 1$	1.0	0.0000	-903.8400				
	(c) $H_0 : \rho = 0$	0.2	0.9213				-754.2183	210.2680
	$H_1 : \rho \neq 0$	0.0	0.0000			-859.3523		
	(d) $H_0 : \lambda = 1$ and $\rho = 0$	0.2	0.9213				-754.2183	299.2434
	$H_1 : \lambda \neq 1$ and $\rho \neq 0$	1.0	0.0000	-903.8400				

Table 5.4. Box-Cox Autogressive Procedure for Dynamic Model - Quarterly Data : 1955 Q.2 - 198 1983 Q.4

Country	Hypothesis	$\hat{\lambda}$	$\hat{\rho}$	$L(\lambda=1,\rho=0)$	$L(\lambda=1,\hat{\rho})$	$L(\hat{\lambda},\rho=0)$	$L(\hat{\lambda},\hat{\rho})$	Test Statistic
The United Kingdom	(a) $H_0 : \lambda = 1$	- 0.4	0.1477				- 15.3276	48.3996
	$H_1 : \lambda \neq 1$	1.0	0.2618		- 39.5274			
	(b) $H_0 : \rho = 0$ given $\lambda = 1$	1.0	0.2618		- 39.5274			4.7134
	$H_1 : \rho \neq 0$ given $\lambda = 1$	1.0	0.0000	- 41.8841				
	(c) $H_0 : \rho = 0$	- 0.4	0.1477				- 15.3276	29.6744
	$H_1 : \rho \neq 0$	- 0.6	0.0000			- 30.1648		
	(d) $H_0 : \lambda = 1$ and $\rho=0$	- 0.4	0.1477				- 15.3276	53.1130
	$H_1 : \lambda \neq 1$ and $\rho\neq 0$	1.0	0.0000	- 41.8841				
The United States	(1) (a) $H_0 : \lambda = 1$	- 0.4	0.7445				-227.2093	74.2914
	$H_1 : \lambda \neq 1$	1.0	-0.1398		-264.3550			
	(b) $H_0 : \rho = 0$ given $\lambda = 1$	1.0	-0.1398		-264.3550			6.4660
	$H_1 : \rho \neq 0$ given $\lambda = 1$	1.0	0.0000	-267.5880				
	(c) $H_0 : \rho = 0$	- 0.4	0.7445				-227.2093	77.4544
	$H_1 : \rho \neq 0$	- 0.6	0.0000			-265.9365		
	(d) $H_0 : \lambda = 1$ and $\rho=0$	- 0.4	0.7445				-227.2093	80.7574
	$H_1 : \lambda \neq 1$ and $\rho\neq 0$	1.0	0.0000	-267.5880				
	(2) (a) $H_0 : \lambda = 1$	0.4	0.8977				-291.6433	28.2110
	$H_1 : \lambda \neq 1$	1.0	-0.0069		-305.7488			
	(b) $H_0 : \rho = 0$ given $\lambda = 1$	1.0	-0.0069		-305.7488			5.8084
	$H_1 : \rho \neq 0$ given $\lambda = 1$	1.0	0.0000	-308.6530				
	(c) $H_0 : \rho = 0$	0.4	0.8977				-291.6433	65.0322
	$H_1 : \rho \neq 0$	0.9	0.0000			-324.1594		
	(d) $H_0 : \lambda = 1$ and $\rho=0$	0.4	0.8977				-291.6433	34.0194
	$H_1 : \lambda \neq 1$ and $\rho\neq 0$	1.0	0.0000	-308.6530				
Japan	(a) $H_0 : \lambda = 1$	0.4	0.0266				-732.2805	39.3390
	$H_1 : \lambda \neq 1$	1.0	0.1106		-751.9500			
	(b) $H_0 : \rho = 0$ given $\lambda = 1$	1.0	0.1106		-751.9500			13.8060
	$H_1 : \rho \neq 0$ given $\lambda = 1$	1.0	0.0000	-758.8530				
	(c) $H_0 : \rho = 0$	0.4	0.0266				-732.2805	61.2018
	$H_1 : \rho \neq 0$	0.9	0.0000			-762.8814		
	(d) $H_0 : \lambda = 1$ and $\rho=0$	0.4	0.0266				-732.2805	53.1450
	$H_1 : \lambda \neq 1$ and $\rho\neq 0$	1.0	0.0000	-758.8530				

(5.2.23) & (5.2.24) and (5.2.25) & (5.2.26) respectively. The results in Tables 5.5 and 5.6 reveal that (i)the linear specifications of static and dynamic models are rejected and the log-linear ones are accepted for the United Kingdom; (ii) the sample statistics for the United States also give the same guidelines as for the United Kingdom, except the case that quantity index of imports is used as the dependent variable in static models; (iii) both specifications, linear and log-linear, are accepted by the Lagrange multiplier test statistics in the case of Japan. Therefore, the underlying Lagrange multiplier procedure cannot provide any direction to the choice of log or log-linear formulation for aggregate import demand of Japan. Also, for the static model of the United States in which quantity index of imports is employed, the test indicates that both models, linear and log-linear, are rejected.

(iv) Andrews' Test

Andrews variables are added to the static and dynamic equations for aggregate import demand of the United Kingdom, the United States and Japan. The ordinary least squares estimates of these equations are displayed in Tables 5.7 and 5.8. In both cases, static and dynamic, the F statistics for the Andrews variables indicate that the linear forms are rejected at the 5 per cent level, except the case for dynamic model of the United States employed by the quantity index of imports.

Table 5.5. Asymptotic Lagrange Multiplier Test for Static Model - 1955 Q.1 - 1983 Q.4

Country	Specification	Constant	Relative Price	Income	$\bar{R}^2$	S.E.	D.W.	Test Statistic
The United Kingdom	Linear	- 6.9253 (0.435)	1.5001 (0.434)	0.3034 (0.005)	0.9746	0.4618	0.7476	56.0371
	Log-Linear	- 4.3089 (0.074)	0.1169 (0.040)	1.6788 (0.019)	0.9860	0.0421	1.0031	0.0132
The United States	Linear (1)	-43.5269 (1.867)	14.7479 (3.985)	0.1401 (0.004)	0.9681	3.5406	0.9681	42.1588
	Log-Linear(1)	-10.1559 (0.265)	-0.0278 (0.062)	2.2008 (0.040)	0.9810	0.0803	0.5298	- 0.00001
	Linear (2)	-56.3312 (3.318)	27.5641 (7.083)	0.1965 (0.007)	0.9523	6.2923	0.3209	7.1491
	Log-Linear(2)	- 6.0110 (0.390)	0.3086 (0.091)	1.6386 (0.059)	0.9408	0.1180	0.2482	28.9037
Japan	Linear	490.0103 (436.603)	-1507.409 (622.898)	0.1398 (0.003)	0.9528	593.408	0.1357	0.1009
	Log-Linear	- 4.4452 (0.201)	-0.2594 (0.095)	1.2122 (0.018)	0.9775	0.1220	0.1819	0.0017

standard errors of the coefficients in parentheses
(1): estimates computed by import value
(2): estimates computed by quantity index of imports

Table 5.6. Asymptotic Lagrange Multiplier Test for Dynamic Model - Quarterly Data : 1955 Q.2 - 1983 Q.4

Country	Specification	Constant	Relative Price	Income	Lagged Dependent Variable	$\bar{R}^2$	S.E.	D.W.	Durbin-h	Test Statistic
The United Kingdom	Linear	- 2.7848 (0.570)	0.4461 (0.357)	0.1295 (0.020)	0.5804 (0.065)	0.9849	0.3545	1.7420	1.7436	41.5141
	Log-Linear	- 2.3182 (0.308)	0.0380 (0.036)	0.9015 (0.118)	0.4668 (0.070)	0.9899	0.0355	1.8739	0.7062	0.0031
The United States	Linear (1)	-11.1560 (3.344)	0.4947 (3.173)	0.0434 (0.010)	0.7159 (0.068)	0.9837	2.5234	2.1931	-1.3728	66.3492
	Log-Linear (1)	- 3.0726 (0.636)	-0.0554 (0.425)	0.6600 (0.135)	0.7065 (0.061)	0.9911	0.0544	2.2663	-1.8316	0.0073
	Linear (2)	- 8.1084 (3.693)	-1.8694 (4.529)	0.0419 (0.011)	0.8232 (0.054)	0.9842	3.6064	2.0649	-0.4108	14.5938
	Log-Linear (2)	- 1.1014 (0.335)	-0.0168 (0.049)	0.2740 (0.080)	0.8534 (0.046)	0.9850	0.0591	2.2195	-1.3475	0.0082
Japan	Linear	832.6424 (133.732)	-1233.577 (191.294)	0.0163 (0.004)	0.9104 (0.027)	0.9956	180.817	1.7820	1.0583	0.1920
	Log-Linear	- 0.5298 (0.172)	- 0.1638 (0.037)	0.1462 (0.043)	0.8770 (0.035)	0.9965	0.0471	1.5554	2.5521	0.2265

standard errors of the coefficients
(1) : estimates computed by import value
(2) : estimates computed by quantity index of imports

Table 5.7. Andrews' Test for Static Model - 1955 Q.1 - 1983 Q.4

Country	Specification	Constant	Relative Price	Income	Andrews' Variable	$\bar{R}^2$	S.E.	D.W.
The United Kingdom	Linear	5.3634 (1.771)	- 4.0374 (-2.859)	1.0124 (5.844)	1.3659 (4.094)	0.9777	0.4326	0.8876
	Log-Linear	- 4.7756 (-14.532)	- 0.0282 (-0.263)	2.8330 (3.575)	0.3939 (1.457)	0.9861	0.0419	1.0334
The United States	Linear (1)	43.4008 (1.350)	-39.2317 (-1.932)	0.3984 (4.174)	0.6682 (2.708)	0.9698	3.4454	0.5881
	Log-Linear(1)	-10.4152 (-16.741)	- 0.0623 (-0.641)	2.7593 (2.276)	0.0891 (0.461)	0.9808	0.0805	0.5312
	Linear (2)	260.4354 (3.066)	-196.9492 (-3.254)	0.8594 (4.835)	1.5352 (3.732)	0.9572	5.9606	0.3411
	Log-Linear(2)	- 6.0653 (-15.402)	- 0.5251 (-0.603)	3.5119 (1.805)	0.5085 (0.963)	0.9408	0.1180	0.2458
Japan	Linear	-4910.213 (- 2.587)	11701.93 (2.563)	0.4624 (4.181)	1.0632 (2.918)	0.9558	574.604	0.1470
	Log-Linear	- 3.0077 (- 2.725)	0.4986 (0.860)	2.2107 (2.932)	0.3673 (1.324)	0.9777	0.1216	0.1864

t-values in parentheses below coefficients
(1): estimates computed by import value
(2): estimtes computed by quantity index of imports

Table 5.8. Andrews' Test for Dynamic Model - Quarterly Data : 1955 Q.1 - 1983 Q.4

Country	Specification	Constant	Relative Price	Income	Lagged Dependent Variable	Andrews' Variable	$\bar{R}^2$	S.E.	D.W.	Durbin-h
The United Kingdom	Linear	2.2343 (1.024)	- 1.5326 (-1.699)	0.4849 (3.220)	0.5299 (7.886)	1.5416 (2.380)	0.9855	0.3473	1.7635	1.6362
	Log-Linear	- 2.9626 (-2.574)	0.0961 (0.905)	0.9224 (7.429)	0.2899 (0.928)	-0.1740 (-0.581)	0.9898	0.0356	1.8528	0.8802
The United States	Linear (1)	22.1606 (1.292)	- 8.5546 (-1.544)	0.1893 (2.548)	0.6660 (9.309)	1.1751 (1.980)	0.9841	2.4909	2.2155	-1.5536
	Log-Linear (1)	- 3.3654 (-4.625)	- 0.0280 (-0.520)	1.3262 (1.632)	0.6999 (11.367)	0.3516 (0.931)	0.9911	0.0545	0.9911	-1.9447
	Linear (2)	91.0864 (3.170)	20.7792 (2.660)	0.4733 (3.803)	0.6670 (9.762)	4.4622 (3.479)	0.9857	3.4385	2.0416	-0.3119
	Log-Linear (2)	- 0.4191 (-0.923)	0.1255 (1.544)	2.5883 (2.432)	0.7706 (12.987)	3.6450 (2.180)	0.9855	0.0581	2.1902	-1.2124
Japan	Linear	-4021.187 (-2.169)	5710.821 (2.153)	0.0408 (4.053)	0.8880 (31.687)	0.6428 (2.625)	0.9958	176.202	1.8505	0.6702
	Log-Linear	- 0.5880 (-1.890)	- 0.2824 (-0.535)	0.1187 (0.917)	0.8791 (24.352)	- 0.0831 (-0.225)	0.9965	0.0473	1.5541	2.5491

t-values in parentheses below coefficients
(1) : estimates computed by import value
(2) : estimates computed by quantity index of imports

5.4. Conclusion

This chapter suggests by some test procedures that the log-linear model is the more appropriate specification of demand behaviour for total imports. While the data might have something to be improved, some tentative conclusions for possible extensions are:

(i) It appears that autocorrelation of the ordinary least squares residuals seems to be a main problem in estimating the equations. To overcome this obstacle, the maximum likelihood method, the Hildreth-Lu and Cochrane-Orcutt methods are used in running the regressions for the Sargan's test. A disturbing implication is that the estimators may lead to inconsistent estimators when the iterated Cochrane-Orcutt procedure is employed for the equation in which there are lagged dependent varaiables[See Betancourt and Kelejan(1981)]. Therefore, further exploration for estimation of dynamic models is required.

(ii) A satisfactory result(in terms of t-statistics, the Durbin-Watson statistics and $\bar{R}^2$) for the United Kingdom has been assessed by the maximum likelihood estimation in which long-run price and income elasticities are 0.1355 and 1.6666 respectively.[4] Most researchers reported the positive price elasticity for the United Kingdom import demand equation as an attenuated estimate of the supply function. Nevertheless, we need more information on such a 'penumbra'.[5]

(iii) Simultaneous test for autocorrelation and functional form also indicates autocorrelation in residuals for all cases.

(iv) The Lagrange multiplier test and Andrews' test reach conflicting choice for the models of the United States. However, Andrews' exact test provides more certain judgments for the models of Japan and the United Kingdom.

(v) Intuitively, there seems to be another defect for the non-normality of estimated residuals resulted from estimating actual economic data. I want to repeat my suggestion that when the necessary underlying assumptions are true or can be given correct measures, the existing procedures do produce superior justifications.[6]

Notes

(1) Since, according to the Cochrane-Orcutt technique, the values of were greater than 0.3, the maximum likelihood method was used. [See in Kmenta(1986)]

(2) There had been a serious problem with autocorrelation in the residuals of the estimated equations for all cases of three countries. To overcome this problem, Cochrane-Orcutt, Durbin two-step, Hildreath-Lu and maximum likelihood estimation procedures are utilized. The asympototic properties of estimators will be discussed in later sections.

(3) Version 4.0 of TSP was used for computations. On this version, software for the maximum likelihood estimation is due to the Beach-MacKinnon method.

(4) The accepted models of J. Thursby and M. Thursby(1984) gave long-run price and income elasticities as 0.14 and 1.12 respectively. Their study covered the period from first quarter of 1959 to third quarter of 1977, and the models were associated with dummy variables to allow structural shifts.

(5) F. W. Taussig introduced this phrase for which the uncertainty about the working of demand and supply can be observed.

(6) I suggested this point in my recent published paper titled as ' Stability of Aggregate Import Demand Function : A Comparative Econometrics', in The Economic Science, Vol. 36, No. 2, Dec. 1988, Faculty of Economics, Nagoya University, Japan.

References

(1) Andrews, D. F. (1971), "A Note on the Selection of Data Transformation", **Biometrica**, 58(No. 1, August), 249-254.

(2) Beach, C. M. and MacKinnon, J. G. (1978), "A Maximum Likelihood Procedure for Regression with Autoregressive Errors", **Econometrica**, 46(No. 1, January), 51-58.

(3) Betancourt, R. and Kelejan, H.(1981), Lagged Endogenous Variables and the Cochrane-Orcutt Procedure, **Econometrica**, 49(No. 4, July), 1073-1078.

(4) Boylan, T. A., Cuddy, M. P., and O'Muircheartaigh(1980), "The Functional Form of the Aggregate Import Demand Equation : A Comparison of Three European Economies", **Journal of International Economics**, 10 (No. 4, November), 561-566.

(5) Box, G. E. P. and Cox, D. R.(1964), "An Analysis of Transformation(with discussion), **Journal of the Royal Statistical Society, B,** 26, 211-246.

(6) Durbin, J. (1960), Estimation of Parameters in Time-Series Regression Models, **Journal of the Royal Statistical Society, B**, 22, 139-153.

(7) Godfrey, L. G. and Wicken, M. R. (1981), "Testing Linear and Log-Linear Regressions for Functional Form", **Review of Economic Studies**, 48(July), 487-496.

(8) Kmenta, J. (1986), **Elements of Econometrics**, Macmillan, New York.

(9) Milliken, G. A. and Graybill, F. A. (1970),"Extensions of the General Linear Hypothesis", **Journal of the American**

Statistical Association, 65(June), 797-807.

(10) Sargan, J. D. (1964), "Wages and Prices in the United Kingdom ", in Hart, P. E. , Mills, G. and Whitaker, J. K.(eds.) **Econometric Analysis for National Economic Planning**, London:Butterworths.

(11) Savin, N. E. and White, K. J.(1978), "Estimation and Testing for Functional Form and Autocorrelation : A Simultaneous Approach", **Journal of Econometrics,** 8(No. 1, February), 1-12.

(12) Seaks, T. G. and Layson, S. K. (1983), "Box-Cox Estimation with Standard Econometric Problems", **The Review of Economics and Statistics**, 65(No. 1, February), 160-164.

(13) Silvey, S.D. (1959),"The Lagrange Multiplier Test", **Annals of Mathematical Statistics**, 30(No. 2, June), 389-407.

(11) Taussig, T. W. (1921), "Is Market Price Determinate?", **The Quarterly Journal of Economics**, 35, 394-411.

(12) White, K. J.(1972), "Estimation of the Liquidity Trap with a Generalised Functional Form", **Econometrica**, 40, (No. 1, January), 193-199.

(13) Thursby, J. and Thursby, M. (1984), "How Reliable are Simple, Single Equation Specifications of Import Demand?", **Review of Economics and Statistics**, 66(No. 1, February), 120-128.

CHAPTER 6

DYNAMIC SPECIFICATION OF THE QUARTERLY AGGREGATE IMPORT DEMAND MODEL

6.1. Introduction

The objective of this chapter is twofold. First, the quarterly aggregate import equations are developed for the United Kingdom, the United States, and Japan, by introducing dynamic elements. Second, stability of the equations is investigated over time. The dynamic formulations are made in two steps. When, in the first step, the Almon polynomial lags are incorporated into models, the estimated residuals are highly sensitive to autocorrelation. Then, in the second step, distributed lags are adjusted to remove the autocorrelated residuals and appropriate models are selected.

