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A time series analysis of the real exchange rate movement in Korea

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A time series analysis of the real

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CHAPTER I. INTRODUCTION

Preamble

To date, the vast majority of the empirical tests concerning Purchasing Power Parity (PPP) have concerned the U.S., European, and Japanese economies. However, there is no reason to confine the study of PPP to nations with similar industrial structures or monetary policies. As shown by Mussa (1979) and Enders (1989), PPP works well for nations experiencing very different inflation rates.

One aim of this dissertation is to analyze the causes of the departures from PPP. Most modern models of exchange rate determination suggest that real shocks can induce changes in the real exchange rate; a real shock which is permanent can induce a permanent deviation from PPP. Monetary shocks, on the other hand, can induce temporary but not permanent deviations from PPP. Even in models in which money is not neutral in the short-run, long-run money neutrality guarantees that money shocks of any variety have no permanent effects on the long-run value of the real exchange rate.

In this light, it is interesting to consider the PPP relationship for the Pacific Rim nations. These nations--particularly Korea and Japan--represent rapidly growing economies with strong trading ties to other Pacific Rim nations as well as to the United States and Europe. A comparison of the performance of PPP between Japan and Korea (both rapidly growing nations) might provide an interesting contrast to that of Korea versus other Pacific Rim nations and to Korea versus the U.S.

To preview our results, we use the methodology of Enders (1988, 1989) and Corbae and Ouliaris (1989) and show that PPP works poorly for the nations in our data set.

Using Korea as the referant nation, real exchange rate appear to be non-stationary and domestic prices are not cointegrated with foreign price levels and the exchange rate. Using a vector-autoregression, we show that real shocks (as measured by industrial production shocks and interest rates) do not induce deviations from PPP. For the case of the U.S./Korean real exchange rate, monetary shocks are associated with changes in th real exchange rates. Perhaps our most important result is that these money shocks cause temporary, but not permanent, changes in the real exchange rate; long-run money neutrality cannot be rejected.

Organization of Study

The organization of the study of PPP is as follows. In Chapter II, we will describe the Korean economy briefly. In Chapter III, we will do the literature review about PPP. This literature review will include the theoretical and empirical performance of PPP. In Chapter IV, we will do the unit root and cointegration test of PPP by employing the methodology of Enders (1988, 1989) and Corbae and Ouliaris (1989). In Chapter V, we will find the sources of PPP disparity by using a vector autoregression (VAR) analysis. Lastly, we will discuss the conclusions of this study.

CHAPTER II. A BRIEF DESCRIPTION OF THE KOREAN ECONOMY

To understand Korea's modern economic growth and development, a brief examination of the historical record is essential.

In 1945, at the end of World War II, Korea was liberated from a 35-year period of Japanese colonial rule. The liberation from Japan brought about the unexpected partition of the country into South and North Korea, and South Korea was cut off from the resources and industrial base of the North. The Korean War (1950-1953) devastated the infrastructure of the South Korean economy. As a result, South Korea had to rely for its subsistence on an agrarian economy after the Korean War. In 1953, for example, the agricultural sector was the main industry in Korea, which accounted for four-fifths of Korea's GNP.

Post-war reconstruction and development was facilitated by the industriousness of its people, their high level of education, and foreign assistance, particularly from the U.S. By the early 1960s, Korea had almost completed easy import substitution in nondurable consumer goods and their inputs. The next stage after easy import substitution would be that import substitution in durable consumer goods and machinery should occur. Instead, South Korea had adopted the export-led industrialization strategy, which resulted in a remarkable rate of economic growth. The reason to adopt the outward-looking industrialization strategy in Korea, rather than to continue import substitution, was that the domestic market was so small and there were few natural resources.

The organization of this chapter is as follows. In Section 1, we will discuss economic growth, industrial structure change, and the change in private consumption patterns. In Section 2, we will examine employment patterns and the quality of human resources in Korea. In Section 3, we will review domestic capital formation. Lastly, open macroeconomic issues in Korea will be discussed.

Economic Growth and Industrial Structure Change[1]

Since the 1960s, the Korean economy has showed rapid economic growth in spite of the world recession (1974-1975) following the first world oil shock and the political instability following President Park's assassination in 1980.

Table 2-1 presents the major indicators of Korean economic growth during the period from 1954 to 1987. In contrast to the average growth rate of 3.6 percent of real GNP in Korea for the period from 1954 to 1962, the Korean economy has recorded an average annual rate of 8.4 percent during the period from 1962 to 1982. The real GNP growth rate in the period from 1962 to 1972 was 9.1 percent per year, a slightly higher rate than that for the following decade. This rapid growth of GNP has brought very fast growth of per capita income, which was partly due to the gradual decline in the population growth rate from about 2.5 percent in the 1960s to 1.6 percent in the 1970s. Korea's per capita real GNP (in 1975 constant dollar), which had grown at an average annual rate of

[1]This part heavily draws on Kim and Park (1985).

Table 2-1. Major indicators of Korean economic growth, 1954-1987[a]

	1954	1962	1972	1982	1987	% Annual Avg. Growth Rate 54-62	62-72	72-82	62-82
1. Population (in million persons)	21.8	26.5	33.5	39.3	42.0	2.5	2.4	1.6	2.0
2. Gross national product (in 1975 constant billion won)	2,319	3,071	7,366	15,509	66,319[b]	3.6	9.1	7.7	8.4
Primary industry (share of GNP, %)	1,186 51.1)	1,391 (45.3)	2,150 (29.2)	2,976 (19.2)	8,584[c] (12.5)	2.0	4.5	3.3	3.9
Manufacturing (Share of GNP, %)	123 (5.3)	279 (9.1)	1,538 (20.9)	5,304 (34.2)	31,073[c] (45.1)	10.8	18.6	13.2	15.9
Social overhead & services (Share of GNP, %)	1,010 42.6)	1,401 (45.6)	3,677 (49.9)	7,229 (46.6)	29,161[c] (42.4)	4.2	10.1	7.0	8.6
Per capita GNP (in 1975 constant won)	106,376	115,887	219,881	394,631	N.A.	1.1	6.6	6.0	6.3
Per capita GNP (in 1975 constant dollar)	220	239	454	815	N.A.	1.1	6.6	6.0	6.3
Per capita private consumption	84,755	100,114	166,388	260,359	N.A.				
3. Exports and imports[d]									
Commodity exports, f.o.b. ($ million)	24	55	1,624	21,853	47,280	10.9	40.3	29.7	34.9
Commodity imports, c.i.f. ($ million)	243	422	2,522	24,251	41,019	7.1	19.6	25.4	22.5
Share of manufactured[e] exports in total # (%)	N.A.	27.0	87.7	93.7	N.A.				

Ratio of commodity exports to GNP # (%)	0.8	2.0	16.4	31.8	N.A.
Ratio of commodity imports to GNP # (%)	7.2	15.6	23.7	36.5	N.A.
4. Investment and savings[d]					
Share of gross domestic investment in GNP # (%)	11.9	12.8	21.7	26.2	29.7
Share of manufacturing investment in total fixed investment # (%)	17.5	20.6	19.4	15.3	N.A.
Domestic saving rate # (%)	6.6	3.3	15.7	21.5	36.6
Foreign saving rate # (%)	5.3	10.7	5.2	4.8	-6.9

[a]The Bank of Korea, Economic Statistics Yearbook, 1982, 1988.

[b]Based on 1980 constant prices. GNP in 1982, based on 1980 constant prices is 41,211.

[c]The share of GDP is calculated based on 1980 constant prices.

[d]Based on current price data.

[e]The Republic of Korea (1982).

1.1 percent for the period from 1954 to 1962, increased at an annual rate of about 6 percent thereafter. Note that per capita GNP in 1982 was U.S.$815, which is about three times greater than that in 1962.

Nobody doubts that the export-oriented industrialization strategy was the major source for the remarkable economic development in Korea since the 1960s. To support the outward-looking (export-oriented) industrialization strategy, a package of policy reforms was designed, in addition to the exchange rate reform of 1964. Exports expanded rapidly in response to these policies. Between 1962 and 1972, exports grew by an average annual rate of 40.3 percent; merchandise exports amounted to $55 million in 1962, but increased to $1,624 million in 1972. This export growth trend continued during the period from 1972 to 1982. The average annual rate of export growth during this period was 29.7 percent.

Export-led growth strategy strengthened the variety of export products; eventually, it changed the industrial structure. Note that in the early 1960s, the major part of export commodities are raw materials (Tungsten, iron ore, rice, etc.), whereas, manufactured exports are only a small portion of the total. Strikingly, the share of manufactured exports in total increased from 27 percent (in 1962) to 93.7 percent (in 1982). Furthermore, this manufacturing sector leads the growth of the overall economy; the manufacturing sector grew by 16 percent per year from 1962 to 1982, compared to 11 percent per year during the 1950s. The growth in the manufacturing sector had caused the industrial structure to change. The portion of the primary sector in GNP has shrunk from about

45 percent in 1962 to 19 percent in 1982. On the other hand, the share of the social overhead and other service sectors remained almost unchanged at about 47 percent between 1962 and 1982. This rapid economic growth and industrial structure change in Korea required a sustained increase in domestic capital accumulation. Domestic capital formation will be discussed in Section 3.