In making reliable forecasts by an econometric model for the evaluation of policy measures, it is important to investigate the stability of the model over time. In order to detect structural change by the well-known Chow test (1960), we need a priori information to identify points of structural change. Since we are lack of this information, stability of the estimated coefficients of the observed dynamic model of the quarterly total imports are tested over the sample period, using the cusum of squares tests which can identify the points of structural change. Finally, the Chow test and the likelihood ratio test are used to reexamine the cases of the United Kingdom and Japan respectively.

6.2. Estimation

Having proposed in the previous chapter that the simple log-linear model is preferred to the linear one, dynamic formulations of aggregate import demand equation are specified in log-linear form. Since the frequency domain analysis for quarterly data performed in Chapter 2 has provided a maximum lag length of seven quarters between GNP and total imports in 1980 prices, the Almon distributed lags are tried for all possible combinations of a length of lag, n, from 1 to 7, a degree of polynomials, p, up to third order, in aggregate import demand model of the underlying sample period 1955 Q.1 to 1983 Q.4. Imposing no endpoint constraints, the polynomial distributed lags are computed on each explanatory variable alternately, and also on both. It is observed that the residuals from all estimated equations, that is, 252 regressions, are characterized by autocorrelation. In the first step, ignoring the autocorrelated residuals, a polynomial of degree one with one period lag is chosen on the basis of $\bar{R}^2$ and significance of coefficients in the equation.

In the second step, a partial adjustment mechanism in total imports is combined to the distributed-lag structure of the first step, with one period lag in one or both of the exaplanatory variables. Among the three countries, an appropriate model for the United Kingdom leads to the following estimated result :

$$\ln M_t = -2.2637 + 0.2473 \ln P_t - 0.2116 \ln P_{t-1} + 0.8822 \ln y_t + 0.4761 \ln M_{t-1} \quad (6.2.1)$$
$$\qquad (-7.315) \quad (1.588) \quad (-1.380) \quad (7.425) \quad (6.803)$$

$\bar{R}^2 = 0.9900$, S.E. = 0.0354, D.W. = 1.9406, Durbin-h = 0.1841.

Both coefficients of the price variables are significant at the 20 per cent level and other estimated coefficients are significant in statistical sense. Only the estimated coefficient of the current price variable shows positive sign and all other parameter estimates have the signs expected from theory. Auto-correlation in the estimated residuals has been removed, as shown by both the Durbin-Watson and Durbin-h statistics. Goldstein and Khan (1976) could not obtain significant coefficients of the price variable for the United Kingdom, in their dynamic model.

This process gives insignificant coefficients of the price variables for the United States and Japan. Therefore, the adaptive expectation hypothesis is used to explain the relative price and level of income and it is combined with partial adjustment mechanism of total imports for these two countries. The estimated models resulted for the United States and Japan are:

The United States

(a) $$\ln M_t = -2.7619 - 0.0728 \ln P_t + 0.5892 \ln y_t + 0.5539 \ln M_{t-1} + 0.1855 \ln M_{t-2} \quad (6.2.2)$$
$$\qquad (-4.284) \quad (-1.691) \quad (4.276) \quad (5.888) \quad (2.137)$$

$\bar{R}^2 = 0.9912$, S.E.= 0.0538, D.W.= 1.9400, Durbin-h= 1.3713.

(b) $$\ln Q_t = \underset{(3.233)}{-1.0901} - \underset{(-1.371)}{0.4307} \ln P_t + \underset{(1.262)}{0.3843} \ln P_{t-1} + \underset{(3.146)}{0.2555} \ln y_t + \underset{(7.689)}{0.7264} \ln Q_{t-1} + \underset{(1.626)}{0.1507} \ln Q_{t-2} \quad (6.2.3)$$

$\bar{R}^2 = 0.9851$, S.E.= 0.0586, D.W.= 1.9734, Durbin-h= 0.9539.

Japan

$$\ln M_t = \underset{(-3.383)}{-0.5780} - \underset{(-3.458)}{0.1333} \ln P_t + \underset{(3.774)}{0.1598} \ln y_t + \underset{(11.828)}{1.0782} \ln M_{t-1} - \underset{(-2.396)}{0.2122} \ln M_{t-2} \quad (6.2.4)$$

$\bar{R}^2 = 0.9966$, S.E.= 0.0463, D.W.= 2.0629, Durbin-h= -1.3948.

In model (b) of the United States, the adaptive expectation hypothesis is formed only on the level of income and then we specify a partial adjustment mechanism for quantity index of imports. The results for the United States and Japan show that (i) the estimated coefficient of the current price in the aggregate import demand model of the United States is significant at the 20 per cent level; (ii) the estimated coefficient of $\ln P_{t-1}$ in the model (b) of the United States turns out to be insignificant; (iii) all other estimated coefficients are statistically significant; (iv) the Durbin-Watson and Durbin-h statistics prevail that the estimated residuals are not autocorrelated.

6.3. Stability Tests

Firstly, two procedures are used to investigate the stability of estimated coefficients of the underlying model over the sample period. The first one is developed by McCabe and Harrison (1980) and it is simple to compute by using the standardized cumulative sum of squares (cusum) of the ordinary least squares residuals. The second procedure is contributed by Brown, Durbin and Evans (1975) and it is based on recursive residuals.

The general linear model can be expressed as

$$y_t = x'_t \beta_t + u_t \tag{6.3.1}$$

where y_t is the observation on the dependent variable, x_t is the column vector of observation on k nonstochastic regressors, β_t is the column vector of parameters and u_t is a stochastic disturbance. u_t's are assumed to be distributed with means zero and constant variances.

Then, the null hypothesis is adopted as

$$H_0 : \quad \beta_t = \beta \quad ; \quad t=1,2,\ldots,n. \tag{6.3.2}$$

(i) Test of McCabe and Harrison (1980)

The primary concern here is to investigate the stability of estimated coefficients of the underlying model over the sample period. The test procedure is suggested by McCabe and Harrison (1980) to use the standardized cumulative sum of squares (cusum) of the ordinary least squares residuals. According to this procedure, the standardized cusum of squares are computed as

$$S_j = \frac{e'_j A_j e}{e'e} \tag{6.3.3}$$

where e is the (nx1) vector of ordinary least squares residuals and

$$A_j = \begin{bmatrix} I_j & 0 \\ 0 & 0 \end{bmatrix}$$

where I is the unit matrix. Then, the standardized cusum of squares diagram can be drawn by computing the critical lines as

$$\pm S^*_L = \pm c + (j-k)/(n-k) \qquad j=k+1,\ldots,n-1$$

$$\pm S^*_U = \pm c + j/(n-k) \qquad j=1,\ldots,n-k-1 \qquad (6.3.4)$$

where c is a constant. The values of c are taken from the table of critical values contributed by Durbin (1969). In the case of a one-sided test , c is read at the significance level for $\frac{1}{2}(n-k)$ -1 when (n-k) is an even number, and linear interpolation is made between the α values for $\frac{1}{2}(n-k) - \frac{3}{2}$ and $\frac{1}{2}(n-k) - \frac{1}{2}$ when (n-k) is an odd number. If sample path of S's crosses $(-S^*_L)$, then the null hypothesis that the estimated coefficients are stable over time, is rejected; if it does not cross $(-S^*_U)$, then the null hypothesis is accepted; otherwise the test is inconclusive. In practice, a two-sided approximate test based on $+S^*_L$ is used in order to avoid the inconclusiveness of the test.

Therefore, the cumulative residual sum of squares series is computed from estimation of each dynamic model by ordinary least squares method. The critical lines $+S^*_L$ and S^*_U for a two-sided test at the 0.05 significance level are constructed for each model. Since in Figure 6.1, the sample path

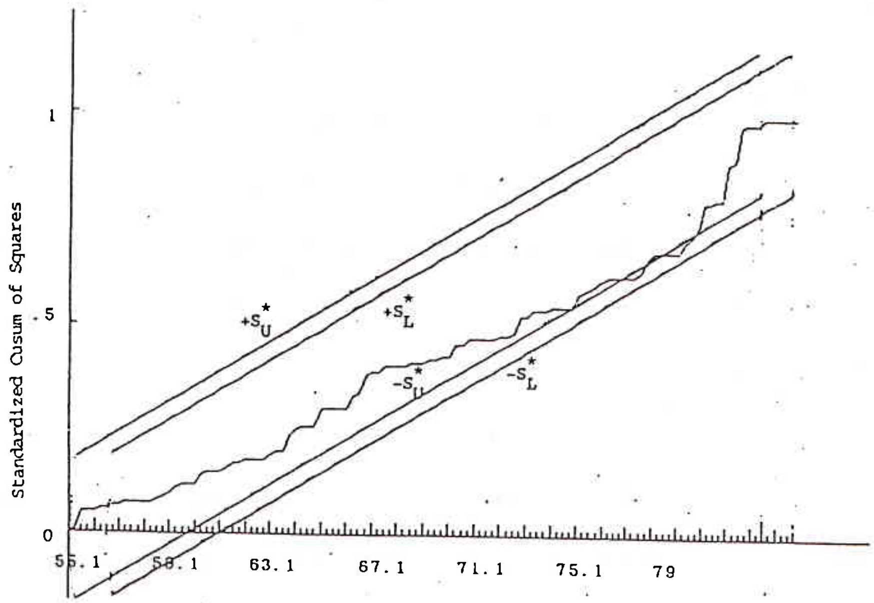


Figure 6.1. Cusum Diagram for the United Kingdom

of the standardized cusum of squares for the United Kingdom does not cross $-S_L^*$, the underlying model is stable over time.

Figures 6.2(a) and (b) are for the United States; the former is for the model formulated in terms of real imports and the latter, by quantity index of imports. In Figure 6.2(a),

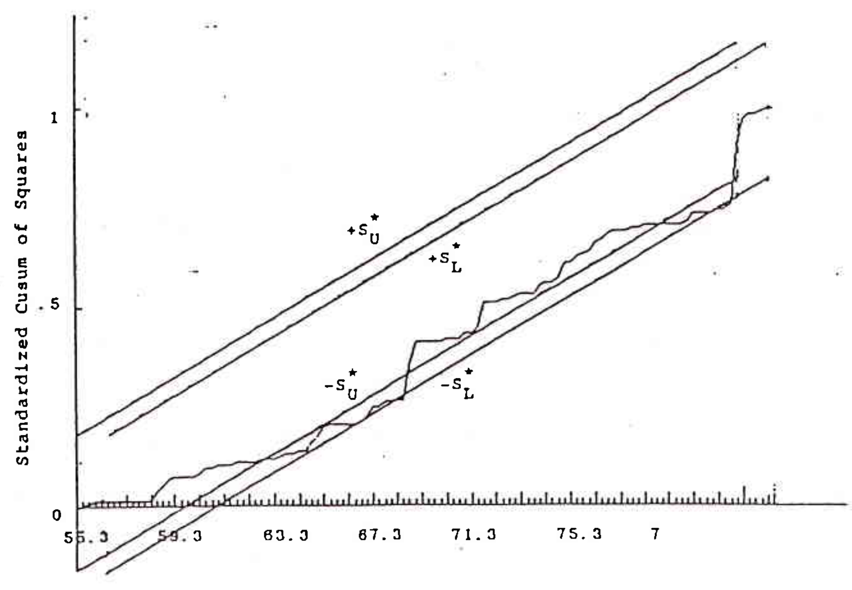


Figure 6.2(a). Cusum Diagram for the United States

the sample path crosses $-S_L^*$ at around j = 47, 53, 105 and 108, i.e. the first quarters of 1967 and 1969, the second quarters of 1981 and 1982 respectively. The evidence of structural change for real imports of the United States during the period between the first quarter of 1967 and that of 1969 agrees with the finding of Stern, Baum and Greene (1979). They observed the structual change in the mid-to late 1960s and the first quarter of 1972 and guessed that it would be due to the increased supply capabilities and behaviour of foreign producers. However, they admitted that there had been lack of detailed information. Again, it seems that instability of parameter estimates occurred during the period from the second quarter of 1981 to that of 1982 due to the effect of the second oil shock.

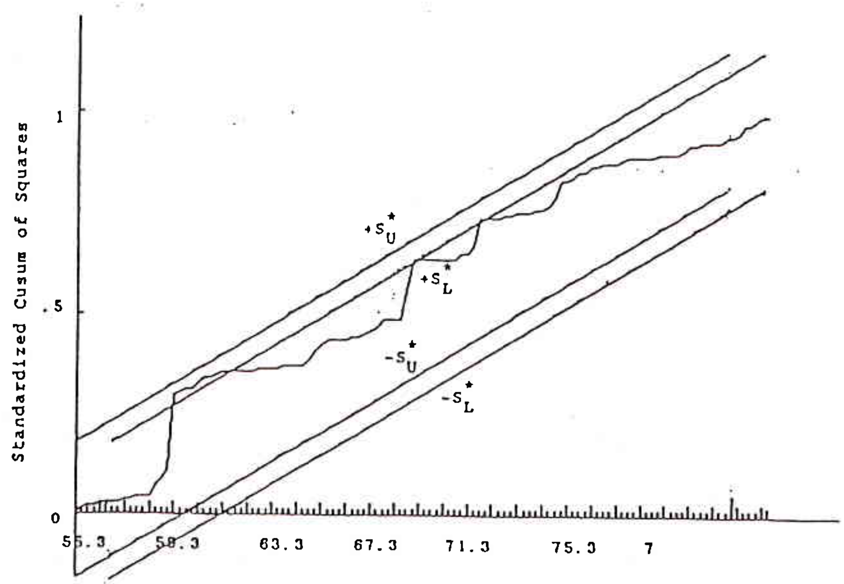


Figure 6.2(b). Cusum Diagram for the United States

For the model employed the quantity index of imports, structural changes had frequently occurred in Figure

6.2(b) during the period from the third quarter of 1958 to the first quarter of 1972, for the plotted line of S's crosses $+S^*_L$ six times. For Japan, Figure 6.3 reveals plausible structural

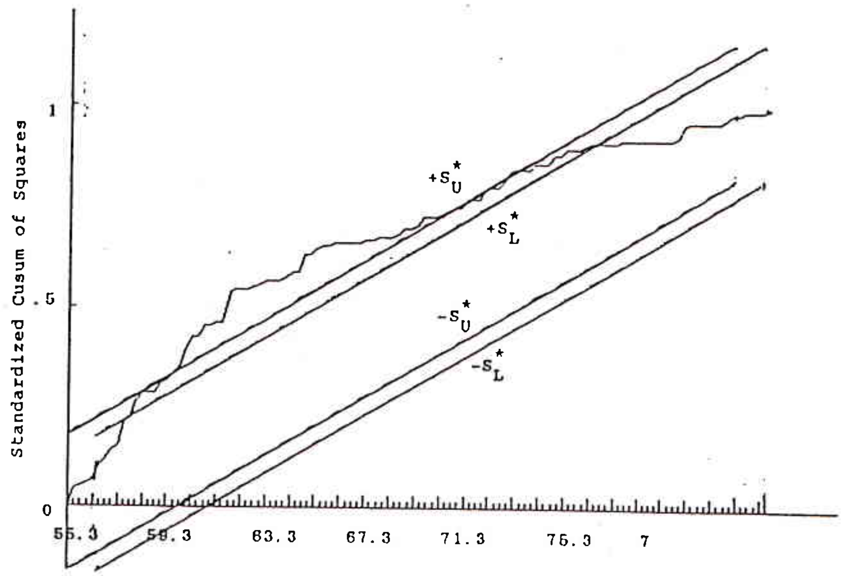


Figure 6.3. Cusum Diagram for Japan

changes in import demand at around j= 12 and 86, which indicates the second quarter of 1958 and the fourth quarter of 1976.

(ii) Test of Brown, Durbin and Evans (1975)

Brown, Durbin, and Evans (1975) developed the cusum test based on recursive residuals. The residuals are defined as

$$w_i = \frac{y_i - x_i b_{i-1}}{[1 + x_i (X'_{i-1} X'_{i-1}) x'_i]^{1/2}} \quad ; \quad i=k+1,\ldots,n \qquad (6.3.5)$$

where k is the number of parameters estimated; y_i and x_i are the vectors of the first i observations on the dependent and independent variables respectively, X_i, the matrix in which its rows are x_1, x_2, ..., x_i, and b_i, the least squares estimates based on the first i observations. Under the null hypothesis that the parameters are constant over time, the w_i's are independent normal variates with means zero and constant variances. This test is to compute the squared recursive residuals w_i^2, and to plot the standardized cumulative sum of squares

$$S'_j = \frac{\sum_{i=k+1}^{j} w_i^2}{\sum_{i=k+1}^{n} w_i^2} \qquad (6.3.6)$$

Then a pair of the critical lines is drawn at the significance level α. The critical lines are calculated as

$$\pm S_{LU} = \pm c + (i-k)/(n-k) \ ; \ i=k+1,\ldots,n. \qquad (6.3.7)$$

where c is the same value in the previous test.

The cusum of squares graph for the United Kingdom drawn by the recursive residulas is shown in Figure 6.4. Instability of the estimated coefficients is indicated by the crossing-points between the first quarter of 1974 and the second quarter of 1975. The evidence of instability is seemed to be explained by the first oil crisis which broke out at the fourth quarter of 1973. A recent study by Italianer (1989) observed a structural break within the period 1979 Q.1-1979 Q.2 in dynamic

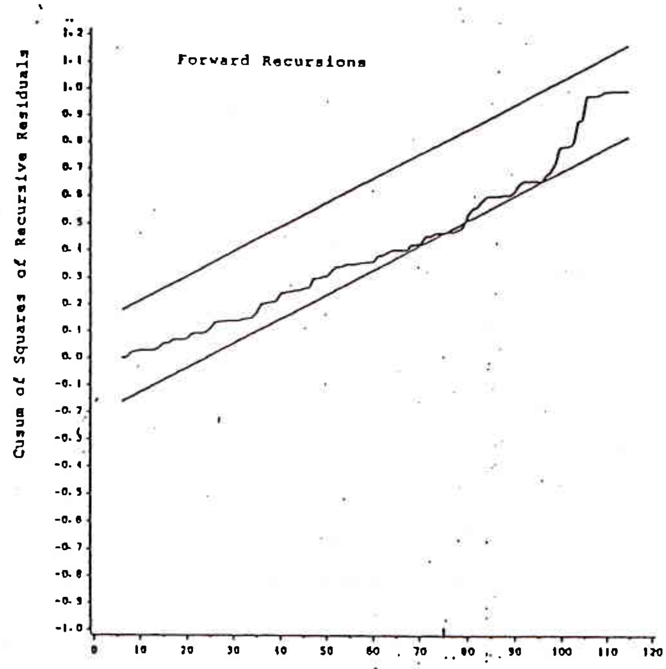


Figure 6.4. Cusum Diagram for the United Kingdom

import equation for the United Kingdom. It was explained by the increase in domestic oil production in the post-1973 era which makes possible to substitute oil imports and verified by a drastic cut in oil import volume over 1970-84 period. Also, an observation that energy consumption of British manufacturing industries decreased in the years between 1972 and 1981 could have affected import demand. However, my result is likely to occur during the first oil crisis, for the United Kingdom started its oil exploration since the post-1973 era. J. Thursby and M. Thursby (1984) also pointed out the importance of a structural shift in the early seventies for aggregate import demand function of the United Kingdom.

As shown in Figure 6.5(a), the sample path for real

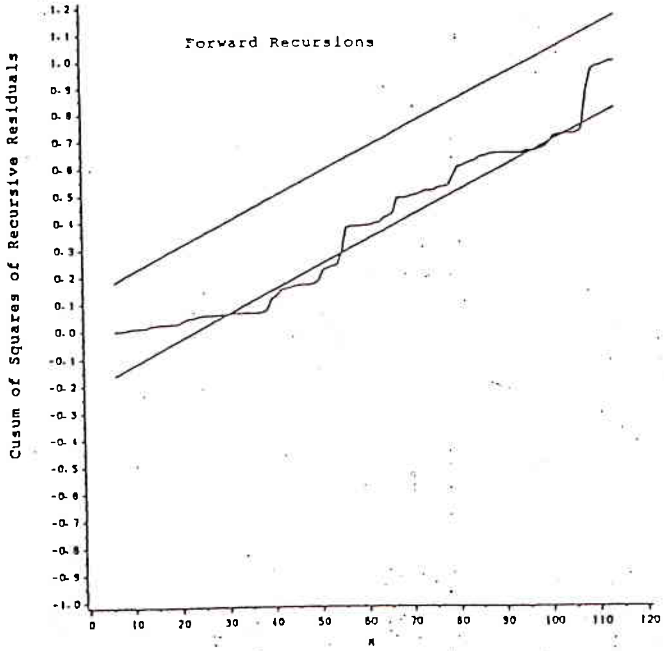


Figure 6.5(a). Cusum Diagram for the United States

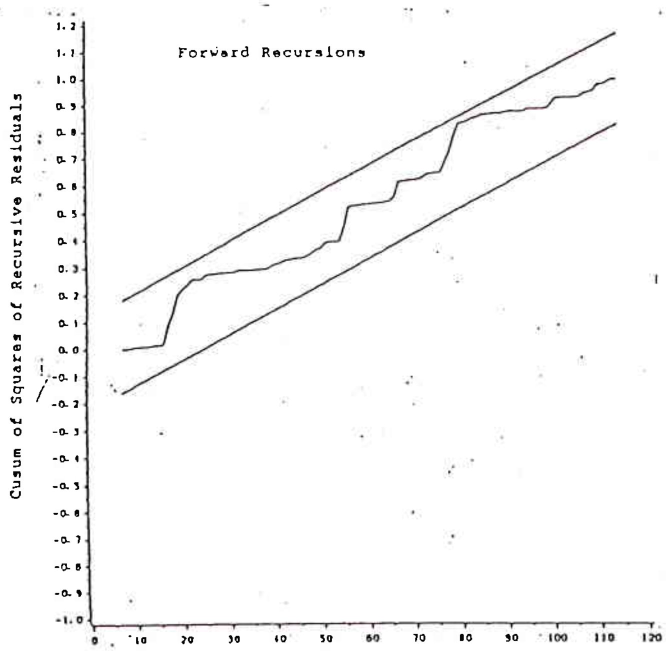


Figure 6.5(b). Cusum Diagram for the United States

imports of the United States gives a similar picture with Figure 6.2(a) of the previous test. However, 6.5(b) displays a completely different evidence with Figure 6.2(b). It seems that the degree of inclusiveness of the test of McCabe and Harrison might be so high in the case of underlying dynamic model of the United States. If we compare the stability of two models for the United States, we observe that the model employed by the quantity index of imports is more appropriate to use for forecasting purpose.

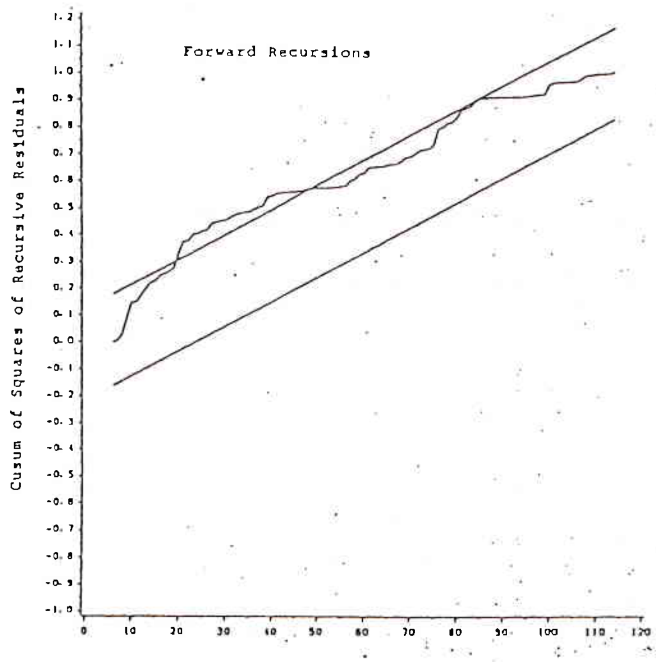


Figure 6.6. Cusum Diagram for Japan

Figure 6.6 shows that the coefficients of dynamic import demand model for Japan vary at around i= 20 and 48, that is, the first quarter of 1960 and the third quarter of 1967, The closeness of the cusum of squares plot and 5 per cent significance line can be seen in the third quarter of 1976 which will be consistent with the previous test. It may therefore be concluded from Figures 6.3 and 6.6 that strong evidence of instability took place between the second quarter of 1958 and the first quarter of 1960 and other possilble instability points occurred in the third quarter of 1967 and the fourth quarter of 1976.

(iii) Chow Test (1960)

The Chow (1960) test is used to determine whether there is a significant structural change at the first quarter of 1974 for the coefficients of the aggregate import demand function of the United Kingdom. The Chow test is based on residual analysis and is a kind of standard analysais of covariance test.

The general linear model expressed by (6.3.1) can be written as

$$\begin{aligned} y_1 &= x_1 \beta_1 + 0 \, \beta_2 + e_1 \\ y_2 &= 0 \, \beta_1 + x_2 \beta_2 + e_2 \end{aligned} \qquad (6.3.8)$$

where 1 refers to first sample of n_1 observations and 2, second sample of n_2 observations. The hypothesis to be tested is

$$H_0 : \quad \beta_1 = \beta_2 .$$

Under the assumption of homogeneity of the variances, Chow showed that null hypothesis can be tested by the F ratio

$$F_{(k, n_1 + n_2 - 2k)} = \frac{\left\| x_1 b_1 - x_2 b_0 \right\|^2 + \left\| x_2 b_2 - x_2 b_0 \right\|^2 / k}{\left\| y_1 - x_1 b_1 \right\|^2 + \left\| y_2 - x_2 b_2 \right\|^2 / (n_1 + n_2 - 2k)}$$

$$\text{for } n > k; \qquad (6.3.9)$$

where b_0, b_1, b_2 are the least squares estimates of β, β_1 and β_2 respectively.

The results of the Chow test for the United Kingdom are reported in Table 6.1. As shown by this table, the Durbin-h statistics assure the validity of ordinary least squares estimation (1) and the pre-test for homoscedasticity supports for applicability of the Chow test (2). The observed F-statistic leads to rejection of the hypothesis of stability at the 5 per cent significance level. However, the critical value at the 1 per cent significance level is $F_{(0.01,5,110)} = 3.188$ and the null hypothesis is accepted at the one per cent significance level. Therefore, when we apply the cusum procedure of Brown et al. to the U. K. model with one per cent significance lines, the graph indicates no change in the coefficients of the equation over time as in Figure 6.7.

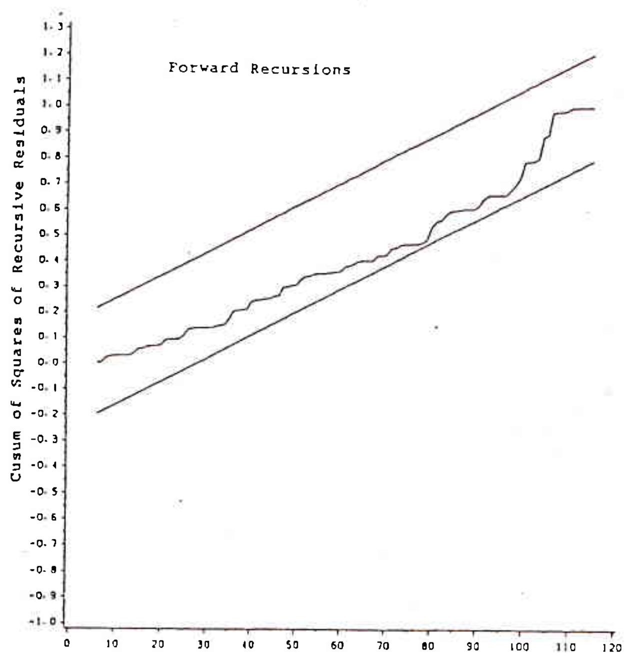


Figure 6.7. Cusum Diagram for the United Kingdom

Table 6.1. Results of the Chow Test for the United Kingdom

Period	Constant	$\ln P_t$	$\ln P_{t-1}$	$\ln y_t$	$\ln M_{t-1}$	$\bar{R}^2$	S.E.	D.W.	Residual Sum of Squares	Durbin-h	Test Statistics
1955 Q.2 - 1983 Q.4	- 2.2637 (-7.315)	0.2473** (1.588)	- 0.2116** (-1.380)	0.8822 (7.425)	0.4761 (6.803)	0.9900	0.0354	1.9406	0.13782	0.1841	Pre-Test
1955 Q.2 - 1974 Q.1	- 3.3875 (-7.789)	- 0.1215# (-0.647)	0.3147# (1.518)	1.2938 (7.862)	0.2695 (2.886)	0.9879	0.0302	1.9603	0.06459	- 0.0454	$F_{(76,39)} = 0.5972$
1974 Q.2 - 1983 Q.4	- 3.1148 (-2.939)	0.6235 (2.086)	- 0.5233** (-1.798)	1.0206 (3.465)	0.5925 (5.374)	0.8019	0.0404	1.8638	0.05550	0.5926	Chow Test $F_{(5,110)} = 3.1003$

** : significant at 20 per cent level
# : not significant

(iv) Likelihood Ratio Test

This test was introduced by J.-M. Dufour (1982) and applicable to a set of regressions more than two. According to this procedure, the data are split into p subperiods which are mutually exclusive as

$$X = \begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ X_p \end{bmatrix} \qquad X^* = \begin{bmatrix} X_1 & 0 & \cdots & 0 \\ 0 & X_2 & \cdots & 0 \\ \vdots & \vdots & \cdots & \vdots \\ 0 & 0 & \cdots & X_p \end{bmatrix}$$

$$y = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_p \end{bmatrix} \qquad u = \begin{bmatrix} u_1 \\ u_2 \\ \vdots \\ u_p \end{bmatrix} \tag{6.3.10}$$

and $r = \text{rank}(X)$. Then, the rank of X^* is $r = \sum_{t=1}^{p} r_t$. If the matrices X_t have full column rank, $r_t = k$ for $t=1,2,\ldots,p$. Under the null hypothesis

$$H_0 : \beta_t = \beta ; \quad t=1,2,\ldots,p ,$$

the linear model will be

$$y = X^* \beta + u .$$

Then, the likelihood ratio test statistic is

$$F = \frac{f}{f_0} \frac{S_0 - S_\Omega}{S_\Omega} \tag{6.3.11}$$

where $S_0 = \min (y - X\beta)'(y - X\beta)$

$$S_\Omega = \sum_{t=1}^{p} S_t$$

$$S_t = \min (y_t - X_t \beta_t)'(y_t - X_t \beta_t) \; ; \; t=1,2,\ldots,p$$

$$f_0 = \sum_{t=1}^{p} r_t - r$$

$$f = \sum_{t=1}^{p} (n_t - r_t)$$

n_t = number of observations in the t-th period.

Under H_0, F follows a $F(f_0, f)$ distribution. A necessary and sufficient condition for H_0 to be testable by the statistic (6.3.11) is

$$\sum_{t=1}^{p} n_t > \sum_{t=1}^{p} r_t > r.$$

Then, the stability of dynamic equation for the Japanese imports is tested at the suspected structural breaks, that is, the second quarter of 1958, the third quarter of 1967 and the fourth quarter of 1976. The dynamic specification for Japan expressed by equation (6.2.4) is estimated by ordinary least squares at each subperiod and also, for the entire period. The results are given in Table 6.2. The test statistic indicates to reject the null hypothesis at the five and one per cent levels of significance.

Possible explanations for being exhibited instability in dynamic import demand model of Japan may be provided as follows :

Table 6.2. Results of the Likelihood Ratio Test for Japan

Period	Constant	$\ln P_t$	$\ln y_t$	$\ln M_{t-1}$	$\ln M_{t-2}$	$\bar{R}^2$	S.E.	D.W.	Residual Sum of Squares	Durbin-h	Test Statistic
1955 Q.3 - 1983 Q.4	- 0.5780 (-3.383)	- 0.1333 (-3.458)	0.1598 (3.774)	1.0782 (11.828)	- 0.2122 (-2.396)	0.9966	0.0463	2.0629	0.233887	- 1.3948	
1955 Q.3 - 1958 Q.2	4.3584 ¤ (0.497)	- 0.3661 ¤ (-0.261)	- 0.4250 ¤ (-0.348)	1.3907 (3.955)	- 0.4690 ¤ (-1.070)	0.7843	0.0767	2.4772	0.041150	- 1.0615	
1958 Q.2 - 1967 Q.3	- 1.8022 (-3.665)	- 1.1899 (-4.031)	0.4133 (4.466)	0.6316 (4.269)	0.0198 ¤ (0.150)	0.9839	0.0428	1.7341	0.058718	1.1951	$F_{(15,94)}$ = 2.
1967 Q.4 - 1976 Q.4	- 2.0472 (-2.406)	- 0.2503 (-3.482)	0.3007 (2.632)	0.8795 (5.272)	- 0.0210 ¤ (-0.129)	0.9787	0.0383	1.8965	0.046901	1.0731	
1977 Q.1 - 1983 Q.4	- 2.3552 * (-1.732)	- 0.2104 (-3.454)	0.2487 (2.827)	0.6745 (3.537)	0.2804 ¤ (1.307)	0.7875	0.0263	2.0114	0.015953	- 0.5523	

* : significant at 10 per cent level
¤ : not significant

(i) The 1957-58 and 1961-62 monetary restraints could have affected import demand through internal demand;

(ii) In 1967, Japan experienced a slight balance of payment deficit;

(iii) Due to the first oil crisis, the yen exchange rate reflected the import prices and subsequently the foreign trade trends were changed. In Tables A.8(a) and A.8(b) of Appendix A, percentage share of imports of fuel jumped from 21.77% in 1973 to 40.14% in 1974 and imports of fuel has been accounted for approximately 50% of total imports since 1974.

6.4. Conclusion

Dynamic specification of import demand equation is in essence on both economic and statistical grounds as mentioned in the earlier parts of my study. Dynamic equations for the United Kingdom, the United States and Japan are set up and estimated by the quarterly data covering the period from 1955 to 1983. Since the stability of the model over time is very important in econometric model-building process, cusum procedures are used to examine parameter constancy. It is evident that the present work cannot be viewed as a finished product. Though it might need many further investigations, some conclusions may be drawn from the results :

(i) For the dynamic model of the United Kingdom, the evidence that structural change had occurred during the period between the first quarter of 1974 and the second quarter of 1975 seems to be acceptable. Nevertheless, the approximate two-sided test and the choice of 1 per cent significance level for the Chow and cusum tests would perhaps be advisiable to represent dynamic behaviour of demand for imports of the United Kingdom by the observed model.

(ii) It is observed in the case of the United States that the model employing the quantity index of imports is preferred to the one employed by the real imports because of the assesment of parameter stability over time. Volker (1982) illustrated the stability of the U.S. import demand function specified by the real imports over the period 1953 Q.3 - 1976 Q.2.

(iii) Since the Japanese economy is sensitive to the world business cycle, specifcation of stable trade functions will be the primary intention of econometric model builders.

Notes

(1) Corsi et al. (1982) pointed out that the presence of serial correlation in the residuals might introduce biases in the Chow test.

(2) The test statistic for homogeneity of variances is given by

$$F_{(n_1-k,n_2-k)} = \frac{\left\| y_2 - x_2 b_2 \right\|^2 / (n_2-k)}{\left\| y_1 - x_1 b_1 \right\|^2 / (n_1-k)}$$

References

(1) Almon, S. (1965), "The Distributed Lag Between Capital Appropriations and Expenditures", **Econometrica**, 33 (No. 1, January), 178-196.

(2) Brown, R. L., Durbin, J., and Evans, J. M. (1975), "Techniques for Testing the Constancy of Regression Relationships over Time", **Journal of the Royal Statistical Society, B**, 37, 149-192.

(3) Chow, G. C. (1960), "Tests of Equality Between Sets of Coefficients in Two Linear Regressions", **Econometrica**, 28(No. 3, July), 591-605.

(4) Cooper, J. P. (1972), "Two Approaches to Polynomial Distributed Lags Estimation : An Expository Note and Comment",**The American Statistician**, 26(No. 3,June), 32-35.

(5) Corsi, P, Pollock, R. E., and Prakken, J. L. (1982), The Chow Test in the Presence of Serially Correlated Errors in **Evaluation the Reliablility of Macro-economic Models** edited by G. C. Chow and P. Corsi.

(6) Durbin, J. (1969), "Tests for Serial Correlation in Regression Analysis Based on the Periodogram of Least-Squares Residuals", **Biometrika**, 56(No.1, March), 1-15.

(7) Dufour, J.-M. (1982), "Generalized Chow Tests for Structural Change : A Coordinate-free Approach", **Internaational Economic Review**, 23(No. 3, October), 565-575.

(8) Goldfeld, S. M. and Quandt, R. E. (1965), "Some Tests for Homoscedasticity", **Journal of the American Statistical Association**, 60(June), 539-547.

(9) Goldstein, M. and Khan, M. (1976), "Large Versus Small Price Changes and the Demand for Imports", **IMF Staff Papers**, 23(No. 2, October), 200-225.

(10) Italianer, A. (1989), "Estimation and Simulation of International Trade Linkages in the QUEST Model", **European Economy**, 30, 61-130.

(11) McCabe, B. P. M. and Harrison, M. J. (1980), "Testing the Constancy of Regression Relationships over Time Using Least Squares Residuals", **Applied Statistics**, 29, 142-148.