The rapid increase in per capita GNP gave rise to a substantial increase in the absolute amount of per capita private consumption expenditures between 1962 and 1982. Per capita private consumption expenditures in 1975 constant prices increased from 100,114 won in 1962 to 260,359 won by 1982. Along with the increase in per capita consumption, the significant change in consumption patterns occurred during two decades. Table 2-2 summarizes the trends in consumption patterns of individual households. The proportion of food expenses in private consumption expenditures declined from 51 percent in 1962 to 41 percent in 1982. In contrast, the share of personal and health expenses in private consumption expenditures increased from 4.1 percent in 1962 to 8.6 percent in 1982. This structural change in consumption patterns may indicate that the welfare of the Korean economy has increased since the 1960s. Table 2.3 confirms that consumer welfare continuously increased during the period from 1982 to 1987. It is striking that consumption for durable goods in 1987 was more than two times that of 1982. On the other hand, the consumption for nondurable goods increased very slowly compared to durable goods.

Table 2-2. Trends in composition of private consumption expenditures (based on the current price series)[a]

(in percent)

	1954	1962	1972	1982
Food	51.7	51.2	47.8	41.0
Beverage	4.5	4.6	4.9	6.0
Tobacco	2.9	3.1	3.9	4.1
Clothing and other personal effects	11.8	11.5	10.1	7.9
Rent and water charges	15.8	7.2	4.9	5.0
Furniture and household equipment	2.2	2.5	2.9	2.9
Household operation	1.7	1.2	1.1	0.8
Personal care and health expenses	2.6	4.1	5.6	8.6
Transportation and communication	2.0	4.7	7.1	9.2
Recreation and entertainment	4.2	3.8	5.5	5.0
Miscellaneous services	2.7	2.1	3.3	5.5
Less net expenditures of nonresidents	0.0	0.0	0.8	0.3
Total	100.0	100.0	100.0	100.0

[a]The Bank of Korea, National Income in Korea, 1982.

Table 2-3. Composition of final consumption of households by type[a]

(in billion won)

	At 1980 Constant Prices					
	1982	1983	1984	1985	1986	1987
Durable goods	972.0	1,227.8	1,468.0	1,476.2	1,841.1	2,350.6
Semi-durable goods	3,213.2	3,435.5	3,568.1	3,675.0	3,937.7	4,296.0
Nondurable goods	14,795.1	15,689.6	16,284.2	16,982.2	18,264.2	19,386.9
Services	7,641.8	8,303.8	9,031.3	9,746.1	10,294.0	11,000.6
Final consumption expenditure in the domestic market	26,622.1	28,656.7	30,351.6	31,879.5	34,337.0	37,034.1
Dir. purchases abroad by res. hshlds.	199.0	156.5	174.5	192.7	117.3	133.9
(less) Purch. in domestic market by non-resident hshds.	245.4	273.4	312.5	395.9	769.7	1,106.9
Final consumption expend.	26,575.7	28,539.8	30,213.6	31,676.3	33,684.6	36,061.1

[a]The Bank of Korea, Economic Statistics Yearbook, 1988.

Employment

Korean economic development since the 1960s has been stimulated by the ready availability of workers, the high mobility of workers from rural to urban areas, and the high level manpower resources. Despite massive unemployment and underemployment already present in both the rural and urban sectors of the economy, Korea's population increased very rapidly until the early 1960s. Tables 2-4 and 2-5 make it clear that the average annual growth rate of the population of age 14 and over was 3 percent during the period from 1963 to 1982, while the average annual growth rate of the total population for the same period was about 2 percent. This is suggestive of the fact that those children born during the post-Korean baby boom were joining the working-age population after the early 1970s. The labor force participation rate of the female population increased strikingly, which implied that the economically active population increased more than the working-age population during the period from 1963 to 1982.

Korea's export-led industrialization strategy provides employment opportunities not only for the persons already unemployed but also for those newly joing the labor force. Note that the increase in nonfarm sector employment induced by the export-led growth strategy caused the industrial structure to change. The portion of nonfarm employment out of total national employment in 1963 was about 36 percent, whereas, it increased to over 50 percent in 1974. It is striking that the absolute level of farm employment has declined since 1974, as shown in Table 2-5.

Table 2-4. Population, labor force, employment and unemployment rate, 1963-1987[a]

(in millions of persons, unless otherwise noted)

Year	Total Population	Population 14 & older	Labor Force			Employed Population			Unemployment Rate (%)		
			Total	Farm	Nonfarm	Total	Farm	Nonfarm	Total	Farm	Nonfarm
1963	27.26	15.09	8.34	5.09	3.25	7.66	4.94	2.72	8.2	2.9	16.4
1964	27.98	15.50	8.45	5.17	3.28	7.80	4.99	2.81	7.7	3.5	14.4
1965	28.71	15.94	8.86	5.23	3.63	8.21	5.07	3.14	7.4	3.1	13.5
1966	29.44	16.37	9.07	5.28	3.79	8.42	5.12	3.30	7.1	3.1	12.8
1967	30.13	16.76	9.30	5.20	4.10	8.72	5.07	3.65	6.2	2.3	11.1
1968	30.84	17.17	9.65	5.26	4.39	9.16	5.16	4.00	5.1	1.9	8.9
1969	31.54	17.64	9.89	5.26	4.63	9.41	5.15	4.26	4.8	2.2	7.8
1970	32.24	18.25	10.20	5.20	5.00	9.75	5.12	4.63	4.5	1.6	7.4
1971	32.88	18.98	10.54	5.09	5.45	10.07	5.02	5.05	4.5	1.5	7.4
1972	33.51	19.72	11.06	5.41	5.65	10.56	5.34	5.22	4.5	1.5	7.5
1973	34.10	20.44	11.60	5.68	5.92	11.14	5.63	5.51	4.0	1.0	6.8
1974	34.69	21.15	12.08	5.77	6.31	11.59	5.71	5.88	4.1	1.2	6.8
1975	35.28	21.83	12.34	5.67	6.67	11.83	5.60	6.23	4.1	1.3	6.6
1976	35.75	22.55	13.06	5.91	7.15	12.56	6.86	6.70	3.9	1.0	6.3
1977	36.41	22.34	13.44	5.71	7.73	12.93	5.65	7.28	3.8	1.1	5.8
1978	36.97	24.02	13.93	5.59	8.35	13.49	5.54	7.95	3.2	0.9	4.7
1979	37.53	24.68	14.21	5.40	8.80	13.66	5.36	8.31	3.8	0.9	5.6
1980	38.12	25.34	14.45	5.17	9.29	13.71	5.11	8.59	5.2	1.1	7.5
1981	38.72	25.97	14.71	5.20	9.51	14.05	5.16	8.89	4.5	0.9	6.5
1982	39.33	26.53	15.08	4.85	10.23	14.42	4.81	9.61	4.4	0.9	6.0
1983	39.93	26.21[b]	15.12	N.A.	N.A.	14.50	4.3	10.2	4.1	N.A.	N.A.
1984	40.51	26.86	15.00	N.A.	N.A.	14.43	3.9	10.5	3.8	N.A.	N.A.
1985	41.06	27.55	15.59	N.A.	N.A.	14.97	3.7	11.2	4.0	N.A.	N.A.
1986	41.57	28.23	16.12	N.A.	N.A.	15.50	3.7	11.8	3.8	N.A.	N.A.
1987	42.08	28.96	16.87	N.A.	N.A.	16.35	3.6	12.8	3.1	N.A.	N.A.

[a]The Republic of Korea (1982, 1988).

[b]All series of economically active population since 1983 were adjusted according to changing the working age from 14 to 15 years old.