(12) Pagano, M. and Hartley, M. J. (1981), "On Fitting Distributed Lag Models Subject To Polynomial Restrictions", **Journal of Econometrics**, 16(No.2, June), 171-198.

(13) Scheffe, H. (1959), **The Analysis of Variance**, John Wiley & Sons, Inc., London.

(14) Stern, R. M., Baum, C. F. and Greene, M. N. (1979), "Evidence on Structural Change in the Demand for Aggregate U. S. Imports and Exports", Journal of Political Economy, 87(No. 1, February), 179-192.

(15) Thursby, J. and Thursby, M. (1984), "How Reliable Are Simple, Single Equation Specifications of Import Demand?", **Review of Economics and Statistics**, 66(No. 1, February), 120-128.

(16) Volker, P. A. (1982), "On the U, S. import Demand Function : A Comment", **Journal of Political Economy**, 90(No.6, December), 1295-1299.

CHAPTER 7

CONCLUSION

This chapter attempts to make an evaluation of the usefulness of this study and discuss some problems from the theoretical and empirical justifications.

My study begins with a brief account of the historical development of world trade focusing on the United Kingdom, the United States and Japan. The historical experience explains the leading roles of the United Kingdom, the United States and Japan in world trade. The trade data are compiled on the basis of commodity groups. Shifts in the commodity patterns of trade will be helpful in explaining the effect of structural change.

At the theoretical level, changes in exports affect national income and the effect of changes in national income takes place on imports with a time lag. In Chapter 2 of this study, I emphasize the Polak's causal model of exports, imports and national income. An effort is made to investigate the patterns of interrelationships between these economic variables by two empirical analyses, conventional cross spectral analysis and causality analysis based on Granger's concept, using historical data of the United Kingdom, the United States and Japan. Exploration of the causal patterns is made both at current and constant price levels. In both analyses, Sims' filter is used for the validity of assumptions of the statistical theory of spectral estimates and causality tests. A well-known property of

Sims' filter is that it approximately flattens the spectral density function and yields white noise processes. Also, this filter is advantageous in carrying out cross spectral analysis, for the literature of spectral analysis points out that violently fluctuating spectrum gives unreliable estimator of the theoretical spectrum.

Detection of leads or lags and lead-lag length in economic relationships might be crucial in formulation of the distributed lag model and useful in considering the time relationships between certain aggregate economic variables for policy makers. Cross spectral analysis provides quantitative estimates of leads or lags and degree of these relationships by phases and coherences at different frequencies. THe information of lead-lag lengths generated by cross spectral analysis is utilized in the formulation of causal models and tests of causality are performed by the F-statistics.

Attempts to measure the import and export elasticities which reflect stability in the balance of payments have started since earlier 1945. A number of statistical investigations to discover the magnitudes of relative price and income elasticities of import demand for the United Kingdom, the United States and Japan is presented in Chapter 3. In the determination of a simple model of import demand, income and relative prices are the two main determinants of imports. It is explained by the perfect-substitutability and imperfect-substitutability approaches in economic theory. In the former, price and income elasticities of import demand are derived from the excess home demand over home supply. In the latter, imports are viewed as any commodity whose demand can be derived from utility theory or production theory. Empirical issues on the estimation of single equation model for aggregate import demand for the three countries under study are divided into prewar and postwar studies and some implications are presented in this chapter. Orcuttization of empirical trade studies stems from the results employing the prewar data. My intuition is made that underestimation of the magnitudes of the relative price elasticities may arise by spurious correlation which can often occurs from using ratio-type variables. Also, I point out that choice between linear and log-linear specifications affects the magnitude of elasticity estimates.

Chapter 4 investigates the effects of measurement error on the price and income elasticity estimates in an aggregate import demand function. In this respect, Orcutt, Kemp and Kakwani had considered the direction and magnitude of the bias in the least squares estimate of the price elasticity when the price variable was measured with errors in the import demand function. However, Kemp and Kakwani specified the import demand equation by relating the dependent quantity variable with only the price variable. The income variable had been lacking in their specification. On the one hand, this is not the exact theoretical formulation of import demand. On the another hand, there had been contributed papers by Leamer, Visco and Oksanen that showed the changes in signs of ordinary least squares coefficients by deletion of a regressor having a higher t-ratio than other regressors in a linear regression. Based on these two main reasons, I provide some statistical propositions in Chapter 4 by making assumptions in the errors-in-variable model of aggregate import demand under large sample scheme. It has been pointed out that degree of collinearity between the price and income variables and the signs of the coefficients of true variables mainly decide the magnitudes and direction of biases of price and income elasticity estimates.

Chapter 5 and Chapter 6 are related. The specification of the functional form for the aggregate import demand model is treated in Chapter 5. Linear and log-linear variants for static and dynamic models are tested by the Sargan's criterion, the Box-Cox extended procedure, the lagrange multiplier statistic and andrews' method, using the quarterly data of the United Kingdom, the United States and Japan. One of the difficulties in estimating static and dynamic models in both linear and log-linear forms for the sargan's criterion is the appearence of the autocorrelated residuals. In econometric literature, autocorrelated residuals are encountered in the estimation process when the disturbances follow an autoregressive process or we specify an incorrect functional form. Therefore, both the separate and simultaneous tests for autocorrelation and functional forms are conducted in the Box-Cox extended procedure.

The results demonstrate an autocorrelation problem in estimated residuals. Both the Sargan's criterion and Box-Cox extended procedure consistently select the log-linear form for all three countries.

The Lagrange multiplier test which is asymptoticall distributed as chi-squares is manipulated by evaluating the log-likelihood function of the models. The Andrews method is advantageous for its applicability of the exact t-distribution. However, the Lagrange multiplier test is inconclusive for the case of Japan. And both the Lagrange multiplier and Andrews procedures cannot provide proper inference for the case of the United States in which the quantity index of imports is employed as dependent variable.

Dynamic specifications are considered by introducing Almon lags, partial adjustment mechanism and adaptive expectation hypothesis in Chapter 6. Autocorrelation in the residuals can be removed in the observed specifications for the United Kingdom, the United States and Japan. Stability of parameters is tested for the reliability of the observed models.

Finally, we may briefly review the salient points of this dissertation as follows:

(1) This study has been mainly confined to the formulation of traditional aggregate import demand relationship by the methodological and empirical aspects.

(2) Spurious correlation of ratio-type variables has been demanding the theoretical development in econometric issues.

(3) The second chapter of this dissertation throws a new light on Polak's pioneer contribution by the historical data. Changes in the coherency estimates between the current and constant price levels assert a plausible effect on patterns of the linkage between imports, exports and income.

(4) Study on errors-in-variable model for the aggregate import demand shows that the ordinary least squares estimate of the coefficient whose variable is measured with errors becomes small when the coefficient of the price variable is negative and that of the income variable is positive.

(5) Most of the statistical tests stemmed from decision theory can verify that the log-linear form is preferred to the linear one in the single equation model of the aggregate import demand for the three countries under study.

(6) In the light of spectral analysis, the resulting lead-lag relationships are very informative in the formulation of the distributed-lag models.

(7) It seems to be optimistic to say that the stable dynamic model of the aggregate import demand for the United Kingdom has been constructed.

(8) This study can support the finding of J. Thursby and M. Thursby (1984) that quantity index of imports should be used as an dependent variable in the specification of aggregate import demand function for the United States from the viewpoint of parameter constancy.

And this dissertation has suggested a number of possible future researches as follows :

(1) In econometric applications, we use the deflated variables in order to get more efficient estimates or to remove the price effect. It is well known that "spurious correlation" between the deflated variables alters the functional and stochastic specification of a linear model. Therefore, I do hope that theoretical contribution on statistical properties of the ratio between two variables will solve the long-existing problem of elasticity estimates in international trade and also, many other econometric applications.

(2) In most econometric analysis of international trade, the estimated price elasticity of import demand for the United Kingdom has been observed with the wrong sign and large sampling error. Most researchers proposed this estimate as an attentuated estimate of the supply curve based on the reason that the demand function seems to fluctuate more than the supply function for the United Kingdom. We should put this reason into practice under the assumption of infinite supply elasticity in a single equation model of aggregate import demand.

(3) Exact sampling distribution of elasticity estimates of import demand under errors-in-variable model should be worked out in the future. Also, measurement error should be considered under a variety of statistical distributions.

(4) With regard to the issue of the functional form, the log-linear relationship for the aggregate import demand is empirically accepted by this study or by most empirical researches.

However, it will be inconsistent with the demand theory when imports is assumed as a consumer good whose demand is derived from utility maximizing behaviour. We need to explore some restraints to conform with our empirical performance.

(5) Stability tests conducted in this study point out that detection of certain "optimal significance level" will make a great service to econometric and statistical world.

APPENDIX A

TABLES

Table A.1. Regional Composition of World Trade in Primary Products and Manufactures : Percentages in Value, 1913

Regions	Exports			Imports			Total			
							Exports		Imports	
	Primary Products	Manufactures	Total	Primary Products	Manufactures	Total	Primary Products	Manufactures	Primary Products	Manufactures
United States & Canada	17.26	10.60	14.84	11.25	12.09	11.55	74.11	25.89	63.38	36.62
United Kingdom & Ireland	6.24	25.27	13.14	18.95	8.16	15.17	30.27	69.73	81.20	18.80
North-West Europe	25.16	47.89	33.41	43.02	24.37	36.50	48.01	51.99	76.65	23.35
Other Europe	14.73	8.34	12.41	12.33	15.38	13.39	75.62	24.38	59.85	40.15
Oceania	3.74	0.13	2.43	0.94	5.02	2.37	98.06	1.94	25.85	74.15
Latin America	12.57	0.74	8.28	4.34	11.93	7.00	96.78	3.22	40.37	59.63
Africa	5.58	0.38	3.70	2.24	6.12	3.60	96.32	3.68	40.50	59.50
Asia	14.72	6.65	11.79	6.93	16.93	10.42	79.54	20.46	43.21	56.79
Total	100.00	100.00	100.00	100.00	100.00	100.00	63.74	36.26	65.03	34.9[illegible]

Source : Computed from P. L. Yates, Forty Years of Foreign Trade, London, 1959, Tables A 19 - A 22, pp. 226-230.

Table A.3. Percentage Shares in Regional Composition of World Trade, 1963 - 1983

Regions	1963	1973	1975	1977	1979	1980	1981	1982	1983
Industrial Countries	64.1	68.0	63.8	62.6	63.3	61.2	60.9	61.6	62.2
Exports	64.2	69.6	64.7	65.8	67.2	66.2	63.2	62.7	63.5
Imports									
Oil Exporting Countries									
Exports		7.3	12.9	13.2	13.0	15.0	14.1	11.9	10.1
Imports		3.6	6.6	7.4	6.4	6.6	8.0	8.3	7.3
Non-Oil Developing Countries									
Exports		11.9	11.3	12.6	12.3	12.9	13.6	14.0	14.7
Imports		14.5	15.8	15.3	15.8	16.7	17.8	17.6	17.5
Eastern Trading Countries									
Exports	12.2	10.0	9.8	9.6	9.3	8.9	9.4	10.5	11.1
Imports	11.7	9.9	10.5	9.4	9.0	9.0	8.7	9.2	9.7

Note : 1. Classification of countries and regions is according to General Agreement on Tariffs and Trade (GATT) system
2. In 1963, there is no division between oil exporting and non-oil developing countries.
3. The figures for 1983 are only estimates.

Source : S. J. Anjaria, N. Kirmani and A. B. Peterson, Trade Policy Issues and Developments, International Monetary Fund Washington, D. C., July 1985, Appendix II Table 1, p. 98.

Table A 4(a). Imports by Commodity Groups : Percentages in Value, 1955-1972 - The United Kingdom

Commodity Group	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	19
Primary Products	82.79	82.32	81.93	80.47	78.68	74.27	73.36	70.62	69.40	66.73	65.95	64.18	60.33	57.94	56.48	54.90	52.45	48.
Food	39.71	40.06	39.44	42.28	40.96	36.30	36.04	35.96	35.56	32.87	31.67	30.59	28.93	25.44	24.54	24.22	23.64	22.
Raw Materials	20.98	19.76	19.85	17.04	16.73	16.44	15.97	14.10	14.27	13.81	12.94	11.92	10.22	9.73	9.47	8.94	7.56	7.
Ores & Other Minerals	5.24	5.79	6.07	4.59	4.19	4.95	4.72	3.84	3.68	4.04	4.37	4.09	3.96	4.17	4.25	4.56	3.87	3.
Fuels	10.57	10.71	11.51	11.71	11.73	10.58	10.97	11.51	11.19	10.25	10.59	10.50	11.32	11.42	10.90	10.45	12.69	
Non-Ferrous Metals	6.29	6.00	5.06	4.85	5.07	6.00	5.66	5.21	4.70	5.76	6.38	7.08	5.90	7.18	7.32	6.73	4.69	
Manufactures	16.90	17.41	17.79	19.24	21.01	25.39	26.24	28.42	29.44	32.18	32.80	34.44	38.28	40.59	42.42	43.85	46.24	
Iron & Steel	2.55	2.72	1.95	1.22	1.01	2.22	1.11	1.16	1.50	1.86	1.36	1.48	1.86	1.96	2.09	2.46	2.10	
Chemicals	2.98	2.85	2.90	3.24	3.50	3.89	3.84	3.75	4.13	4.43	4.93	4.94	5.11	5.26	5.58	6.00	5.79	
Engineering Products	3.21	3.76	4.07	4.76	5.45	6.15	7.85	7.08	7.58	8.67	9.41	10.60	11.74	11.91	12.32	14.34	14.13	
Road Motor Vehicals	0.85	0.79	0.99	1.26	1.28	2.01	1.16	1.51	1.21	1.59	1.90	1.69	2.67	4.04	4.47	3.30	4.61	
Textiles & Clothing	2.23	2.36	2.66	2.81	3.14	3.90	4.39	4.08	4.20	4.39	3.63	3.82	4.12	4.32	4.37	4.27	5.12	
Other Manufactures	5.08	4.93	5.22	5.95	6.63	7.22	7.89	10.24	10.82	11.24	11.57	11.91	12.78	13.10	13.50	13.48	14.49	
Unspecified Miscellaneous	0.31	0.27	0.28	0.29	0.31	0.34	0.40	0.96	1.16	1.09	1.25	1.38	1.39	1.47	1.10	1.25	1.31	

Source : Computed from Annual Abstract of Statistics, various Central Statistical Office (CSO), London.

Table A.5(a). Exports by Commodity Groups : Percentages in Value, 1955-1972 - The United Kingdom

Commodity Group	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
Primary Products	17.96	19.21	18.37	17.07	17.19	16.25	16.17	18.51	18.36	17.55	17.22	17.32	17.28	17.45	16.56	16.64	15.23	16.06
Food	6.37	6.11	6.49	6.32	6.11	5.86	5.97	6.26	6.61	6.94	6.78	6.87	6.92	6.00	6.30	6.48	6.51	6.88
Raw Materials	3.16	3.01	3.15	2.76	2.91	2.91	3.00	4.10	4.01	3.57	3.12	2.99	2.63	2.63	2.47	2.34	2.08	2.37
Ores & Other Minerals	0.41	0.43	0.41	0.52	0.80	0.49	0.54	0.89	0.80	0.76	0.78	0.82	0.92	0.87	0.88	0.82	0.85	0.80
Fuels	4.85	5.08	4.57	4.12	3.57	3.73	3.35	3.64	3.82	3.06	2.73	2.56	2.53	2.61	2.35	2.50	2.57	2.44
Non-Ferrous Metals	3.17	4.58	3.75	3.35	3.80	3.26	3.31	3.62	3.12	3.22	3.81	4.08	4.28	4.54	4.64	4.34	3.24	3.57
Manufactures	77.20	76.70	78.07	79.79	79.75	80.20	80.47	78.51	78.62	79.44	79.74	79.46	79.58	79.59	80.45	79.94	81.94	81.04
Iron & Steel	5.38	5.47	6.42	5.88	5.74	6.05	5.74	4.93	4.69	4.77	4.79	4.10	4.39	4.15	3.91	4.31	4.30	3.00
Chemicals	8.15	7.81	8.14	8.30	8.87	8.98	8.89	8.57	8.53	9.16	9.21	9.12	9.56	9.44	9.43	9.71	9.62	9.06
Engineering Products	26.21	26.41	27.47	28.45	28.92	29.74	32.19	30.75	30.65	29.63	29.70	30.17	30.27	29.81	29.39	30.74	31.54	30.01
Road Motor Vehicals	15.21	16.61	16.29	18.34	17.95	17.03	15.57	14.20	14.53	14.39	14.88	15.23	14.13	14.36	14.80	13.37	13.92	13.06
Textiles & Clothing	11.77	10.32	10.06	8.87	8.32	8.10	7.57	7.03	6.87	7.18	6.79	6.17	6.17	6.12	6.30	6.43	6.04	6.04
Other Manufactures	10.48	10.07	9.69	9.95	9.95	10.22	10.51	13.03	13.35	14.31	14.37	14.67	15.06	15.71	16.54	15.38	16.44	17.10
Unspecified Miscellaneous	4.04	4.09	3.56	3.14	3.06	3.55	3.36	2.98	3.02	3.01	3.04	3.22	3.14	2.96	2.99	3.42	2.83	2.90

Source : Computed from Annual Abstract of Statistics, various Central Statistical Office (CSO), London.