Table 2-5. Annual rate of increase in population, labor force, and employment[a]

(in percent)

Year	Population: Total Population	Population: 14 yrs. & Over	Labor Force: Total	Labor Force: Farm	Labor Force: Nonfarm	Employment: Total	Employment: Farm	Employment: Nonfarm
1963	2.8	---	---	---	---	---	---	---
1964	2.7	2.7	1.3	1.6	0.9	1.8	1.0	3.3
1965	2.6	2.8	4.9	1.2	10.7	5.3	1.6	11.7
1966	2.6	2.7	2.4	0.1	4.4	2.6	1.0	5.1
1967	2.4	2.4	2.5	-1.5	8.2	3.6	-1.0	10.6
1968	2.4	2.5	3.8	1.2	7.1	5.0	1.8	9.6
1969	2.3	2.7	2.4	0.0	5.5	2.7	-0.2	6.5
1970	2.2	3.5	3.2	-1.1	8.0	3.6	-0.6	8.7
1971	2.0	4.0	3.3	-2.1	9.0	3.3	-2.0	9.1
1972	1.9	3.9	4.9	6.3	3.7	4.9	6.4	3.4
1973	1.8	3.7	4.9	5.0	4.8	5.5	5.4	5.6
1974	1.7	3.5	4.1	1.6	6.6	4.0	1.4	6.7
1975	1.7	3.2	2.2	-1.7	5.7	2.1	-1.9	6.0
1976	1.6	3.3	5.8	4.3	7.2	6.2	4.5	7.6
1977	1.6	3.5	2.9	-3.4	8.1	2.9	-3.6	8.7
1978	1.5	2.9	3.6	-2.1	8.0	4.3	-1.9	9.2
1979	1.5	2.7	2.0	-3.4	5.4	1.3	-3.2	4.5
1980	1.6	2.7	2.0	-4.3	5.6	0.4	-4.7	3.4
1981	1.6	2.5	1.8	0.6	2.4	2.5	1.0	3.5
1982	1.6	2.2	2.5	-6.7	7.6	2.6	-6.8	8.1
Average annual rate of increase:								
63-72	2.3	3.0	3.2	0.7	6.3	3.6	0.9	7.5
72-82	1.6	3.0	3.1	-1.1	4.5	3.2	-1.0	6.3

[a]Economic Planning Board, Major Statistics of Korean Economy, 1982. Referred to in Kim and Park (1985).

Apparently, the rapid increase in non-farm employment was absorbed by the manufacturing and social overhead and other service sectors.

The rapid economic development in Korea has not been made possible without quality labor. The rapidly growing economy requires a correspondingly rapid increase in educated manpower and its qualitative improvement in the future. In this context, Korea continuously increased investments in education to meet the various industrial demands. Table 2-6 shows that the portion of the working age population with formal education increased from 57 percent of the total in 1960 to about 87 percent by 1980. The share of the working-age population with a higher-level education (above midle school) increased from about 20 percent of the total to 60 percent during the same period. The most important fact is that the educational level of the female population increased considerably during the two decades. This implied that the potential labor force increased.

We can not go to the conclusion of this section without mentioning the following. Nobody doubts that economic development can be facilitated by high-quality human resources. The problems in the Korean educational system are that 1) high-quality educational institutions are distributed in favor of metropolitan areas such as Seoul and Pusan; that is, there are regional imbalances in opportunities and the quality of education, and 2) educational facilities and teachers are in short supply compared with foreign countries.

Table 2.6 Composition of population aged 14 and over by sex and educational level[a]

(in thousand persons)

Educational Level[b]	Both Sexes				Male				Female			
	1960[c]		1980		1960[c]		1980		1960[c]		1980	
	Population	% Share	Population	% Share	Population	% Share	Population	% Share	Population	% Share	Population	% Share
Primary Sch	5,775	37.5	7,066	27.6	2,988	39.3	2,863	22.6	2,786	35.7	4,203	32.5
Middle Sch	1,522	9.9	6,128	23.9	1,060	13.9	3,078	24.3	462	5.9	3,050	23.5
High School	1,133	7.4	6,831	26.7	853	11.2	4,042	32.0	280	3.6	2,789	21.5
Jr. College	175	1.1	388	1.5	149	2.0	274	2.2	26	0.3	114	0.9
University College +	206	1.3	1,891	7.4	184	2.4	1,412	11.2	23	0.3	479	3.7
Sub-Total	**8,811**	**57.2**	**22,304**	**87.1**	**5,234**	**68.8**	**11,669**	**92.2**	**3,577**	**45.8**	**10,635**	**82.1**
Persons w/o formal educ.	6,520	42.3	3,298	12.9	2,336	30.7	981	7.8	4,184	53.6	2,317	17.9
Unknown	75	0.5	.6	0.0	33	0.4	0.3	0.0	41	0.5	0.3	0.0
Total	**15,405**	**100.0**	**25,603**	**100.0**	**7,603**	**100.0**	**12,651**	**100.0**	**7,802**	**100.0**	**12,952**	**100.0**

[a]Economic Planning Board. Referred to in Kim and Park (1985).

[b]Classified by the number of years in school as the following: Primary school for 1-6 years of schooling; middle school for 7-9 years of schooling; high school for 10-12 years of schooling; junior college for 13-14 years of schooling; and university, college, and above for 15 years and over in school.

[c]The population with unknown age is not included.

Capital Formation

Domestic capital accumulation is a necessary condition for economic growth, employment expansion, and enhancement of labor productivity. Korea's gross domestic investment was less than 15 percent of the GNP until 1965, except for the years 1957 and 1963. Since the mid-1960s the ratio of gross domestic investment to GNP rose by above 20 percent and reached a high of 30 percent by the late 1970s, as shown in Table 2.7.

There are two ways to finance the increase in gross domestic investment. One way is to increase domestic saving, and the other way is to import foreign capital. Until 1962, the gross domestic saving rate was less than 5 percent of the GNP. Since 1963, it increased rapidly to 18.2 percent in the early 1970s and exceeded 26.0 percent in the peak years of 1978 to 1979. The deceleration of the economic growth rate was attributed to the decline of the domestic saving rate (20.3 percent) in the early 1980s. The domestic gross saving has shown a large contribution to gross domestic investment since 1963. The share of the gross domestic investment financed by gross domestic saving was about 34 percent in the early 1960s. It then rose to 75 percent by the early 1970s.

The inflow of foreign capital may be very sensitive to the real interest rate differential, the balance of payments situation, and the domestic saving-investment gap. This foreign capital inflow shows large fluctuations as shown in table 2-7. The average ratio of foreign saving to GNP was 9.9 percent during the period from 1961 through 1963, which is greater than the 7.7 percent in the period from 1954 through 1956. This

Table 2-7. Trends in the ratio of sectoral gross saving to GNP, 1954-82[ab]

(in percent)

Year	Gross Domestic Saving Rate: Govt.	Business	Hshld	Total[c]	Foreign Saving Rate	Statistical Discrepancy	Gross Saving[c] =Gross Domestic Investment
1954	-2.7	5.0	4.4	6.6	5.3	--	11.9
1955	-2.3	4.3	3.2	5.2	7.0	--	12.2
1956	-2.9	4.4	-3.4	-2.0	10.9	--	8.9
1957	-3.0	4.5	4.1	5.5	9.8	--	15.3
1958	-3.1	5.0	3.0	4.8	8.1	--	12.9
1959	-2.7	5.7	1.2	4.2	6.9	--	11.2
1960	-2.0	5.3	-2.5	0.8	8.6	1.5	10.9
1961	-1.8	5.9	-1.3	2.9	8.6	1.7	13.2
1962	-1.5	7.1	-2.3	3.3	10.7	-1.1	12.8
1963	-0.4	7.1	2.0	8.7	10.4	-1.0	18.1
1964	0.5	6.5	1.8	8.7	6.9	-1.6	14.0
1965	1.7	7.7	-2.1	7.4	6.4	1.2	15.0
1966	2.8	7.5	1.6	11.8	8.4	1.3	21.6
1967	4.1	7.9	-0.6	11.4	8.8	1.7	21.9
1968	6.1	7.8	1.1	15.1	11.2	-0.4	25.9
1969	5.9	7.7	5.2	18.8	10.6	-0.6	28.8
1970	6.5	7.5	3.4	17.3	9.3	0.2	26.8
1971	5.4	7.5	2.5	15.4	10.7	-0.8	25.2
1972	3.6	9.1	3.0	15.7	5.2	0.7	21.7
1973	4.2	11.4	7.9	23.5	3.8	-1.7	25.6
1974	2.3	12.1	6.1	20.5	12.4	-1.9	31.0
1975	4.0	11.3	3.4	18.6	10.4	0.4	29.4
1976	6.2	10.9	6.0	23.1	2.4	-0.0	25.5
1977	5.6	10.9	8.6	25.1	0.6	1.6	27.3
1978	6.5	9.9	10.0	26.4	3.3	1.5	31.1
1979	7.2	9.7	9.7	26.6	7.6	1.2	35.4
1980	6.2	8.2	5.5	19.9	10.2	1.4	31.5
1981	6.7	8.3	4.6	19.6	7.9	0.9	28.4
1982	6.7	9.7	5.1	21.5	4.8	-0.1	26.2
Average for period:							
54-56	-2.6	4.6	1.4	3.3	7.7	--	11.0
61-63	-1.2	6.7	-0.5	5.0	9.9	-0.1	14.8
71-73	4.4	9.3	4.5	18.2	6.6	-0.6	24.2
80-82	6.5	8.7	5.1	20.3	7.6	0.7	28.7

[a]The Bank of Korea, National Income in Korea, 1982.

[b]Based on the current price series.

[c]Totals may not add up due to rounding.

ratio declined to 6.6 percent during 1971 through 1973, but increased again to almost 7.6 percent in 1980 through 1982 because of the sharp increase in world oil prices in 1979 and 1980.

Table 2-8 shows the current trend for the gross saving and gross investment. It is striking that the outflow of domestic capital occurs. This is indicative of the unprecedented event-current account surplus[2].

Sectoral contributions to the domestic capital formation are presented in Table 2-9. Note that both the government and business sectors have contributed most to the increase in domestic saving since the mid-1960s. The government sector shows a positive contribution to the gross domestic saving since 1964. The average annual government saving ratio to gross domestic investment was about 22.9 percent in 1980 through 1982, which was greater than 18.2 percent in 1971 through 1973. This result implies that the government has played a very important role in domestic capital formation. The average business saving ratio to gross domestic investment was about 41.8 percent during the period 1954 through 1956. In the early 1960s, it increased to about 45.3 percent. The portion of the business saving to GNP was about 6.7 percent during this period. The business saving ratio to gross domestic investment was about 38.4 percent in the period from 1971 through 1973. In the early 1980s, it declined to 30.8 percent, but was still much larger than that

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[2]Following the Keynesian absorption approach, Current Account = (Saving - Investment) + (Tax - Government Spending). Given balanced budget in the government sector, current account equals the saving investment gap.

Table 2-8. Current trend for the saving and investment[a]

(in billion won)

	1982	1983	1984	1985	1986	1987
GROSS SAVING	12,197.9	16,486.1	20,120.6	22,329.2	29,115.5	36,453.4
Private	9,077.4	12,218.6	15,437.9	17,277.6	23,378.7	29,626.7
Non-financial corporate enterprises	4,187.9	5,920.7	6,690.4	7,607.2	10,277.3	---
Financial institutions	-152.0	250.2	614.1	480.4	409.2	---
Individuals	5,041.5	6,047.7	8,133.4	9,190.0	12,692.2	---
General government	3,120.5	4,267.5	4,682.7	5,051.6	5,736.8	6,826.7
GROSS INVESTMENT	12,555.1	16,357.1	20,111.0	21,886.6	29,021.7	36,997.6
Gross domestic capital formation	14,509.6	17,620.8	21,207.3	22,644.8	24,983.0	29,022.9
Private	12,180.0	14,873.8	18,027.5	19,218.3	21,647.6	25,304.3
Non-financial corporate enterprises	10,069.7	11,289.7	12,931.1	14,798.6	17,136.7	---
Financial institutions	566.9	303.8	394.5	344.2	329.2	---
Individuals	1,543.4	3,280.3	4,701.9	4,075.5	4,181.7	---
General government	2,329.6	2,747.0	3,179.8	3,426.5	3,335.4	3,718.6
Net lending to the rest of the world	-1,954.5	-1,263.7	-1,096.3	-758.2	4,038.7	7,974.7
STATISTICAL DISCREPANCY	-357.2	129.0	9.6	442.6	93.8	-544.2

[a]The Bank of Korea, Economic Statistics Yearbook, 1988.

Table 2-9. Trends in the composition of gross saving by sector, 1954-82[a]
(in percent)

Year	Gross Domestic Saving Rate				Foreign Saving Rate	Statistical Discrepancy	Gross Saving =Gross Domestic Investment
	Govt.	Business	Hshld	Total			
1954	-22.8	41.8	36.7	55.7	44.3	--	100.0
1955	-19.1	35.5	26.2	42.6	57.4	--	100.0
1956	-32.6	48.9	-37.8	-22.2	122.2	--	100.0
1957	-19.9	29.5	26.5	36.1	63.9	--	100.0
1958	-24.2	38.6	23.1	37.5	62.5	--	100.0
1959	-24.3	51.0	11.1	37.1	62.1	--	100.0
1960	-18.8	49.2	-22.9	7.5	78.9	13.5	100.0
1961	-14.1	45.0	-9.6	21.4	65.4	13.2	100.0
1962	-12.1	55.4	-17.8	25.5	83.3	-8.8	100.0
1963	-2.0	39.0	11.0	48.0	57.5	-5.4	100.0
1964	3.3	46.0	12.9	62.2	48.8	-11.1	100.0
1965	11.4	51.6	-14.0	49.1	42.6	8.3	100.0
1966	12.8	34.8	7.3	54.8	39.1	6.0	100.0
1967	18.7	35.8	-2.6	51.9	40.2	7.9	100.0
1968	23.6	30.3	4.4	58.3	43.1	-1.4	100.0
1969	20.5	26.9	17.9	65.3	36.8	-2.2	100.0
1970	24.3	27.8	12.5	64.7	34.7	0.6	100.0
1971	21.4	29.6	9.8	60.9	42.5	-3.4	100.0
1972	16.4	42.0	14.0	72.5	24.2	3.3	100.0
1973	16.3	44.7	31.0	92.0	14.8	-6.8	100.0
1974	7.3	39.0	19.7	66.0	40.0	-6.0	100.0
1975	13.6	38.3	11.4	63.3	35.5	1.2	100.0
1976	24.2	42.9	23.5	90.6	9.5	-0.1	100.0
1977	20.5	39.9	31.7	92.1	2.2	5.7	100.0
1978	20.8	31.7	32.2	84.7	10.6	4.7	100.0
1979	20.4	27.4	27.3	75.1	21.6	3.3	100.0
1980	19.6	26.1	17.4	63.2	32.4	4.4	100.0
1981	23.6	29.1	16.4	69.1	27.9	3.0	100.0
1982	25.5	37.1	19.5	82.1	18.4	-0.5	100.0
Average for period:							
54-56	-23.6	41.8	12.7	30.0	70.0	--	100.0
61-63	-8.1	45.3	-3.4	33.8	66.9	-0.7	100.0
71-73	18.2	38.4	18.6	75.2	27.3	-2.5	100.0
80-82	22.9	30.8	17.8	71.5	26.2	2.3	100.0

[a]The Bank of Korea, National Income in Korea, 1982.

of the government and the household. On the other hand, household saving showed a large fluctuation compared to the government and the business sectors. The reason for this difference is that household saving includes saving in the form of addition to grain inventories, which usually fluctuates annually with the level of major food output in Korea. In summary, the business sector has maintained the leading role in capital accumulation in Korea.

We are now in a position to discuss the allocation of gross domestic investment by the industrial sector. Annual fixed investment for selected periods is shown in Table 2-10. The sectoral cumulative fixed investment shows a stable pattern since 1962; the share of gross fixed investment allocated to the primary sector was about 9 percent during two decades. During this period, the manufacturing sector and the social overhead and other service sector's share of gross fixed investment was about 24 percent and 67 percent, respectively.

This relatively stable pattern of resource allocation by a major sector implies that economic development, led by the growth of the manufacturing sector, was made possible not only by the rapid expansion of investment in that sector but also by complementary contributions of the other sectors to the manufacturing sector.

Table 2-11 makes it clear that the capital formation in the manufacturing sector and service sectors (finance, insurance, real estate, and business services) increased very rapidly in short time period (1982-1986), whereas, the primary sector showed slow capital

Table 2-10. Investment allocation for selective periods[a]

(in billion won)

	Primary Sector	Manufac-turing	Social Overhead and Services[c]	Total
Cumulative fixed investment[b]				
1953-1961	225.3 (12.2)	476.6 (25.8)	1,142.3 (62.0)	1,844.2 (100.0)
1962-1971	858.9 (9.0)	2,325.4 (24.5)	6,313.4 (66.5)	9,497.7 (100.0)
1972-1981	3,253.3 (9.1)	8,139.1 (22.7)	24,433.4 (68.2)	35,825.8 (100.0)
1953-1981	4,337.5 (9.2)	10,941.1 (23.2)	31,889.1 (67.6)	47.167.7 (100.0)

[a]Bank of Korea; National Income in Korea, 1982.

[b]The percentage composition of cumulative fixed investment by major sector is shown in prices.

[c]Includes the construction industry.

formation. The sector for construction showed a declining trend for capital formation, which implies the effects of the current recession in the construction industry.

The Current Open Macroeconomic Issues

The recent macroeconomic performance of the Korean economy has been outstanding. The Korean economy registered a remarkable growth rate of 12.5 percent in 1986. Strikingly, in 1986, the national current account shifted from a chronic deficit to a surplus that amounted to $4.62

Table 2-11. Composition of capital formation by kind of economic activity[a]

(in billion won)

	At 1980 Constant Prices				
	1982	1983	1984	1985	1986
GROSS FIXED CAPITAL FORMATION	12,820.1	15,016.9	16,617.5	17,355.7	20,019.9
Industries	10,895.0	12,773.6	14,098.5	14,705.6	17,434.2
Agriculture, forestry and fishing	863.2	1,085.4	1,197.6	1,120.8	1,389.2
Mining and quarrying	105.8	107.8	121.1	132.6	135.6
Manufacturing	2,694.3	2,754.6	3,675.5	4,494.7	5,855.6
Electricity, gas and water	1,306.6	1,582.7	1,411.2	1,423.2	1,520.6
Construction	383.7	352.8	433.7	432.2	361.5
Wholesale & retail trade, rest. & hotel	754.9	574.8	722.8	731.3	1,010.6
Transport, storage, communication	1,551.4	2,304.0	2,193.8	2,318.1	2,403.1
Finance, insurance, real estate, and business services	2,896.5	3,685.3	3,913.0	3,664.8	4,278.4
Community, social & personal services	3386	326.2	429.8	387.9	479.6
Producers of government services	1,925.1	2,243.3	2,519.0	2,650.1	2,585.7
Public administration & defense	1,232.9	1,619.3	1,661.1	1,755.4	1,641.3
Social, recreational, sanitary and related community services	476.9	489.7	597.4	701.8	689.7
Others	215.3	134.3	260.5	192.9	254.7
Increase in stocks	-266.9	-271.9	874.6	413.4	-367.9
GROSS CAPITAL FORMATION	12,553.2	14,745.0	17,492.1	17,769.1	19,652.0

[a]The Bank of Korea, Economic Statistics Yearbook, 1988.

billion (5 percent of the GNP), as shown in Table 2-12. This significant event of current account surplus, which Korean economic policy makers had never confronted, has led to some political and economic issues and problems. Note that the improvement in the current account was accompanied by bilateral trade imbalances: a growing trade surplus with the United States since 1982 and a widening deficit with Japan. The Washington response to this trade imbalance with Korea is very plain: import liberalization, capital account liberalization, exchange rate appreciation, raising real wages, cutting taxes, and so on.