Table A.5(b). Exports by Commodity Groups : Percentages in Value, 1973-1983 - The United Kingdom

Commodity Group	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Primary Products	18.05	18.85	16.88	17.54	18.84	20.12	23.83	27.25	31.03	32.01	34.10
Food	7.41	6.74	7.43	6.86	7.12	8.41	7.40	7.03	7.29	7.22	7.15
Raw Materials	2.31	2.22	1.72	1.96	1.77	1.62	1.69	1.41	1.31	1.29	1.35
Ores & Other Minerals	0.81	0.95	0.84	0.91	0.86	1.02	1.29	1.50	1.13	1.03	1.10
Fuels	3.10	4.79	4.21	5.00	6.54	6.71	10.64	13.57	18.86	20.23	21.59
Non-Ferrous Metals	4.42	4.15	2.68	2.81	2.55	2.36	2.81	3.74	2.44	2.24	2.91
Manufactures	78.86	77.44	79.25	79.08	78.17	76.86	73.16	69.77	65.99	64.92	63.15
Iron & Steel	3.58	3.39	3.48	3.26	3.18	3.12	3.14	2.08	2.43	2.33	2.19
Chemicals	10.39	12.96	10.94	11.90	11.93	11.87	12.08	11.16	10.88	11.01	11.43
Semi-Manufactures	7.58	6.85	6.50	7.11	7.33	7.04	6.92	7.03	5.41	5.07	5.45
Machinery for Specialized Industries	13.09	12.70	14.83	13.60	12.51	12.42	11.46	11.35	10.54	9.96	8.38
Office and Telecommunications Equipment	4.97	4.67	4.81	4.93	4.60	4.69	4.67	4.34	4.14	4.49	5.01
Road Motor Vehicles	9.67	8.57	9.46	9.40	8.98	8.68	7.75	6.67	6.22	5.60	5.10
Other Machinery & Transport Equipment	15.28	14.76	16.49	15.61	16.11	15.42	14.09	14.74	14.51	15.04	13.89
Household Appliances	1.11	1.09	1.12	1.08	1.05	1.16	1.08	1.10	0.99	0.99	0.94
Textiles	5.21	4.74	3.72	3.85	3.73	3.50	3.30	2.88	2.36	2.15	2.12
Clothing	1.48	1.40	1.36	1.63	1.87	1.89	1.85	1.71	1.66	1.51	1.43
Other Cosumer Goods	6.50	6.31	6.54	6.71	6.88	7.07	6.82	6.71	6.85	6.77	7.21
Unspecified Miscellaneous	3.09	3.71	3.87	3.38	2.99	3.02	3.01	2.98	2.98	3.07	2.75

Source : Computed from Annual Abstract of Statistics, various issues, Central Statistical Office (CSO), London

Table A.6(a). Imports by Commodity Groups : Percentages in Value, 1955-1972 - The United States

Commodity Group	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
Primary Products	71.34	68.55	67.28	65.22	59.05	59.05	59.77	57.65	56.00	53.47	49.85	46.24	43.26	40.13	36.71	36.11	33.41	32.66
Food	29.31	27.34	27.19	29.03	24.77	23.75	24.53	23.55	23.42	22.28	19.61	18.74	18.20	16.91	15.27	15.99	14.43	13.60
Raw Materials	16.74	14.42	12.36	11.14	12.18	11.17	10.68	10.26	10.08	9.35	8.54	7.47	6.20	5.91	5.79	4.70	4.52	4.57
Ores & Other Minerals	7.82	7.97	8.15	6.71	6.54	6.96	6.34	7.31	6.14	5.67	5.37	5.10	4.64	3.82	3.64	3.57	2.88	2.37
Fuels	9.18	10.23	12.06	12.99	10.43	10.46	11.36	11.25	11.07	10.73	10.40	8.86	8.39	7.84	7.75	7.70	8.16	9.64
Non-Ferrous Metals	8.29	8.59	7.52	5.35	5.13	6.71	6.86	5.28	5.29	5.44	5.93	6.07	5.83	5.65	4.26	4.14	3.41	3.40
Manufactures	26.32	28.93	29.80	32.10	38.29	38.33	37.30	39.67	40.75	43.35	46.73	50.37	52.79	56.22	59.59	60.70	63.35	64.40
Iron & Steel	1.18	1.86	1.98	1.59	3.76	3.77	2.81	3.16	3.87	3.97	5.78	5.11	5.12	6.18	5.02	5.08	5.98	6.27
Chemicals	3.06	2.99	3.03	2.91	2.99	3.01	3.11	3.15	3.33	3.80	3.66	3.74	3.59	3.41	3.41	3.63	3.84	3.83
Engineering Products	3.62	4.18	4.59	5.23	6.33	6.51	7.05	7.55	7.70	8.52	9.85	12.15	13.02	12.90	14.38	15.30	14.94	16.07
Road Motor Vehicals	1.39	2.18	3.34	5.21	6.33	4.93	3.91	4.40	4.46	4.97	5.62	8.35	10.30	12.99	14.63	14.72	17.35	17.30
Textiles & Clothing	4.19	4.48	4.23	4.40	4.96	5.61	5.40	6.26	6.29	6.09	6.27	5.92	5.44	5.48	5.86	6.02	6.39	6.14
Other Manufactures	12.88	13.24	12.63	12.76	13.92	14.50	15.02	15.15	15.10	16.01	15.55	15.10	15.32	15.26	16.29	15.94	15.15	16.05
Unspecified Miscellaneous	2.34	2.52	2.92	2.68	2.66	2.62	2.93	2.68	3.25	3.18	3.42	3.39	3.95	3.65	3.70	3.19	3.24	2.00

Source : Computed from Yearbook of International Trade Statististics, various issues, United Nations.

Table A.6(b). Imports by Commodity Groups : Percentages in Value, 1973-1983 - The United States

Commodity Group	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Primary Products	36.18	46.02	46.30	46.47	47.67	42.19	46.30	48.20	45.41	40.04	36.60
Food	13.76	11.19	10.84	10.18	9.93	9.53	9.05	8.02	7.71	7.86	7.84
Raw Materials	4.73	3.55	3.08	3.33	3.33	3.41	3.28	2.55	2.40	2.18	2.53
Ores & Other Minerals	2.39	2.26	2.48	2.23	1.85	1.70	1.62	1.53	1.59	1.19	1.00
Fuels	11.76	25.13	27.24	27.86	29.89	24.59	29.26	32.88	31.07	26.64	22.39
Non-Ferrous Metals	3.54	3.89	2.66	2.87	2.67	2.96	3.09	3.22	2.64	2.16	2.84
Manufactures	61.24	51.77	51.09	51.44	50.48	56.02	52.05	49.86	52.73	57.72	61.22
Iron & Steel	4.35	5.36	4.85	3.70	4.05	4.24	3.64	3.09	4.48	4.09	2.77
Chemicals	3.76	4.13	4.04	4.20	3.90	4.24	4.12	4.17	4.17	4.52	4.81
Semi-Manufactures	6.35	4.60	4.33	4.71	4.67	5.14	4.80	4.30	4.28	4.27	4.69
Machinery for Specialized Industries	4.32	3.80	4.38	3.72	3.73	4.40	4.49	4.32	4.59	4.63	4.31
Office and Telecommunications Equipment	3.42	3.03	3.09	3.67	3.31	3.49	3.61	3.77	4.02	4.88	6.28
Road Motor Vehicles	14.46	11.71	11.78	11.99	11.85	12.83	11.50	10.77	10.70	12.52	13.82
Other Machinery & Transport Equipment	8.12	6.59	6.41	5.98	6.05	6.73	6.70	6.79	7.05	7.60	8.07
Household Appliances	4.65	3.23	3.01	3.74	3.67	4.25	3.39	3.15	3.66	3.94	4.32
Textiles	2.27	1.61	1.27	1.35	1.21	1.23	1.03	1.00	1.13	1.13	1.22
Clothing	3.12	2.30	2.63	2.96	2.79	3.20	2.80	2.73	2.99	3.47	3.89
Other Cosumer Goods	6.42	5.41	5.30	5.42	5.25	6.27	5.97	5.77	5.66	6.67	7.04
Unspecified Miscellaneous	2.58	2.21	2.61	2.09	1.85	1.79	1.65	1.94	1.86	2.24	2.18

Source : Computed from International Trade, various Issues, GATT.

Table A.7(a). Exports by Commodity Groups : Percentages in Value, 1955-1972 - The United States

Commodity Group	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
Primary Products	34.20	36.45	37.24	34.20	35.01	37.32	37.36	34.66	36.03	36.32	34.59	34.10	32.05	29.67	27.53	30.06	28.11	29.37
Food	16.53	17.21	15.79	18.03	20.11	18.67	19.73	20.58	21.49	21.70	21.08	21.27	18.87	16.89	15.02	16.02	16.27	17.77
Raw Materials	6.24	6.72	8.08	7.12	6.84	8.99	8.27	6.35	6.34	6.44	5.47	5.17	5.19	5.19	4.46	4.88	4.88	5.10
Ores & Other Minerals	2.64	2.97	3.00	1.20	1.79	3.02	3.46	2.09	2.24	2.62	2.48	2.38	2.69	2.54	2.73	2.99	1.89	1.78
Fuels	7.36	7.97	8.86	6.14	4.97	4.09	3.82	3.75	4.13	3.65	3.51	3.27	3.54	3.09	3.02	3.92	3.61	3.36
Non-Ferrous Metals	1.43	1.58	1.51	1.63	1.30	2.55	2.08	1.89	1.83	1.91	2.05	2.02	1.76	1.96	2.30	2.25	1.46	1.36
Manufactures	63.56	61.51	60.77	64.60	63.77	60.46	60.33	62.91	61.29	60.64	61.98	62.04	64.92	67.66	69.25	66.54	68.44	67.51
Iron & Steel	4.38	4.39	5.39	3.46	2.35	3.26	2.46	2.21	2.28	2.56	2.33	1.87	1.80	1.80	2.60	2.95	1.81	0.55
Chemicals	7.28	6.76	6.88	7.82	8.37	8.61	8.59	8.73	8.47	9.06	8.89	8.95	9.00	9.68	9.03	8.88	8.74	8.38
Engineering Products	23.35	22.40	23.44	25.36	25.22	23.00	24.88	26.23	25.62	26.29	26.88	26.96	27.85	27.21	28.21	28.29	28.15	28.50
Road Motor Vehicals	15.28	15.64	12.90	13.86	12.50	13.28	12.02	13.20	11.96	11.47	12.26	12.43	14.53	17.23	17.45	15.14	18.01	16.77
Textiles & Clothing	3.51	2.89	2.74	2.97	3.12	2.91	2.83	2.71	2.55	2.75	2.60	2.52	2.28	2.11	2.14	1.95	1.96	2.10
Other Manufactures	9.76	9.43	9.42	11.13	11.85	9.39	9.55	9.83	10.41	8.49	9.01	9.31	9.46	9.63	9.82	9.33	9.78	11.17
Unspecified Miscellaneous	2.24	2.04	1.99	1.20	1.22	2.22	2.31	2.43	2.68	3.04	3.43	3.86	3.03	2.67	3.22	3.40	3.45	3.12

Source : Computed from Yearbook of International Trade Statististics, various issues, United Nations.

Table A.7(b). Exports by Commodity Groups : Percentages in Value, 1973-1983 - The United States

Commodity Group	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Primary Products	36.01	34.20	32.31	31.18	30.89	31.53	32.16	32.73	30.36	30.26	30.00
Food	24.15	21.56	20.25	19.66	19.25	20.63	19.20	18.53	18.48	17.11	17.82
Raw Materials	5.75	5.19	4.27	4.74	5.20	5.02	5.64	5.21	4.29	4.25	4.39
Ores & Other Minerals	2.14	2.25	2.18	1.88	1.79	1.93	2.58	2.71	1.72	1.56	1.72
Fuels	2.43	3.62	4.34	3.82	3.65	2.86	3.29	3.79	4.54	6.18	4.91
Non-Ferrous Metals	1.54	1.58	1.27	1.08	1.00	1.09	1.45	2.48	1.33	1.16	1.16
Manufactures	61.02	63.96	65.98	67.53	67.77	67.06	66.52	65.97	67.29	66.95	67.14
Iron & Steel	1.89	2.69	2.39	1.73	1.45	1.27	1.37	1.49	1.28	1.05	0.76
Chemicals	9.03	9.90	9.06	9.67	10.18	10.88	11.69	11.62	10.21	10.52	11.01
Semi-Manufactures	3.47	3.69	3.40	3.53	3.48	3.30	3.26	3.31	3.28	3.05	3.15
Machinery for Specialized Industries	11.33	11.65	14.25	13.90	13.02	12.34	11.63	11.79	12.50	11.88	9.30
Office and Telecommunications Equipment	5.75	5.58	5.11	5.72	6.34	5.99	5.93	6.20	7.22	8.11	9.65
Road Motor Vehicles	8.11	8.25	9.57	9.73	10.11	9.56	8.63	6.75	7.02	6.57	7.29
Other Machinery & Transport Equipment	15.52	15.61	16.25	16.61	16.32	16.75	17.03	17.46	19.13	19.23	19.67
Household Appliances	1.54	1.56	1.41	1.64	1.69	1.69	1.49	1.46	1.40	1.53	1.44
Textiles	1.78	1.90	1.57	1.78	1.71	1.64	1.86	1.73	1.60	1.35	1.21
Clothing	0.41	0.42	0.39	0.46	0.53	0.50	0.54	0.57	0.56	0.48	0.45
Other Consumer Goods	2.19	2.71	2.58	2.76	2.94	3.14	3.07	3.59	3.09	3.18	3.21
Unspecified Miscellaneous	2.97	1.84	1.71	1.29	1.34	1.41	1.32	1.31	2.35	2.79	2.86

Source : Computed from International Trade, various issues, GATT.

Table A.8(a). Imports by Commodity Groups : Percentages in Value, 1955-1972 - Japan

Commodity Group	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
Primary Products	88.96	85.89	79.47	79.35	80.01	80.28	78.21	75.85	77.40	77.43	80.36	80.89	78.30	77.44	76.77	74.74	75.08	74.27
Food	32.74	22.49	17.57	22.94	19.40	17.19	15.58	17.34	20.77	21.64	22.73	22.55	19.55	18.01	17.51	16.95	18.21	18.54
Raw Materials	32.00	31.74	25.86	28.64	28.71	28.03	26.52	23.72	23.73	20.74	20.40	21.32	19.30	19.63	18.24	16.21	14.60	15.55
Ores & Other Minerals	11.68	17.11	17.81	9.80	14.99	16.20	17.47	14.54	13.04	14.11	14.30	14.41	15.27	14.32	14.71	15.89	14.45	11.89
Fuels	11.70	12.78	15.89	16.98	15.51	16.54	16.07	18.47	17.97	17.73	19.90	18.94	19.21	20.63	20.18	20.71	24.14	24.37
Non-Ferrous Metals	0.84	1.77	2.34	0.99	1.40	2.32	2.57	1.78	1.89	3.21	3.03	3.67	4.97	4.85	6.13	4.98	3.60	3.92
Manufactures	11.03	14.10	20.52	20.62	19.97	19.65	21.73	24.13	22.57	22.43	19.43	18.83	21.44	22.25	22.90	24.79	24.24	25.01
Iron & Steel	0.41	1.89	7.12	0.79	1.30	1.95	2.70	1.99	1.33	2.22	1.72	1.40	3.00	1.77	1.47	1.40	0.50	0.43
Chemicals	3.25	5.06	4.29	5.49	6.15	5.91	5.79	5.33	5.48	5.77	5.08	5.22	5.23	5.39	5.19	5.30	6.07	4.00
Engineering Products	4.77	4.32	5.64	10.01	8.27	7.04	8.58	11.19	10.10	8.35	6.83	6.11	8.32	9.24	9.92	11.23	11.31	10.01
Road Motor Vehicals	0.92	0.95	1.10	1.26	1.52	1.94	1.75	2.08	1.90	2.04	1.88	1.90	0.43	0.46	0.40	0.42	0.40	0.47
Textiles & Clothing	0.36	0.40	0.53	0.45	0.41	0.41	0.31	0.40	0.58	0.67	0.60	0.62	0.94	1.23	1.33	1.64	1.09	2.00
Other Manufactures	1.32	1.48	1.84	2.62	2.32	2.40	2.59	2.74	3.18	3.38	3.40	3.58	3.52	4.16	4.59	4.72	4.07	6.00
Unspecified Miscellaneous	0.01	0.01	0.01	0.03	0.02	0.07	0.06	0.02	0.03	0.14	0.21	0.28	0.26	0.31	0.33	0.47	0.76	0.72

Source : Computed from International Trade, various Issues, GATT.

Table A.8(b). Imports by Commodity Groups : Percentages in Value, 1973-1983 - Japan

Commodity Group	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Primary Products	73.79	79.63	81.92	81.05	81.24	76.81	77.49	80.70	80.02	79.03	76.92
Food	18.92	15.59	17.89	16.74	16.82	16.83	15.09	12.05	12.96	12.72	13.70
Raw Materials	17.10	10.95	8.87	10.22	10.15	10.19	11.15	8.64	6.70	7.05	6.79
Ores & Other Minerals	11.64	9.68	8.62	8.00	7.67	7.00	7.01	6.78	5.86	5.92	6.00
Fuels	21.77	40.14	44.33	43.80	44.15	39.81	41.13	50.03	51.52	50.35	47.13
Non-Ferrous Metals	4.36	3.27	2.21	2.29	2.45	2.98	3.11	3.20	2.98	2.99	3.30
Manufactures	25.77	20.10	17.70	18.47	18.32	22.39	21.53	18.64	19.24	20.23	22.24
Iron & Steel	0.60	0.64	0.33	0.40	0.36	0.51	0.82	0.64	0.76	0.94	1.08
Chemicals	5.09	4.46	3.75	4.33	4.45	5.00	4.90	4.62	4.82	5.46	6.02
Semi-Manufactures	3.40	2.32	2.04	2.13	2.14	2.60	2.36	2.19	1.97	1.99	2.89
Machinery for Specialized Industries	2.82	2.35	2.14	1.81	1.73	1.91	1.83	1.59	1.48	1.67	1.58
Office and Telecommunications Equipment	2.01	1.63	1.52	1.57	1.57	1.61	1.50	1.44	1.52	1.56	1.80
Road Motor Vehicles	0.50	0.40	0.52	0.45	0.51	0.66	0.66	0.44	0.34	0.39	0.48
Other Machinery & Transport Equipment	3.47	3.00	2.92	3.04	2.82	3.73	3.29	3.34	3.78	3.23	4.28
Household Appliances	0.70	0.63	0.62	0.60	0.61	0.70	0.65	0.52	0.46	0.50	0.59
Textiles	2.95	1.61	1.33	1.41	1.23	1.91	1.84	1.18	1.16	1.23	1.19
Clothing	1.49	1.34	0.94	1.23	1.23	2.18	1.63	1.09	1.28	1.40	1.20
Other Cosumer Goods	2.74	1.72	1.59	1.50	1.67	2.18	2.05	1.59	1.67	1.86	1.93
Unspecified Miscellaneous	0.44	0.27	0.30	0.48	0.44	0.80	0.98	0.66	0.74	0.74	0.84

Source : Computed from International Trade, various issues, GATT.