It is interesting to examine the sources of the current account surplus of the Korean economy in 1986. The world economic environment was unusually favorable to the Korean economy in 1986: the collapse of oil prices, the Japanese Yen appreciation, and the Korean won depreciation. Mahn-Je Kim and Sung-Tae Ro (1989) argued that "these three blessings" have contributed to the 1985-86 improvement in the balance of payments by 90 percent.[3] This implies the vulnerability of the Korean economy to external shocks.

Most Korean economists are dubious about the sustainability of the current account surplus. They are worried about future external shocks

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[3]The changes in world economic conditions in 1986 have been popularly dubbed the "three blessings." The "three blessings" are the collapse of oil prices, the Japanese Yen appreciation, and the decline in international interest rates. Note that the Korean economy imports 100 percent of its crude oil and also is ranked as the fourth largest developing country debtor. According to Kim and Ro (1989), the overall impact of the strong Yen on GNP and the current account was definitely positive. They also argued that the drop in oil prices improved the current account balance by 54.5 percent of the total surplus.

Table 2-12. Macroeconomic performance of Korea, 1984-87[a]

	1984	1985	1986	First Half of 1987
GNP growth[b]	8.4	5.4	12.5	15.3
Consumption	5.2	5.1	6.7	7.5
Fixed capital formation	10.7	4.4	15.0	14.7
Commodity exports	11.5	3.6	26.3	26.1
Commodity imports	11.3	-0.7	19.7	21.5
GNP deflator	3.8	4.1	2.3	2.0
Wholesale prices	0.7	0.9	-2.2	-0.5
Consumer prices	2.3	2.5	2.3	2.1
Value, billion dollars				
Current account balance	-1.37	-0.89	4.62	4.15
Trade balance	-1.04	-0.02	4.21	2.98
Exports	26.33	26.44	33.91	20.68
Imports	27.37	26.46	29.71	17.70
Invisible trade balance and net transfers	-0.34	-0.87	0.41	1.17

[a]The Bank of Korea, Monthly Bulletin (June 1989).

[b]GNP and inflation figures represent the percentage change from the same period of the previous year.

that are unfavorable to the Korean economy. Tensions in the Middle East may cause oil prices to rise. If the U.S. would cut its trade deficit, there would be serious adverse effects on Korean exports because the U.S. is the largest purchaser of Korean exports. Current labor turmoil disrupts the production of automobiles, ships, electronics, and footwear--all crucial export items. Labor disputes could have two negative effects on the Korean economy. One is that the sharp rises in wage rates will erode Korea's competitiveness. The other is that many American buyers will turn to Taiwan or other developing countries for a more stable supply of manufactured goods. Contrary to the views of the Korean economists, Dornbush (1989) argued that the Korean external balance shows all the signs of a trend toward surpluses. He indicated that, even with a rising share of investment in GDP, there was a very significant increase in savings and, hence, an improvement in the external balance. His argument is based upon a Keynesian framework of income-expenditure analysis. Note that this Keynesian absorption approach is valid in circumstances such as fixed prices and excess capacity.

Even though Korean economists think that current account surpluses, like deficits, are external imbalances and should be adjusted on the grounds of economic welfare, there are many constraints on macroeconomic adjustment policies in Korea. At the end of 1986, Korea's gross foreign debt amounted to $44.5 billion, equivalent to 46.8 percent of GNP, placing Korea fourth among the world's debtor nations.[4] This external debt problem places some restrictions on adjustment policies. The Korean government wants to reduce the external debt to about 20 percent of GNP by 1991, the level found in many problem-free debtor countries.

To reduce the current account surplus, the Keynesian absorption approach is recommended. Note that this approach is valid in a world

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[4]For more details about statistics, see Kim and Ro (1989).

where fixed prices and excess capacity are assumed. Policies that tend to increase absorption are not appropriate in the presence of rising prices and high growth rate, which the Korean economy currently shows.

The drastic import liberalization plan may hurt the Korean economy very seriously. As we have already argued, the Korean economies were accustomed to the export-oriented industrialization strategy so that the accelerated market opening and cuts in tariffs would threaten the stability of the Korean economy.

The current labor problems are apparent obstacles to the macroeconomic adjustment policies. Labor disputes may cause Korean exporters to lose buyers and their competitiveness over foreign exporters because of the increase in wage rates.

Kim and Ro (1989) have argued that the role of exchange rate policy for surplus management is limited, in the sense that the Korean won is not so undervalued as to justify a drastic appreciation. In addition, the effects of exchange rate changes on the balance of payments are ambiguous and controversial.[5] In contrast, Williamson (1989) argued that the real equilibrium exchange rate of any fast-growing economy would tend to appreciate systematically over time because of the productivity bias. In addition, he pointed out that sitting on an undervalued exchange rate long enough may invite a wage explosion.

The new experience of a current account surplus has brought about macroeconomic issues, both domestically and internationally, which Korean

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[5]For more details about this argument, see Kim and Ro (1989).

policymakers have never before met. Internally, the current account surplus caused the money supply to increase, which resulted in price instability. Externally, the Korean economy has received the market opening pressure from its major trade partners. Under these circumstances, the Korean government has showed its endeavor to accelerate the free trade economy: Korean policymakers formulated and announced a comprehensive program of surplus management on 17 April 1987.[6] The major contents of the program are summarized as follows.

First, Korea has taken specific measures to keep the free trade principles. In 1981, Korea embarked on an ambitious liberalization program and carried it out continuously, despite structural constraints. This program has been accelerated since 1986, the year in which Korea showed its first current account surplus. This market opening program contains the following issues: 1) automatic import license approval drastically expanded (94.7 percent import liberalization ratio in 1988); 2) slashed tariffs; 3) streamlined import procedures; 4) legal reforms for intellectual property rights; 5) an opening service sector (banking services, insurance market, advertising market, etc.); and 6) agricultural market moves toward greater liberalization.

Second, to get rid of bilateral trade imbalances with the U.S., Korea initiated specific and unprecedented programs to accelerate imports from the U.S. The Korean government provides foreign currency loans to

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[6] For more details, see The Republic of Korea (1989).

increase imports of capital goods, equipment, and raw materials from countries that have a trade deficit with Korea, most notably from the United States.

Third, the government will take measures to restrain exports of low value-added products that increase Korean export volume without providing substantial benefits to the Korean economy. Furthermore, the government will intensify import and export diversification.

Fourth, public-sector investment will be expanded to promote more balanced growth of the economy. Infrastructure investment for the agricultural sector will also be increased.

Fifth, regardless of the validity of the won appreciation, the Korean government appreciated the won. The value of the won rose by 15.8 percent in 1988.

CHAPTER III. LITERATURE REVIEW

Purchasing Power Parity (PPP) has been a major building block for the monetary approach to exchange rate determination during the 1970s and 1980s. The monetary economists have viewed the PPP doctrine as a simple extension of the traditional Quantity Theory of Money to the open economy. But this approach has been attacked on empirical grounds (Dornbush, 1980; Daniel, 1986).

Cassel (1916) argued that the rate of exchange between two countries is primarily determined by the quotient between each country's real purchasing power of money. He also proposed to call this real parity "The Purchasing Power Parity." But this kind of PPP notion has been traced to the 16th century (see Einzig, 1962). The proponents of PPP asserted that the exchange rate would be set to equilibrate to a ratio of aggregate price indices for the two countries or that the percentage change in the exchange rate should equal the difference between the percentage rates of inflation in the two countries.

Note that both the exchange rate and each country's aggregate price level are determined simultaneously and endogenously in the real world. Considering this simultaneity and endogeneity of the exchange rate and aggregate price level, the PPP would be regarded as the equilibrium relationship of each country's real purchasing power rather than a precise theory of exchange rate determination.

In Section 1, we will discuss the theoretical formulation for PPP. In Section 2, we will also review purchasing power disparity from the theoretical point of view. In Section 3, we will show empirical evidence for both the failure of PPP and the support for PPP. In Section 4, we will discuss the implications for the deviations from PPP. Lastly, we will derive the real exchange rate in terms of monetary shocks and real shocks by using Dornbush's discrete time version model.

Theoretical Review for PPP

The pure theory of international trade says that 1) autarkic price difference in the same good between countries would occur by the factor endowment difference (Hecksher-Ohlin-Samuelson theorem) or technological difference (Ricardian theory) and 2) in the assumed absence of transport costs and trade restrictions, price of the homogeneous good would be equalized by trade between countries.

This spatial arbitrage of law of one price is the basis for the strong or absolute version of PPP in an integrated, competitive market system. As Dornbush (1985) argued, the law of one price for individual goods extends to the aggregate price levels when 1) domestic price index function has the same functional form with the foreign price index function and 2) the same goods enter each country's market basket.

In this context, the spatial arbitrage of the law of one price takes the following formula of the strong or absolute version of PPP.

$$(1) \quad ep^* = p,$$

where e denotes the number of units of domestic currency per unit of foreign currency, p^* indicates the foreign price level, and p indicates the domestic price level.

In equation (1), the left-hand side is the foreign price level, which is expressed in domestic currency units.

This absolute version of PPP implies that the real exchange rate (ep^*/p) is 1 at all time spans. If we would restrict ourselves into the very hypothetical economy--in which each country produces homogeneous goods within a perfect competition market system in which there are no trade restrictions, no transportation costs, no informational barriers, and there is an internationally identical price index function--then we could not elicit any objection to equation (1) as a theoretical statement.

In reality, this hypothetical economic environment is not true. Trade impediments cause the real exchange rate to deviate from its long-run real exchange rate ($\frac{ep^*}{p} = 1$).

With no trade obstacles, perfect commodity arbitrage ensures that the law of one price prevails throughout the world. Notice that the failure of the law of one price for each good does not mean market failure. Market efficiency would be obtained provided that the price system could capture all of the trade impediment costs. Trade impediments themselves do not indicate market inefficiency.

Even though the law of one price would not prevail in the real world, it will not preclude the fact that the domestic price level is highly correlated with the foreign price level in common currency units.

The weak or relative version of PPP relies on the Cassel-Ricardo Neutral-Money Version of PPP. As Cassel (1916) said, in the presence of unusually different rates of money supply ratio between countries during a wartime, the rate of exchange should be expected to deviate from its old parity in proportion to the inflation rate of each country.

As Samuelson (1964) argued, Cassel's PPP doctrine simply meant that the economy was in a standard money neutrality proposition. The absolute price level of all goods could double or halve without affecting the relative price ratio and thus the real resource allocation pattern.

The weak or relative version of PPP states that the percentage change in the exchange rate equals the percentage change in the relative price ratios between two countries. This statement has taken the following form:

$$(2)\ ep^* = rp$$

where r could be any constant. In other words: $\hat{e} = \hat{p} - \hat{p}^*$, where a $\wedge$ denotes a percentage change.

Note that r is any constant reflecting the given obstacles to trade. As we have already argued, PPP theory is an equilibrium relationship between the domestic price level (P) and the foreign price level (ep^*), rather than the exchange rate determination. In the time series context, if there is an equilibrium relationship between p and ep^*, there should exist a unique cointegrating vector which makes the linear combination of ep^* and p stationary (Enders, 1988). In this case, p and ep^* could be nonstationary stochastic processes.

In a strict sense, the absolute or strong version of PPP would not hold because the price index function would be different internationally and each country would produce different kinds of goods; furthermore, there would be trade obstacles in a different way between countries. On the other hand, the relative version of PPP may hold in a weak sense if there is no money illusion in the economy. The constant r in the relative version of PPP would be a way of circumventing the qualifications arising from any obstacles to the absolute version of PPP.

The next issue is what kind of price index is appropriate in calculation of PPP. If we believe in money neutrality, any kind of price index, such as wholesale price indexes, consumer price indexes, Gross Domestic Product (GDP) deflators, production cost indexes, or relative export price indexes, can be used in calculation of PPP.

Samuelson (1964) argued that the relative export price indexes would not be appropriate for calculating PPP. But if we interpret that p (domestic price level) is the price of exportables and ep^* (foreign price level) is the price of importables, then the real exchange rate (ep^*/p) is the relative price of importable goods in terms of exportable goods. In the context of money neutrality, the relative price of importable goods would not be changed by the monetary disturbances.

In a Ricardian framework, Samuelson (1964) argued that production cost parity would not be appropriate in the sense that the borderline goods would be changed by the demand shock in some countries.[1] The

[1]For more details see Samuelson, 1964.

change in borderline goods causes the change in exchange rate. Interpreting Houthakker's production cost parity as the production cost index parity, Houthakker's production cost parity could be used in calculation of PPP. If we restrict ourselves within an artificial economy with constant returns to scale technology and perfect competition market structure, the marginal cost (market price) of any good is the function of only the factor prices. Note that a money neutral economy does not alter the relative factor prices and thus does not change the price level, which is the marginal cost of any good.

In short, none of these price indexes would matter in a money neutral economy.

Note that the constant r in the relative version of PPP is a function of economic environment, such as trade obstacles, demand condition, and the change of relative efficiency of labor. In an empirical study, we have to give attention to choosing the particular time span. The time span we choose may consist of different economic environments, which gives rise to a misleading PPP. Samuelson (1964) argued this situation in the following way. If some economic balance such as trade balance is the function of real exchange rate, that is, $F(W/Rw) = 0$, where $W/Rw = p/ep^*$ and W and w denote unit labor costs at home and abroad in the respective currencies, then the function F could change.

As stated by Samuelson (1964, p. 153), "Naive PPP must assume that the function F is not a function with time. Sophisticated PPP asserts that F has not changed much or estimates how it has changed. Unless very sophisticated, indeed, PPP is a misleadingly pretentious doctrine, promising us what is rare in economics, detailed numerical predictions."

Purchasing Power Disparities (Theoretical Review)

Deviations from PPP can be explained several different ways. In this section, we first consider structural departures from PPP which cause equilibrium relative prices to change. The second thing we consider is transitory deviations from PPP. These transitory deviations from PPP are usually the result of the differential speed adjustment of prices in goods and assets markets. In addition to these deviations from PPP, econometric misspecification can yield misleading PPP estimates.

Balassa (1964) indicated the structural deviations from PPP by emphasizing the importance of nonmonetary factors in the process of price determination. In a Ricardian framework, he argued that the currency of the country with higher productivity was highly overvalued relative to that of the country with lower productivity. According to his argument, a very substantial overvaluation of the dollar can not be wholly attributed to statistical defects of the calculation. But the critical assumption of his argument is that there is a sectoral difference of technology between traded and nontraded goods. With internationally smaller difference of technology in the service (a nontraded good) sector and perfect factor mobility within each country (equalized wages within each country), services will be relatively more expensive in countries with higher levels of productivity.[2]

In the presence of nontraded goods with technological differences between countries, the law of one price for all goods in the economy does not hold. Note that the law of one price is the basis for the strong or absolute version of PPP. In this way, Balassa pointed out the existence of systematic differences between purchasing power and exchange rates.

The validity of the relative version of PPP was criticized by Balassa (1964) in the following sense. The process of technological improvement and wage adjustment speed is the key factor in determining the general price level in each country. But these processes do not follow the same course in every country, so the causation does not run from the change in the relative general price level to the change in the exchange rate.

In the previous line of framework, the growing country's relative price level will increase (Dornbush, Fischer, and Samuelson, 1977). A uniform rise in traded goods productivity at home will increase the wages in that sector, which implies a nationwide wage increase. With no productivity gains in the nontraded goods sector, the price of nontraded goods will increase, which results in the increase in the relative price level. Thus, real factors (nonmonetary factors) can induce systematic deviations from PPP.

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[2]In the context of a relative factor endowment difference between countries (Hecksher-Ohlin Samuelson framework, 2=good 2=factor model), Bhagwati (1984) explained the reason why services are cheaper in the poor countries.

In addition to the structural departures from PPP, we are now in a position to explain the relatively persistent and often large deviations from PPP. Dornbush (1976) argued that exchange rate overshooting would arise from the differential adjustment speed of markets. That is, exchange rates and asset markets adjust quickly relative to goods markets. The validity of his argument is that wage levels are determined by long-term labor contracts, whereas exchange rates behave like asset prices. Monetary disturbances could cause the real exchange to deviate from the long-run level even though money is neutral in the long run.

Market imperfections can cause the real exchange rate to deviate from its long-run level. A monopolistic competition market structure could be desirable if it enhanced product variety; Dixit and Stiglitz (1977) show how this market structure could be welfare improving. With this market structure and only one factor (labor) with linear technology, each firm can set prices as a fixed and common markup over wages. Then the real exchange rate (ep^*/p) is expressed as (ew^*/w). Considering wage stickiness, flexible exchange rate movement can cause the real exchange rate to deviate from its long-run level.