Table A.9(a). Exports by Commodity Groups : Percentages in Value, 1955-1972 - Japan

Commodity Group	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
Primary Products	16.21	14.49	12.55	13.71	12.76	11.45	11.33	11.74	10.01	9.28	8.86	8.05	7.18	6.71	6.88	6.73	5.83	5.25
Food	7.68	8.21	7.50	9.30	8.46	7.37	7.11	7.40	5.87	5.28	4.41	4.16	3.83	3.47	3.69	3.52	3.00	2.41
Raw Materials	4.81	3.78	3.21	2.64	3.15	3.05	3.09	3.24	3.04	2.79	2.64	2.35	2.01	1.77	1.69	1.61	1.58	1.57
Ores & Other Minerals	0.08	0.03	0.03	-	-	-	-	-	-	-	-	-	-	0.08	0.06	0.05	0.13	0.11
Fuels	0.35	0.45	0.17	0.43	0.37	0.40	0.47	0.40	0.31	0.35	0.35	0.38	0.29	0.23	0.31	0.26	0.25	0.25
Non-Ferrous Metals	3.28	2.01	1.64	1.33	0.78	0.63	0.66	0.70	0.79	0.86	1.46	1.22	1.05	1.16	1.13	1.29	0.87	0.91
Manufactures	83.75	85.49	87.43	86.27	87.22	88.53	88.65	88.26	89.97	90.07	90.57	91.31	92.34	92.75	92.50	92.44	93.38	93.84
Iron & Steel	12.95	8.96	7.35	8.55	7.34	9.61	9.02	10.81	12.87	13.63	15.27	13.23	12.16	13.26	13.57	14.75	14.78	12.03
Chemicals	4.68	4.28	4.42	4.81	4.84	4.19	4.48	5.33	5.80	5.75	6.47	6.85	6.42	6.24	6.38	6.37	6.21	6.22
Engineering Products	16.17	9.37	9.77	11.51	14.46	16.46	19.40	19.36	19.63	20.30	20.16	22.85	34.29	33.85	33.96	34.52	34.11	38.07
Road Motor Vehicals	5.94	12.69	14.87	13.46	12.55	10.18	10.79	9.72	11.48	12.57	14.71	14.72	6.23	7.63	8.32	9.68	13.41	14.30
Textiles & Clothing	34.52	29.86	33.60	29.80	27.99	28.30	25.36	23.22	20.66	19.32	16.88	16.47	14.85	14.11	13.01	11.39	10.54	9.10
Other Manufactures	9.49	20.33	17.42	18.14	20.04	19.79	19.60	19.82	19.53	18.50	17.08	17.19	18.39	17.66	17.26	15.73	14.33	14.60
Unspecified Miscellaneous	0.04	0.02	0.02	0.02	0.02	0.02	0.02	-	0.02	0.65	0.57	0.64	0.48	0.54	0.62	0.83	0.70	0.91

Source : Computed from International Trade, various issues, GATT.

Table A.9(b). Exports by Commodity Groups : Percentages in Value, 1973-1983 - Japan

Commodity Group	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Primary Products	5.31	6.16	4.30	3.87	3.68	3.64	3.89	4.25	3.48	3.15	3.24
Food	2.38	1.68	1.45	1.40	1.17	1.20	1.28	1.31	1.21	1.07	1.03
Raw Materials	1.71	1.84	1.36	1.22	1.14	0.98	1.00	0.94	0.83	0.76	0.74
Ores & Other Minerals	0.14	0.14	0.13	0.10	0.09	0.12	0.15	0.13	0.11	0.10	0.10
Fuels	0.24	0.45	0.39	0.18	0.20	0.27	0.35	0.39	0.36	0.30	0.29
Non-Ferrous Metals	0.84	2.05	0.97	0.97	1.08	1.07	1.11	1.48	0.97	0.92	1.08
Manufactures	93.61	92.35	94.39	95.12	95.46	95.52	95.10	94.70	95.68	95.92	95.78
Iron & Steel	14.38	19.43	18.22	15.60	13.07	12.16	13.70	11.93	10.98	11.29	8.75
Chemicals	6.08	7.56	7.30	5.87	5.78	5.65	6.42	5.87	5.14	5.32	5.57
Semi-Manufactures	3.14	3.08	3.30	3.08	2.99	2.88	3.21	3.17	3.11	3.08	3.17
Machinery for Specialized Industries	8.04	8.09	9.09	8.44	9.07	10.48	10.69	10.31	11.08	10.39	10.21
Office and Telecommunications Equipment	5.25	3.85	4.36	5.83	5.09	5.68	6.10	6.18	6.47	6.78	8.96
Road Motor Vehicles	13.27	13.18	14.55	16.13	17.76	19.52	20.10	21.68	21.34	21.44	21.55
Other Machinery & Transport Equipment	21.42	20.18	21.04	21.19	22.67	20.84	16.72	16.42	17.49	17.57	16.91
Household Appliances	10.42	8.07	8.04	10.40	10.58	10.81	10.80	11.36	12.40	12.23	12.87
Textiles	6.63	5.53	6.24	4.91	4.61	3.93	3.89	3.94	3.85	3.67	3.62
Clothing	1.00	0.59	0.59	0.62	0.57	0.60	0.34	0.38	0.38	0.40	0.45
Other Consumer Goods	3.98	2.79	2.66	2.95	3.27	3.07	3.13	3.46	3.44	3.75	3.72
Unspecified Miscellaneous	1.08	1.49	1.31	1.01	0.86	0.84	1.01	1.05	0.84	0.93	0.98

Source : Computed from International Trade, various issues, GATT.

APPENDIX B

GRAPHS

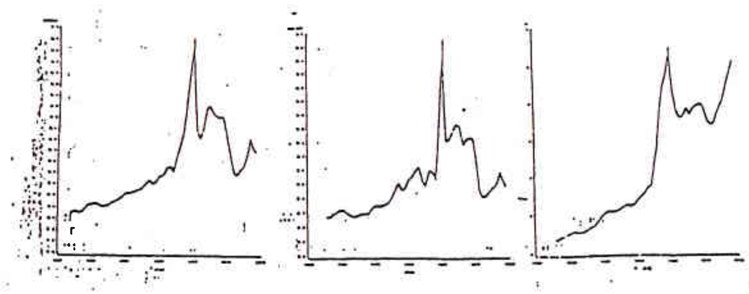


Figure 1. Imports, Exports, and GNP of the United Kingdom, 1855-1938. (At Current Prices)

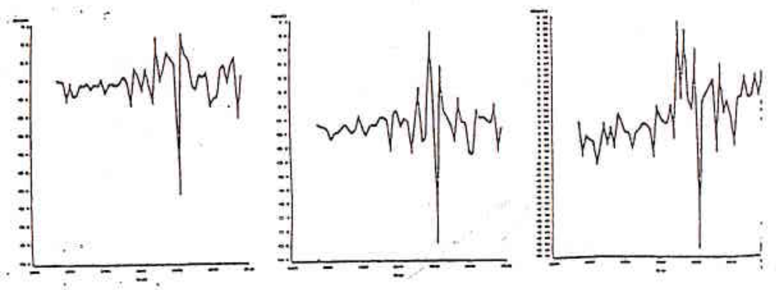


Figure 2. Pre-whitened Value of Figure 1.

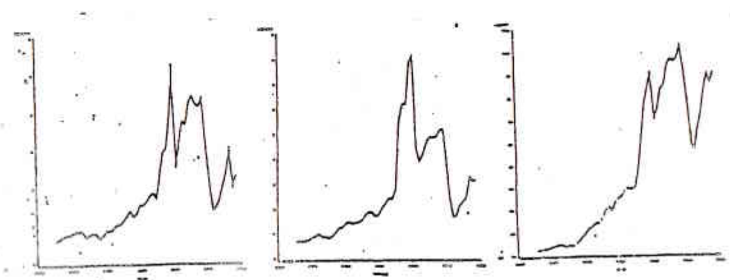


Figure 3. Imports, Exports, and GNP of the United States, 1855-1938. (At Current Prices)

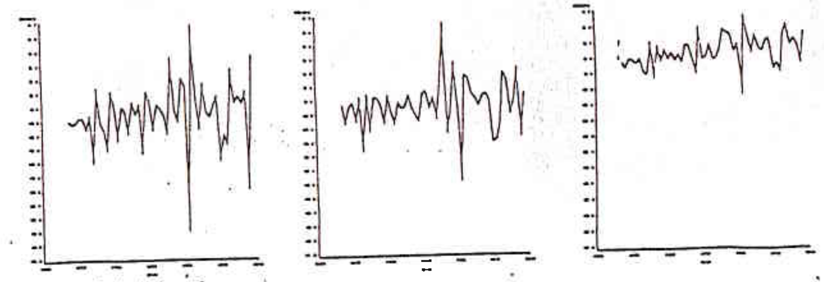


Figure 4. Pre-whitened Value of Figure 3.

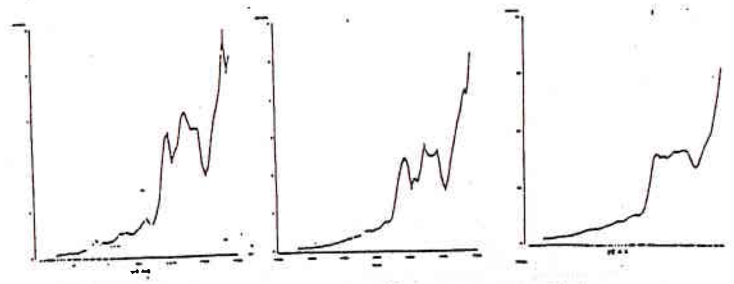


Figure 5. Imports, Exports, and GNP of Japan, 1885-1938. (At Current Prices)

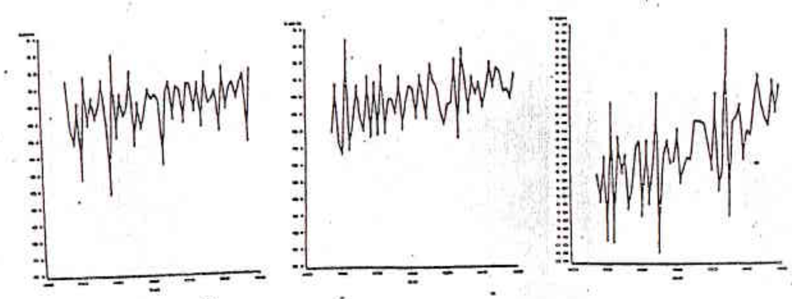


Figure 6. Pre-whitened Value of Figure 5.

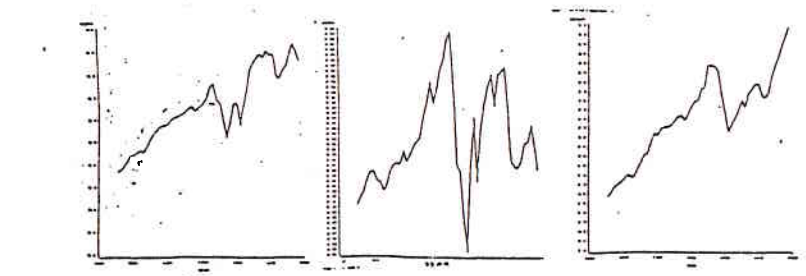


Figure 7. Imports, Exports, and GNP of the United Kingdom, 1855-1938. (At 1913 Prices)

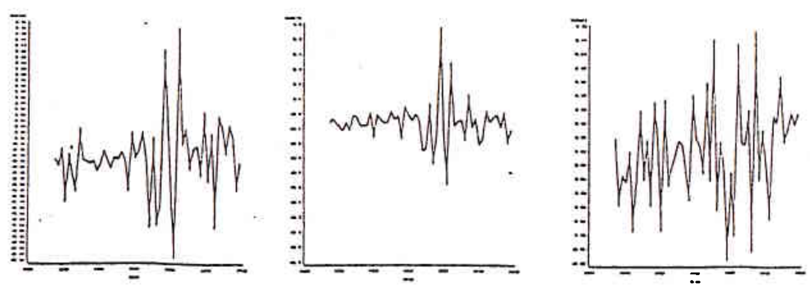


Figure 8. Pre-whitened Value of Figure 7.

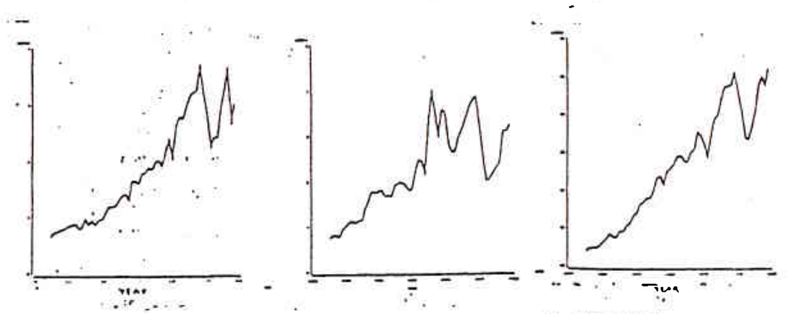


Figure 9. Imports, Exports, and GNP of the United States, 1855-1938. (At 1913 Prices)

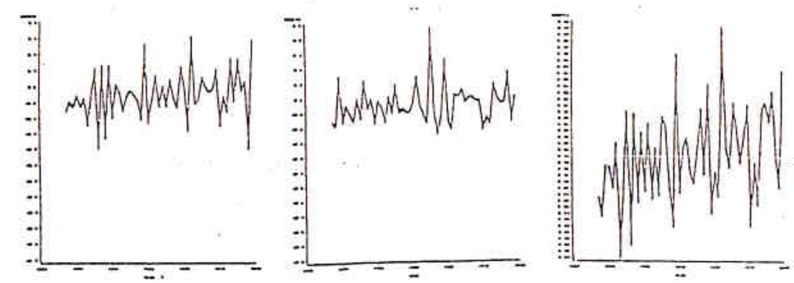


Figure 10. Pre-whitened Value of Figure 9.

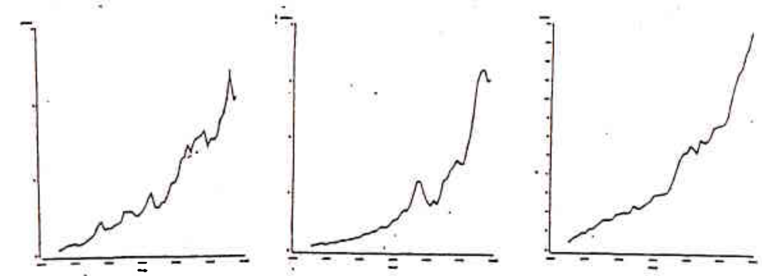


Figure 11. Imports, Exports, and GNP of Japan, 1865-1938. (At 1913 Prices)

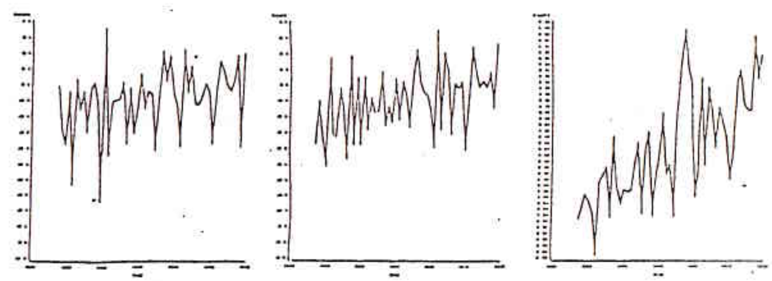


Figure 12. Pre-whitened Value of Figure 11.

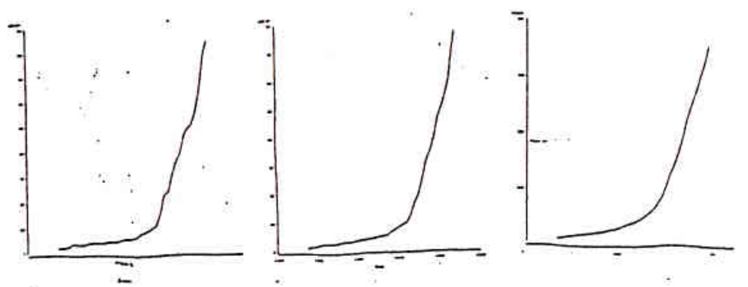


Figure 13. Imports, Exports, and GNP of the United Kingdom, 1947-1985. (At Current Prices)

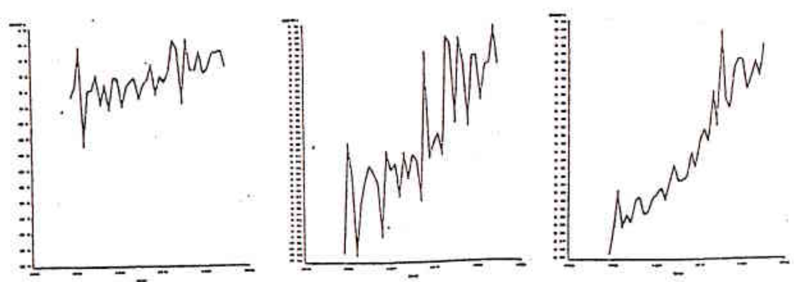


Figure 14. Pre-whitened Value of Figure 13.

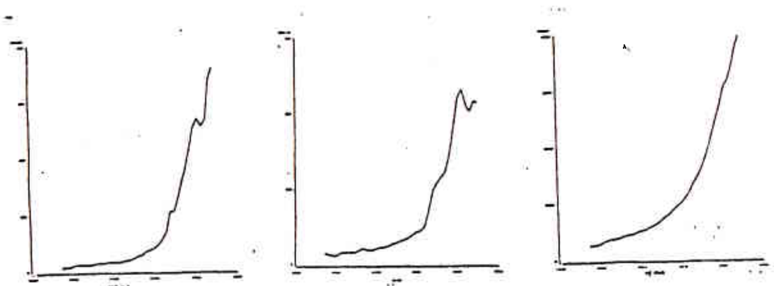


Figure 15. Imports, Exports, and GNP of the United States, 1947-1985. (At Current Prices)

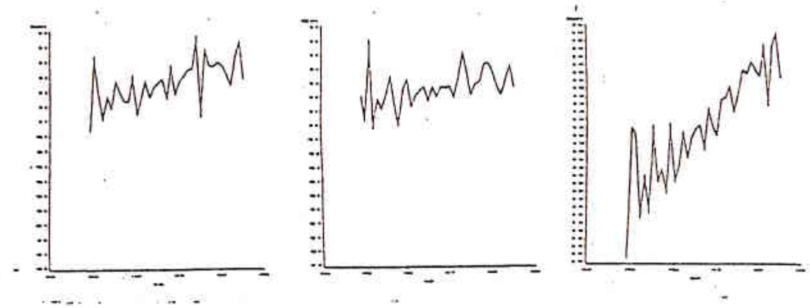


Figure 16. Pre-whitened Value of Figure 15.

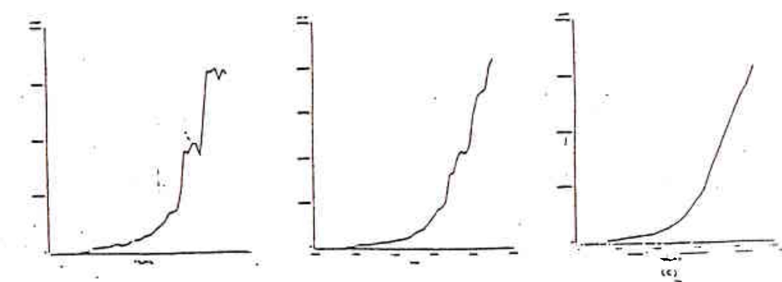


Figure 17. Imports, Exports, and GNP of Japan, 1947-1985. (At Current Prices)

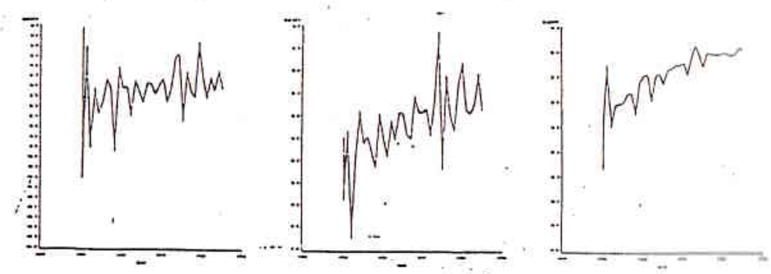


Figure 18. Pre-whitened Value of Figure 17.