In the context of imperfectly competitive markets and exchange rate volatility, Dornbush (1987) argued that the extent of price adjustment depends on the product substitutability, the relative number of domestic and foreign firms, and market structure. His position is that the relative exchange rate deviates from its long-run level in the short run. Contrary to the standard monetary view that the real exchange rate is independent of exchange rate, his argument depends on the assumption of sticky wages and exogenous exchange rate movements. Furthermore, he assumes that domestic and foreign goods are less than fully homogeneous and substitutable.

Empirical Evidence (Two Divergent Views)

Failure of PPP

The law of one price was flagrantly and systematically violated by empirical data (Isard, 1977). Isard (1977) showed some evidence that exchange rate changes substantially alter the relative dollar equivalent prices of the most narrowly defined domestic and foreign manufactured goods for which prices can easily be matched. Furthermore, these relative price changes seem to persist for at least several years and can not be shrugged off as transitory. In this context, he casts doubt on forming the aggregate price index which obeys the law of one price.

Kravis and Lipsey (1978) have also shown tests of the law of one price on very disaggregated manufactured goods. Their evidence is that there are substantial deviations from the law of one price even for traded goods. Their empirical study supports Balassa's (1964) hypothesis of structural deviations from PPP. Balassa's evidence is that the higher a country's relative per capita GDP, the higher its relative price level.

Hsieh (1982) has formed the determination of the real exchange rate by using the productivity approach with Ricardian framework. He emphasizes the real factors in the determination of real exchange rates. His argument is that if real factors are as important in exchange rate determination as the nominal forces, then the monetary approach to exchange rate determination can explain only part of the movement of exchange rates. His econometric results are consistent with his view. Eventually, his work has supported Balassa's hypothesis of structural deviations from PPP.

Dornbush (1985) has argued that, once real exchange rate (ep^*/p) has followed random walk, PPP performance will depend upon the particular price index chosen for comparison. In his empirical study, he has used GDP deflators because they have a clear methodological definition. His empirical study said that relative GDP deflators expressed in a common currency unit are far from constant, which implies that the weak version of PPP does not hold. He has shown some evidence that PPP performance depends upon different price indices (CPIs, WPIs, and GDP deflators) in case real exchange rate movement is nonstationary. That is, different price indices yield a different correlation of inflation rates expressed in U.S. dollars. The striking fact is that this result depends upon whether the data are quarterly or annual.

Frenkel (1981) has indicated two sources for the deviations from PPP. One is the real shocks to the economic system, which causes the relative price to change. He argued that the purchasing power disparities during the 1970s would be explained well by the real shocks (oil embargo, supply shocks, commodity booms and shortages, shifts in the demand for money, differential productivity growth). The other one is the different speed of adjustment between the price indices of goods and services and the exchange rate. The modern monetary approach to exchange rate determination (Mussa, 1979) views the exchange rates as the relative prices of assets, which are fundamentally different from the price indices of goods and services. The exchange rates, like other asset prices, are very sensitive to the "news" which alters expectations concerning the future course of events. In this context, exchange rates reflect not only current circumstances but also reflect future events.

Support for PPP

Hakkio (1984) reexamined the PPP theory in a multi-exchange rate world. He argued that the failure of PPP would be the result of imprecise parameter estimates. That is, many of the empirical studies for purchasing power disparities use the bilateral exchange rate model, which ignores international interdependence. His multilateral exchange rate model does take into account the cross-sectional variability in the data set. By doing this, he was unable to reject the hypothesis that PPP theory holds in several currencies simultaneously.

Edison (1987) asserted that a naive version of the PPP relationship did not adequately represent the exchange rate (dollar/pound). After taking into account the effects of changes in structural factors, he has supported the Ricardo-Cassel neutrality version of PPP in the long run.

Contrary to the Keynesian theory, monetary approach to exchange rate determination asserts that exchange rate changes will be proportional to relative inflation rate. This assertion implies that the causation runs from the change in the relative inflation rate to the change in the exchange rate. Krugman (1978) pointed out that simple regression tests lead people to reject the hypothesis of PPP. He also argued that the recognition of the endogeneity of both prices and exchange rates made PPP test results considerably more favorable, while not definitive, to PPP hypothesis.

Frenkel (1981) argued that PPP theory worked well in the 1920s but not during the 1970s. Contrary to this view, Davutyan and Pippenger (1985) contended that PPP did not collapse during the 1970s. They argued that Frenkel's finding of the collapse of PPP during the 1970s was the result of an increase in the importance of real shocks relative to monetary shocks. In addition, they believe that PPP works at least as well under monetary stability as it does during inflation.

Frankel (1985) found that the real exchange rate did not follow the random walk hypothesis in the long run. He was also unable to reject the random walk hypothesis in the short run. Thus, the hypothesis of the nonstationarity of the real exchange rate has not been established convincingly.

Implications of Purchasing Power Disparity

The deviations from purchasing power parity poses some macroeconomic issues. The issues considered are as follows.

With strict PPP, there is no problem in comparing real incomes internationally. The failure of the relative version of PPP implies that the economies concerned are not in the money neutrality proposition. Then, there could be systematic deviations from PPP, which is the Balassa's hypothesis. That is, purchasing power disparity implies that the relative prices between tradables and nontradables differ internationally. These internationally different relative prices can lead us to the distortion of international income comparison. As Samuelson (1974) argued, one country's real income relative to its counterparts could be overstated or understated depending on the chosen price index.[3]

Dornbush (1985) argued that real interest differential between countries equals the expected rate of real appreciation ($\dot{R}/R$, $R = p/ep^*$):[4]

$$r^* = r + \dot{R}/R$$

where, r = domestic real interest rate, r^* = foreign real interest rate, and $\dot{R} = \frac{dR(t)}{dt}$, t; time subscript.

If the relative version of PPP holds, $\dot{R}/R$ will vanish. Under no restrictions on capital mobility, real interest rates would become equalized across countries.

As Dornbush (1985) found, we can postulate the actual real exchange rate adjustment mechanism as follows: $\dot{R}/R = (1/S)(R' - R)$, where R' is the trend level of real exchange rate and S is a constant.

$$(3)\ R = R' + S(r - r^*)$$

Following the Keynesian absorption approach, if we assume that $Y = f\ (R - R')$, $f' < 0$, Y: Total GNP, then the policy implications would be as follows. Loosening monetary policy relative to its counterparts

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[3]See Samuelson (1974) for more details.

[4]See Dornbush (1985) for more details.

will eventually cause real depreciation so that real output will increase. The mechanism would be that the increase in competitiveness because of both the decrease in real interest rate and real exchange rate depreciation dominates the cost factor with the real exchange rate depreciation.

Notice that the real exchange rate is the relative price of home goods between countries provided that the price index function is the same across countries. Either persistent productivity differential or change in aggregate demand patterns makes the real exchange rate (relative price of home goods) nonstationary, which results in intrinsic differential real interest rate across countries. Along this argument, we say that the real interest rate in developing countries is lower than that of developed countries.

The nonstationarity of the real exchange rate increases the portfolio diversification risk (Branson and Henderson, 1984). PPP deviations motivate the international portfolio diversification. If we assume the mean preserving spread for asset returns, then the nonstationarity of the real exchange rate will increase the risk premium.

McKinnon (1988) has proposed a new monetary standard centered on fixed exchange rates between the Japanese yen, the German mark, and the U.S. dollar. His argument is summarized as follows (Dornbush, 1987).

McKinnon's position is that fixed exchange rates are superior to flexible exchange rates in the sense that:

1) With fixed exchanges, we can adjust to real disturbances and achieve price stability.

2) In the presence of incomplete commodity markets and exchange rate volatility resulting from money demand shocks, fixed exchange rates are socially preferably to flexible exchange rates.
3) The real exchange rate could not affect the current account.
4) PPP is a good nominal anchor to equilibrium exchange rates.
5) World monetary growth should be targeted to achieve price level.

Contrary to this argument, with a microtheoretical approach, Lapan and Enders (1980) argued that exchange regime comparison should be based on the people's preferences. Furthermore, in the presence of nontraded goods, they argued that the relative prices (tradables versus nontradables) are more stationary in the flexible exchange regime.

One of Dornbush's (1987) arguments is that the trend changes in equilibrium real exchange rates between Europe, the U.S., and Japan occur because of the emergence of the newly industrialized countries like Korea, Brazil, and other trading countries. In this line of argument, our point is that if the real exchange rate (Korea versus the U.S., Japan, Germany) is nonstationary, then the PPP exchange rate (real exchange rate) can not be used as a nominal anchor to equilibrium exchange rates.

If we interpret the real exchange rate as the relative price of importables in terms of exportables, then the nonstationarity of the real exchange rates makes the resource allocation pattern more complicated. Considering nontradable sectors, then the complexity of the resource allocation pattern would be strengthened.

Note that PPP is the major building block for the monetary approach to exchange rate determination. The nonstationarity of the real exchange rate implies that the exchange rate behavior suggested by the monetary approach is not appropriate.