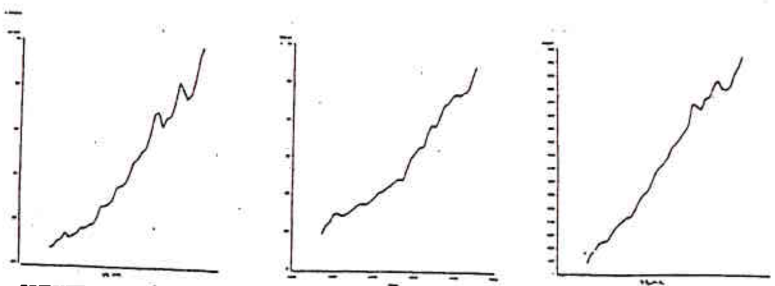


Figure 19. Imports, Exports, and GNP of the United Kingdom, 1947-1985. (At 1980 Prices)

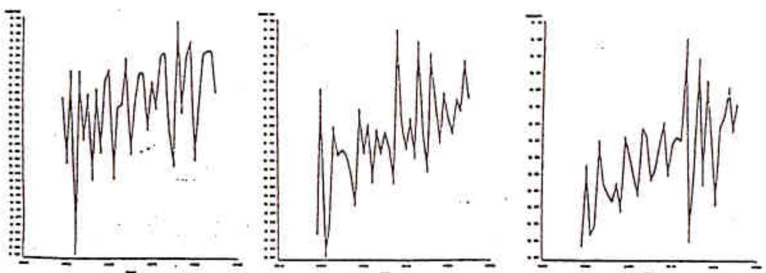


Figure 20. Pre-whitened Value of Figure 19.

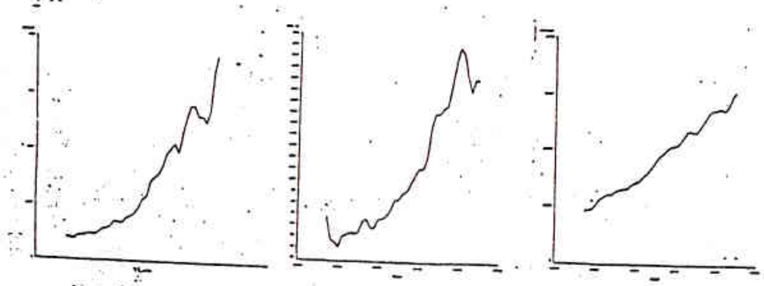


Figure 21. Imports, Exports, and GNP of the United States, 1947-1985. (At 1980 Prices)

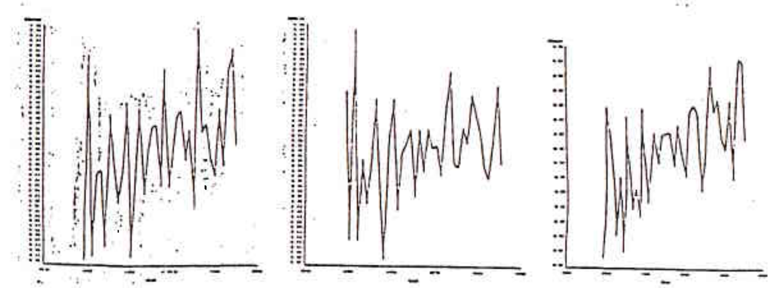


Figure 22. Pre-whitened Value of Figure 21.

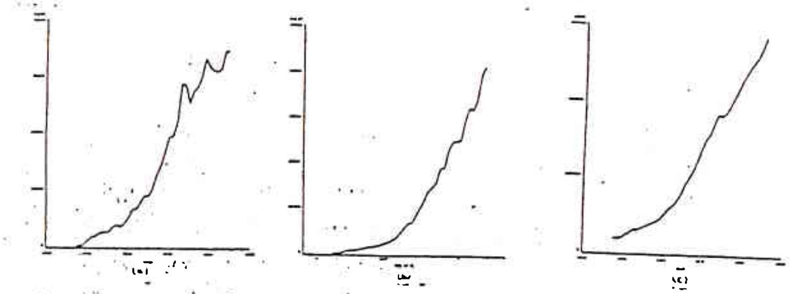


Figure 23. Imports, Exports, and GNP of Japan, 1947-1985. (At 1980 Prices)

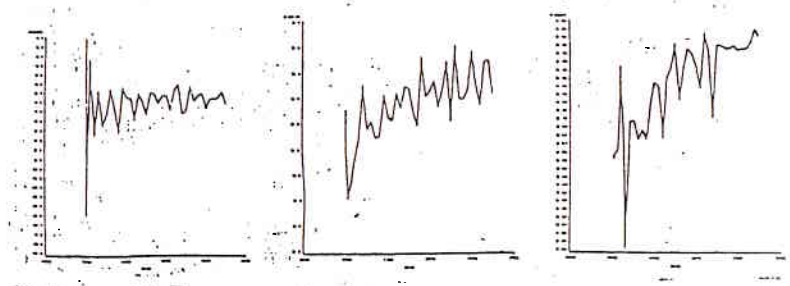


Figure 24. Pre-whitened Value of Figure 23.

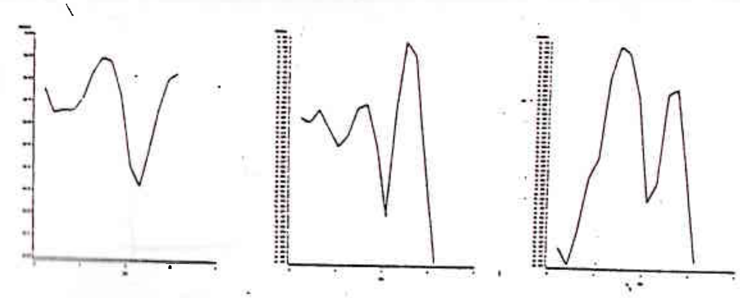


Figure 25. Coherencies for the United Kingdom, 1885-1930, (at Current Prices)

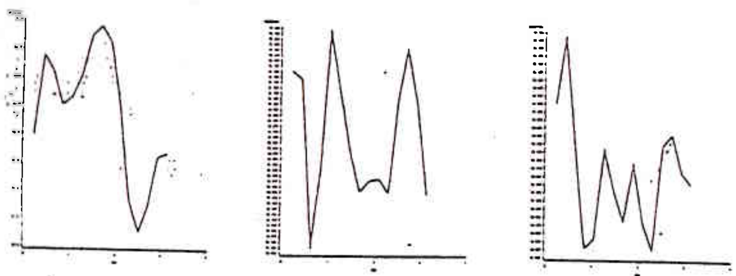


Figure 26. Coherencies for the United Kingdom, 1885-1930, (at 1913 Prices)

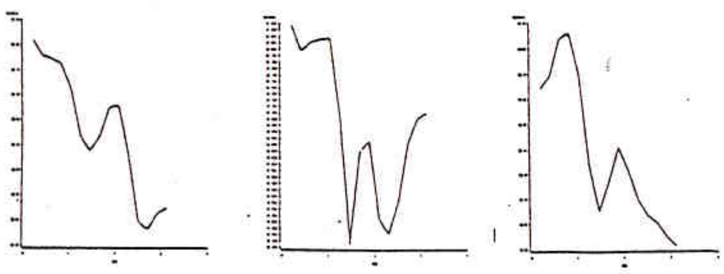


Figure 27. Coherencies for the United States, 1885-1930, (at Current Prices)

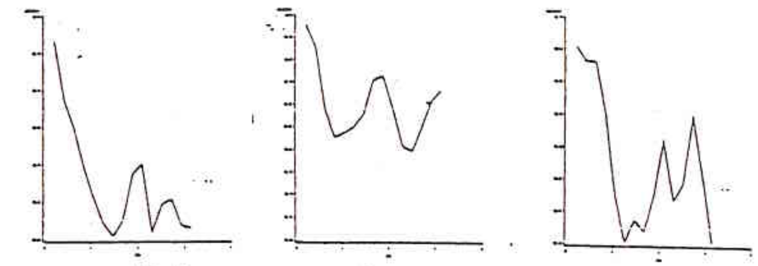


Figure 28. Coherencies for the United States, 1885-1930, (at 1913 Prices)

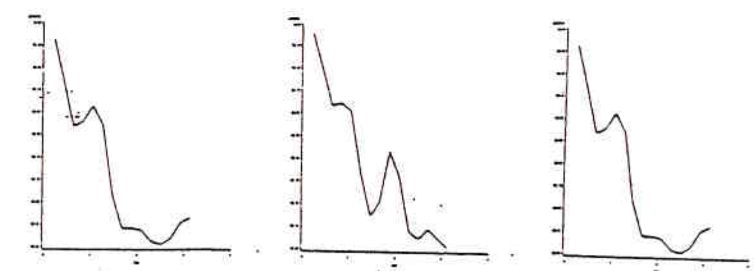


Figure 29. Coherencies for Japan, 1885-1930, (at Current Prices)

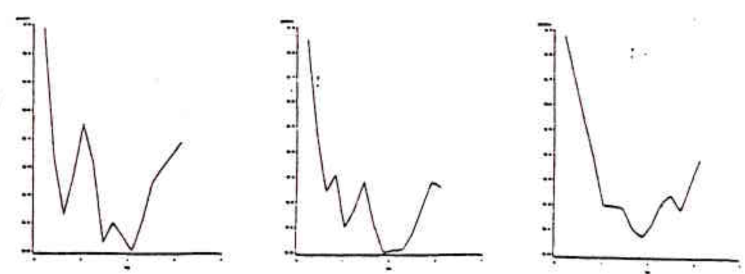


Figure 30. Coherencies for Japan, 1885-1930, (at 1913 Prices)

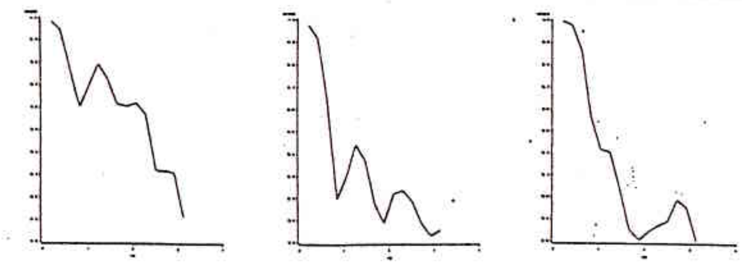


Figure 31. Convergence for the United Kingdom, 1947-1986, (a) Current Prices)

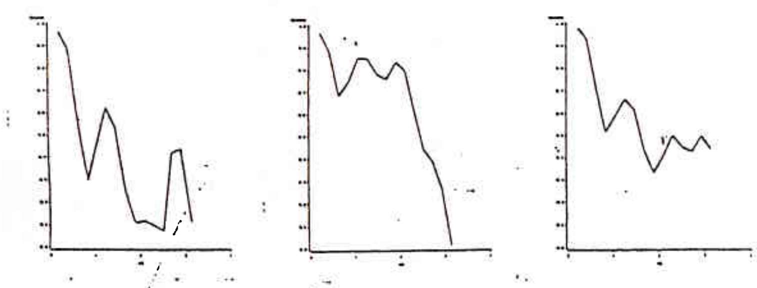
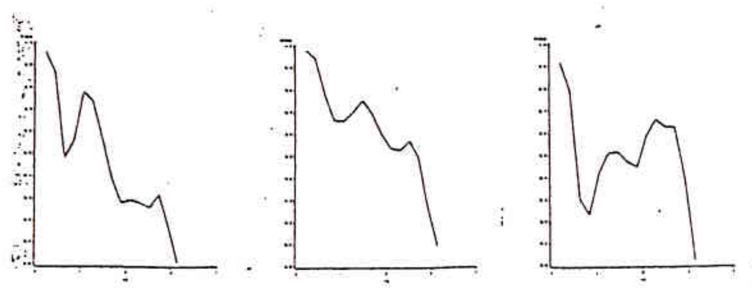


Figure 32. Convergence for the United Kingdom, 1947-1986, (b) 1980 Prices)



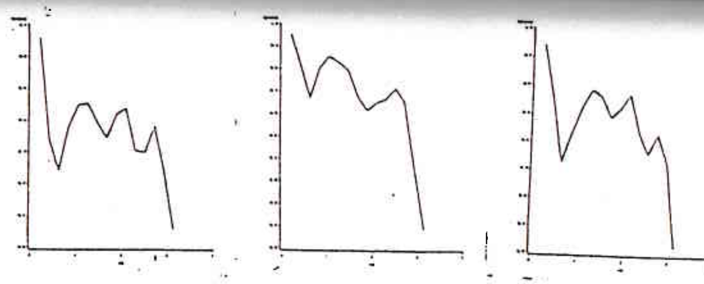


Figure 34. Convergence for the United States, 1947-1985, (b) 1980 Prices)

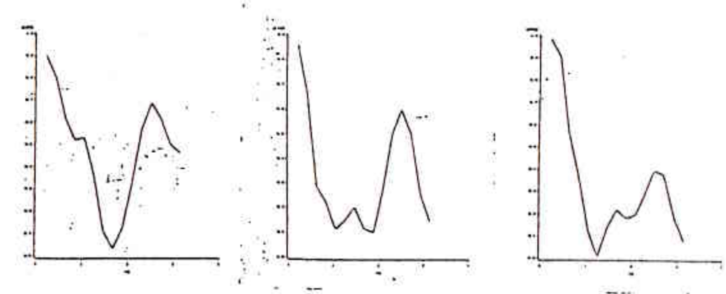
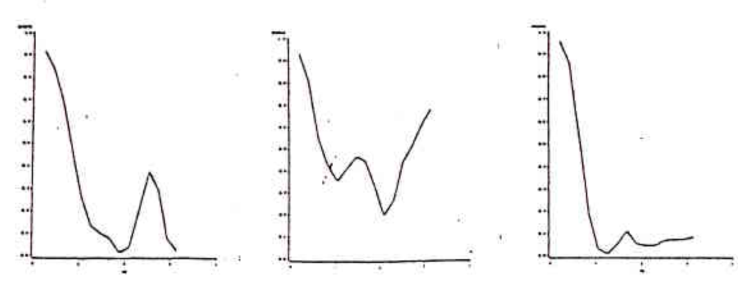


Figure 35. Convergence for Japan, 1947-1985, (a) Current Prices)



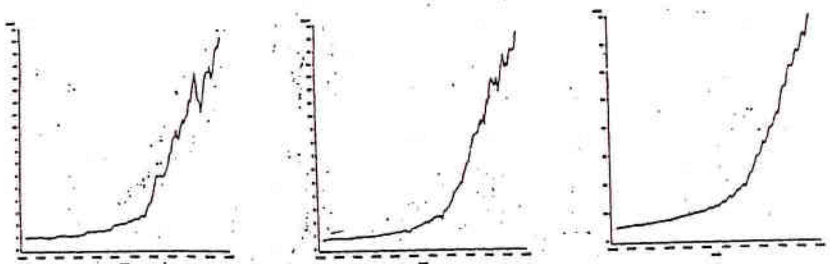


Figure 37. Imports, Exports, and GNP of the United Kingdom, 1955 Q.1-1983 Q.4. (At Current Prices)

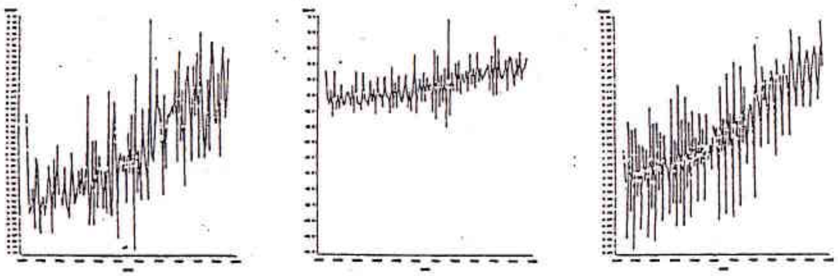


Figure 38. Prewhitened Value of Figure 37.

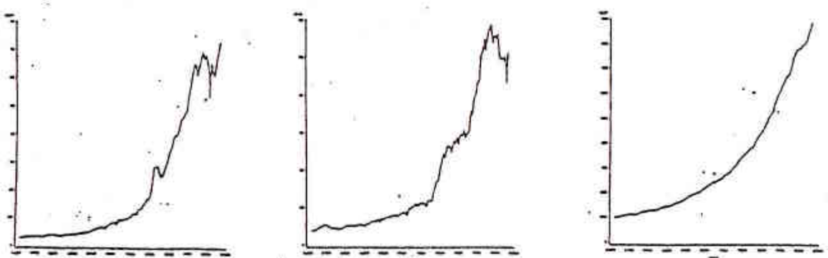


Figure 39. Imports, Exports, and GNP of the United States, 1955 Q.1-1983 Q.4. (At Current Prices)

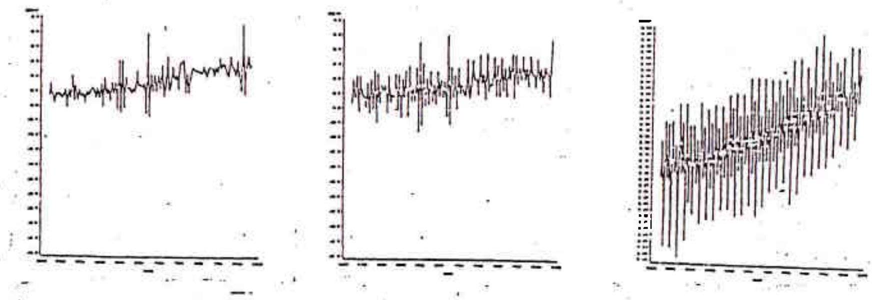


Figure 40. Prewhitened Value of Figure 39.

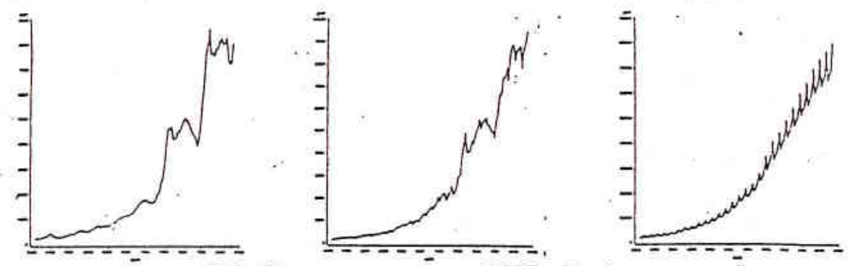


Figure 41. Imports, Exports, and GNP of Japan, 1955 Q.1-1983 Q.4. (At Current Prices)

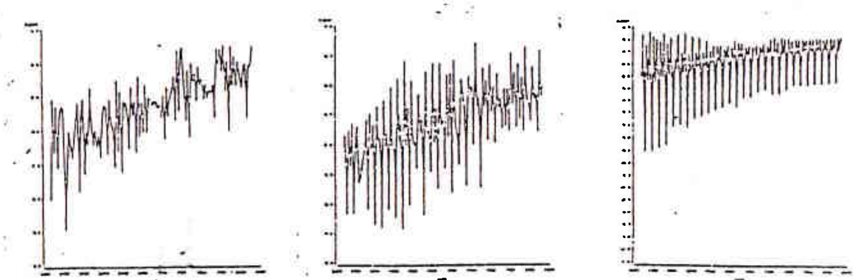


Figure 42. Prewhitened Value of Figure 41.

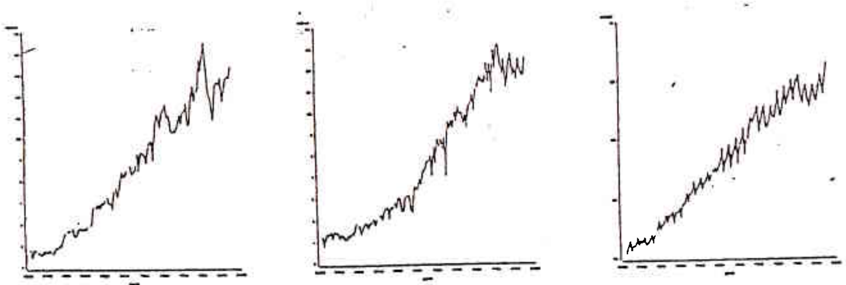


Figure 43. Imports, Exports, and GNP of the United Kingdom, 1955 Q.1–1983 Q.4. (At 1980 Prices)

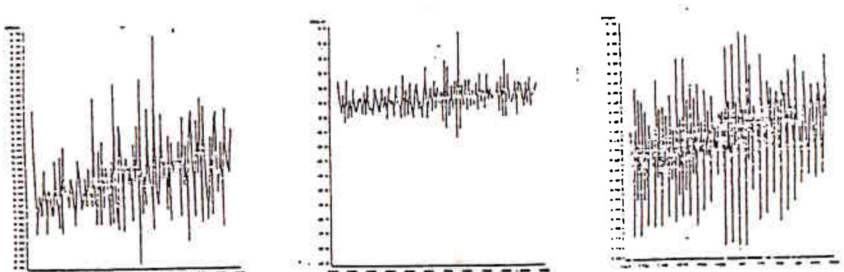


Figure 44. Pre-whitened Value of Figure 43.

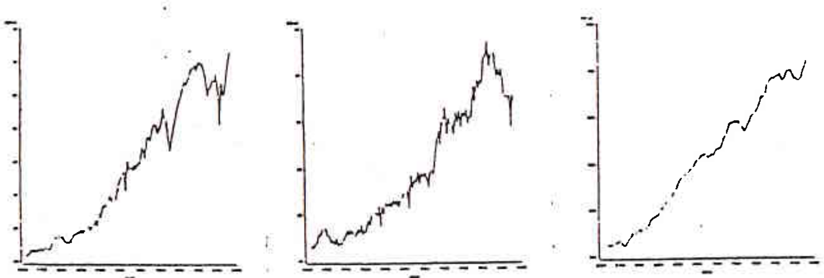


Figure 45. Imports, Exports, and GNP of the United States, 1955 Q.1–1983 Q.4. (At 1980 Prices)

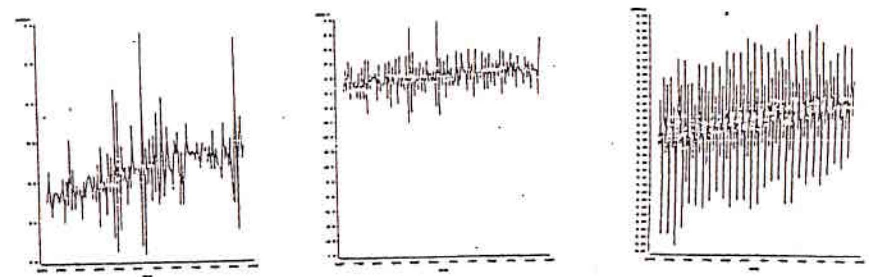


Figure 46. Pre-whitened Value of Figure 45.

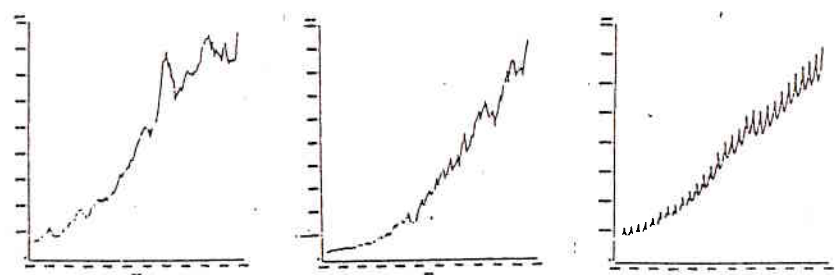


Figure 47. Imports, Exports, and GNP of Japan, 1955 Q.1–1983 Q.4. (At 1980 Prices)

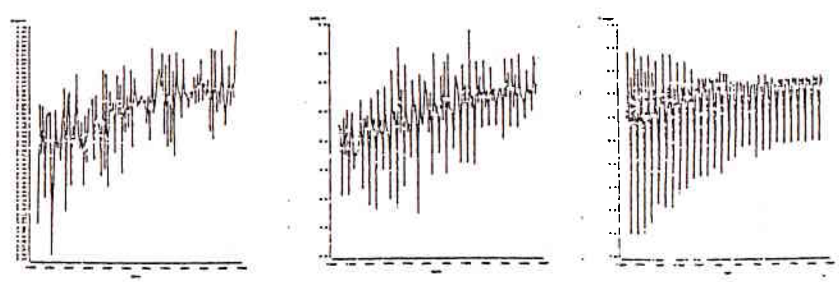


Figure 48. Pre-whitened Value of Figure 47.

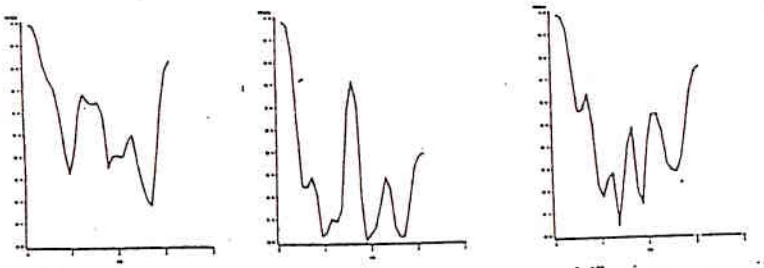


Figure 49. Coherencies for the United Kingdom, 1958 Q.1-1983 Q.4. (a) Current Prices

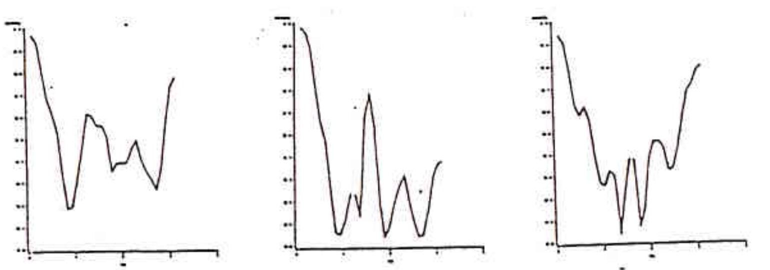


Figure 50. Coherencies for the United Kingdom, 1958 Q.1-1983 Q.4. (b) 1958 Prices

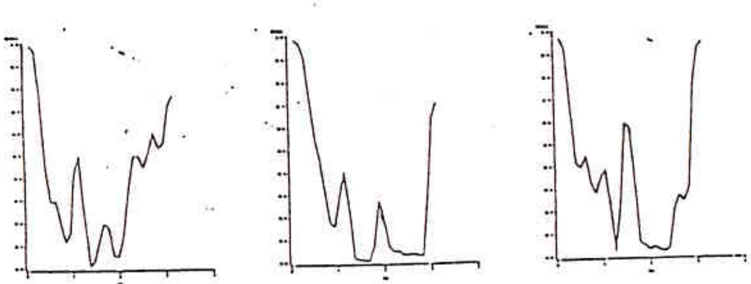


Figure 51. Coherencies for the United States, 1958 Q.1-1983 Q.4. (a) Current Prices

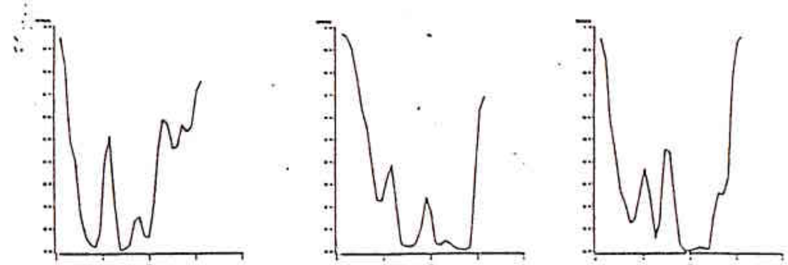


Figure 52. Coherencies for the United States, 1958 Q.1-1983 Q.4. (b) 1958 Prices

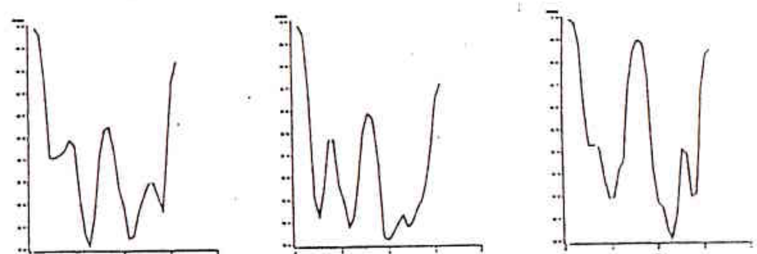


Figure 53. Coherencies for Japan, 1958 Q.1-1983 Q.4. (a) Current Prices

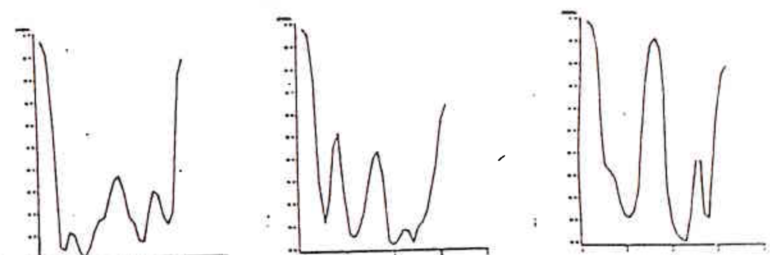


Figure 54. Coherencies for Japan, 1958 Q.1-1983 Q.4. (b) 1958 Prices

APPENDIX C

DATA SOURCES

DATA SOURCES

United Kingdom

1885 - 1939

Nominal Values of Imports and Exports : Overseas Trade Table 3 from B. R. Mitchell and Phyllis Deane, Abstract of British Historical Statistics, Cambridge University Press, 1971, 234-284.

Price Deflators for Imports and Exports : Table 64 from C. H. Feinstein, Statistical Tables of National Income, Expenditure, and Output of the U.K. , 1855-1965, Cambridge University Press, 1976, T139.

Nominal and Real GNP : Table K1 from B. Mitchell, European Historical Statistics 1750-1975, 2nd Revised ed., The Macmillan Press Ltd., 1981, 818-826.

1947 - 1985

Nominal Values of Imports and Exports : Central Statistical Office, Annual Abstract of Statistics, various issues, London.

Unit Value Indexes of Imports and Exports :

1947 - 48 United Nations, Yearbook of International Trade Statistics, 1969.

1949 - 54 International Monetary Fund, International Financial Statistics, Yearbook 1979.

1955 - 85 International Monetary Fund, International Financial Statistics, Supplement on Price Statistics, 1986.

Nominal GNP :

1947 - 75 Central Statistical Office, Economic Trends, Annual Supplement 1985 Edition, London.

1976 - 85 Central Statistical Office, Annual Abstract of Statistics, London, 1988.

GNP Deflators : GDP deflators are used as proxies for GNP deflators.

1955 Q.1 - 1983 Q.4

Nominal Values of Imports and Exports : United Nations, Monthly Bulletin of Statistics, various issues.

Unit Value Indexes of Imports and Exports :

1955 Q.1 - 1969 Q.4 United Nations, Monthly Bulletin of Statistics, various issues.

1970 Q.1 - 1971 Q.4 International Monetary Fund, International Financial Statistics, Supplement on Price Statistics, Supplement Series, No. 2, 1981.

1972 Q.2 - 1983 Q.4 International Monetary Fund, ibid, Supplement Series, No. 10, 1986.

Nominal and Real GDP : Central Statistical Office, Economic Trends, Annual Supplement 1985 Edition, London, 1985.

Wholesale Price Index :

1955 Q.1 - 1957 Q.4 International Monetary Fund, International Financial Statistics, 1956-1958.

1957 Q.1 - 1971 Q.4 Central Statistical Office, Economic Trends, Annual Supplement 1980 Edition, London, Col. 2, pp. 113-115.

1972 Q.1 - 1983 Q.4 International Monetary Fund, International Financial Statistics, Supplement on Price Statistics, Supplement Series No. 10, 1986, p. 88.

United States

1885 - 1939

Nominal Values of Imports and Exports : Series U187-200 from U.S. Department of Commerce, Historical Statistics of the United States : Colonial Times to 1971 Part 2, Bureau of the Census, Washington, D.C., 1975, 884-885.

Real Values of Imports and Exports : 1913 nominal values multiplied by quantity indexes at 1913=100 as in Robert E. Lipsey, Price and Quantity trends in the Foreign Trade of the United States, Princeton University Press, 1963.

Nominal GNP : Appendix B. Table 1 from Robert J. Gordon (ed.), The American Business Cycle : Continuity and Change, The University of Chicago Press, 1986, 781-783.

GNP Deflators : Appendix A from Robert J. Gordon, Macroeconomics, 4th ed.. Little, Brown and Company, Boston, 1987, 581-583.

1947 - 1985

Nominal Values of Imports and Exports : United Nationa, Yearbook of International Trade Statistics, various issues.

Unit Value Indexes of Imports and Exports : The same source as the United Kingdom.

Nominal GNP : Table 3 from U.S. Department of Commerce, Survey of Current Business, Bureau of the Census, Washington, D.C. , 1986 February.

GNP Deflators : The same source as in 1885-1939.

1955 Q.1 - 1983 Q.4

Nominal Value of Imports and Exports & Unit Value Indexes of Imports and Exports : The same source as the United Kingdom.

Nominal GNP :

1955 Q.1 - 1982 Q.4 U.S. Department of Commerce, The National Income and Product Accounts of the United States, 1929-1982.

1983 Q.1 - 1983 Q.4 U.S. Department of Commerce, Survey of Current Business, Bureau of the Census, Washington D.C., 1986 March.

GNP Deflators : The same source as for annual data.

Import Quantity Index : United Nations, Monthly Bulletin of Statistics, various issues.

Wholesale Price Index :

1955 Q.1 - 1958 Q.4 United Nations, Monthly Bulletin of Statistics, various issues.

1959 Q.1 - 1969 Q.4 International Monetary Fund, International Financial Statistics, 1973 Supplement.

1970 Q.1 - 1971 Q.4 International Monetary Fund, International Financial Statistics, Supplement on Price Statistics, Series No. 2, 1981, p.117.

1972 Q.1 - 1983 Q.4 International Monetary Fund, International Financial Statistics, Supplement on Price Statistics, Series No. 10, 1986, p.134.

Japan

1885 - 1939

Nominal and Real Values of Imports and Exports : Table 1-3 from I. Yamazawa and Y. Yamamoto, Estimates of Long-term Economic Statistics of Japan since 1868, Vol. 14 : Foreign Trade and Balance of Payments, Toyo Keizai Shinposha, Tokyo, 1974, 176-191.

Nominal and Real GNP : Tables 1 and 18 from K. Ohkawa, N. Takamatsu and Y. Yamamoto, Estimates of Long-term Economic Statistics of Japan since 1868, Vol. 1 : National Income, Toyo Keizai Shinposha, Tokyo, 1974, 178-179,218.

1947 - 1985

Nominal Values of Imports and Exports : Japan Tariff Association, **The Summary Report** of Trade of Japan, various issues.

Unit Value Indexes of Imports : International Monetary Fund, International Financial Statistics, Yearbook 1986. (Indexes for 1947-1949 are extrapolated from the data series)

Unit Value Indexes of Exports : International Monetary Fund, International Financial Statistics, Supplement on Price Statistics, 1986.(Indexes for 1947-1949 are extrapolated from the data series.)

Nominal and Real GNP : 1947 - 1950 K. Ohkawa et al., op. cit.
1951 - 1964 Economic Planning Agency, Annual Report of National Accounts, various issues.
1965 - 1985 Ibid.

1955 Q.1 - 1983 Q.4

Nominal Values of Imports and Exports : Bank of Japan, Economic Statistics of Japan, various issues.

Unit Value Indexes of Imports and Exports :

1955 Q.1 - 1955 Q.4 International Monetary Fund, International Financial Statistics,1956.

1956 Q.1 - 1965 Q.4 Bank of Japan, Economic Statistics of Japan, various issues.

1966 Q.1 - 1972 Q.4 Japan Tariff Association, The Summary Report of Trade of Japan, various issues.

1973 Q.1 - 1983 Q.4 Economic Planning Agency, Annual Report on Business Cycle Indicators, Japan, various issues.

Nominal GNP and GNP Deflators :

1955 Q.1 - 1964 Q.1 Economic Planning Agency, Annual Report on National Income Statistics, 1977, Japan.

1964 Q.2 - 1983 Q.4 Economic Planning Agency, Report on Revised National Accounts on the Basis of 1980, Vol. 1, Japan, 1987.

Wholesale Price Index :

1955 Q.1 - 1958 Q.4 Economic Planning Agency, Annual Report on Business Cycle Indicatorsa, Japan, Aug. 1975.

1959 Q.1 - 1969 Q.4 International Monetary Fund, International Financial Statistics, 1973 Supplement.

1970 Q.1 - 1971 Q.4 International Monetary Fund, International Financial Statistics, Supplement on Price Statistics, Series No. 2, 1981, p. 75.

1972 Q.1 - 1983 Q.4 International Monetary Fund, International Financial Statistics, Supplement on Price Statistics, Series No. 10, 1986, p. 81. Supplement.