Real Exchange Rate Determination (Two-Country Version of the Dornbush Model)

Most modern models of exchange rate determination suggest that any variety of monetary shocks can induce temporary but not permanent deviations from PPP. Real shocks, on the other hand, can induce changes in the real exchange rate; a real shock which is permanent can induce a permanent deviation from PPP.

To prove these propositions, we have employed a discrete-time version of the Dornbush model (two-country version);[5]

$$m(t) - P(t) = - a^{-1}r(t) + \delta y(t) \quad \ldots (1)$$

[portfolio balance]

$$m^*(t) - P^*(t) = - a^{-1} r^*(t) + \delta y^*(t) \quad \ldots (1')$$

$$r(t) = r^*(t) + e(t+1) - e(t) \quad \ldots (2)$$

[interest parity]

$$P(t+1) - P(t) = b[e(t) + P^*(t) - P(t)] - \gamma y(t) - fr(t) \quad \ldots (3)$$

[price adjustment]

$$P^*(t+1) - P^*(t) = - b^*[e(t)+P^*(t)-P(t)] - \gamma^* y^*(t) - fr^*(t) \quad \ldots (3')$$

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[5]Following Dornbush (1976) and Backus (1986), we have adapted the model in a two-country version. We have assumed the perfect foresight world.

where P and e denote the domestic prices and the nominal exchange rate, * denotes foreign country's counterpart, m denotes money supply, and r denotes the nominal interest rate. The term y(t) denotes a productivity shock (or income shock). All the parameters are positive constants. All variables but r are in logs. Price adjustment equations (3 and 3') represent the excess demand for domestic goods. For simplicity, we have assumed that both economies have the same parameter values in the portfolio balance equation.

To solve the model, we have to distinguish endogenous variables from exogenous variables. The endogenous variables are P(t), $P^{*}(t)$, e(t), r(t), and $r^{*}(t)$, whereas the exogenous variables are m(t), $m^{*}(t)$, y(t), and $y^{*}(t)$.

Substituting (1) and (1') into (2), (3) and (3') yields the vector first-order difference equation;

$$\begin{bmatrix} e(t+1) \\ P(t+1) \\ P^{*}(t+1) \end{bmatrix} = \begin{bmatrix} 1 & a & -a \\ b & (1-b-af) & b \\ -b^{*} & b^{*} & (1-b^{*}-af) \end{bmatrix} \begin{bmatrix} e(t) \\ P(t) \\ P^{*}(t) \end{bmatrix} + \begin{bmatrix} \alpha\delta(y(t)-y^{*}(t))-\alpha(m(t)-m^{*}(t)) \\ -(\gamma+fa\delta)y(t) + fam(t) \\ -(\ {}^{*}+fa\delta)y^{*}(t) + fam^{*}(t) \end{bmatrix}$$

The stability condition in the vector difference equation restricts the parameter space. That is, $\left| A - \lambda_i I \right| = 0$, where

$$A = \begin{bmatrix} 1 & a & -a \\ b & (1-b-af) & b \\ -b^{*} & b^{*} & (1-b^{*}-af) \end{bmatrix}$$: the characteristic roots are less than 1 in absolute value.

Rewriting the above vector difference equation, then

$$\left[I - AL\right]\begin{bmatrix} e(t+1) \\ P(t+1) \\ P^*(t+1) \end{bmatrix} = \begin{bmatrix} \alpha\delta(y(t) - y^*(t) - \alpha(m(t) - m^*(t)) \\ - (\gamma + fa\delta)\ y(t) + fam(t) \\ - (\gamma^* + fa\delta)\ y^*(t) + fam^*(t) \end{bmatrix}$$

Multiplying $(I - AL)^{-1}$ in both sides then yields

$$\begin{bmatrix} e(t+1) \\ P(t+1) \\ P^*(t+1) \end{bmatrix} = \left[I - AL\right]^{-1} \begin{bmatrix} \alpha\delta[y(t) - y^*(t)] - a[m(t) - m^*(t)] \\ - (\gamma + fa\delta)\ y(t) + fam(t) \\ - (\gamma^* + fa\delta)\ y^*(t) + fam^*(t) \end{bmatrix}$$

where L is the lag operator.

If we assume that the characteristic equation has three distinct roots (for example, $|\lambda_1| \geqslant 1$, $|\lambda_2| < 1$, $|\lambda_3| < 1$), then the paths of the price levels $[P(t+1), P^*(t+1)]$ and the nominal exchange rate are determined by the future, current, and past values of the relative money supply shocks and the relative productivity shocks.[6]

We are now in a position to see the long-run properties of this model. Note that the "steady state" solution has the following properties:

1) Money supply "shock" has a temporary but not permanent effect on real exchange rates.

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[6]To map all bounded sequences into bounded sequences, we applied $(I\text{-}AL)^{-1}$ such that we choose the "backward" expansion if $|\lambda| < 1$ and the forward expansion if $|\lambda| > 1$.

Proof

We have already proved the fact that the time paths of e(t), P(t), $P^*(t)$ are determined by the future, current, and past values of monetary shock, which implies that monetary shock has a temporary effect on the real exchange rate $[e(t) + P^*(t) - P(t)]$.

We are now in a position to prove the second part of the proposition; monetary shock has no permanent effect on the real exchange rate.

Consider the steady-state version of the model;

$$\overline{m} - \overline{P} = - a^{-1} \overline{r} + \delta \overline{y} \quad \ldots \text{(B1)}$$

$$\overline{m}^* - \overline{P}^* = - a^{-1} \overline{r} + \delta \overline{y}^* \quad \ldots \text{(B2)}$$

$$0 = b \overline{R} - \gamma \overline{y} - f \overline{r} \quad \ldots \text{(B3)}$$

$$0 = - b^* \overline{R} - \gamma^* \overline{y}^* - f \overline{r} \quad \ldots \text{(B4)}$$

where $\overline{R} = \overline{e} + \overline{P}^* - \overline{P}$, and bar denotes the superscript, which indicates the steady-state value of the variable.

Manipulating (B3) and (B4) yields $\overline{R}$ and $\overline{r}$;

$$\overline{R} = \frac{\gamma \overline{y} - \gamma^* \overline{y}^*}{b + b^*}, \quad \overline{r} = - \frac{\gamma \overline{y} + \gamma^* \overline{y}^*}{2f}$$

Substituting $\overline{r}$ into (B1) yields $\overline{P}$;

$$\overline{P} = \overline{m} - \delta\,\overline{y} + a^{-1}\left[\frac{-(\gamma\overline{y} + \gamma^{*}\,\overline{y}^{*})}{2f}\right]$$

Substituting $\overline{r}$ into (B2) yields $\overline{P}^{*}$;

$$\overline{P}^{*} = \overline{m}^{*} - \delta\,\overline{y}^{*} + a^{-1}\left[\frac{-(\gamma\,\overline{y} + \gamma^{*}\,\overline{y}^{*})}{2f}\right]$$

Substituting $\overline{P}$ and $\overline{P}^{*}$ into $\overline{R}$, we can get $\overline{e}$;

$$\overline{e} = \frac{\gamma\,\overline{y} + \gamma^{*}\,\overline{y}^{*}}{b + b^{*}} + (\overline{m} - \overline{m}^{*}) - \delta(\overline{y} - \overline{y}^{*})$$

$\frac{\partial\overline{e}}{\partial\overline{m}} = 1$, $\frac{\partial\overline{P}}{\partial\overline{m}} = 1$; it shows the conventional homogeneity property.

$\frac{\partial\overline{R}}{\partial\overline{m}} = 0$; monetary shock has no permanent effect on the real exchange rate.

Q.E.D.

2) Productivity shock (real shock) has a permanent effect on the real exchange rate.

<u>Proof</u>

$\frac{\overline{R}}{\overline{y}} = \frac{\gamma}{b + b^{*}}$, $\frac{\overline{R}}{\overline{y}^{*}} = \frac{-\gamma^{*}}{b + b^{*}}$; real shock does matter in the long run.

Q.E.D.

CHAPTER IV. UNIT ROOT AND COINTEGRATION TESTS OF PPP IN THE KOREAN ECONOMY

The literature review suggests that there is considerable controversy concerning the appropriateness of the PPP assumption. To date, the vast majority of the empirical tests have concerned the U.S., European, and Japanese economies. In a sense, such tests are most favorable to PPP; the implicit assumption is that PPP should perform best between economies with similar industrial structures. However, this assumption may not be valid. As shown by Mussa (1979), PPP works well for nations experiencing very different inflation rates. Enders' (1989) study of PPP during the greenback and gold-standard periods shows that PPP works well for nations experiencing very rapid growth rates.

In this light, it is interesting to consider the PPP relationship for the Korean economy. Korea represents a rapidly growing economy with strong trading ties to other Pacific Rim nations as well as to the U.S. and Europe. A comparison of the performance of PPP between Japan and Korea (both rapidly growing nations) might provide an interesting contrast to that of Korea versus other Pacific Rim nations and to Korea versus the U.S. The methodology that follows is that of Enders (1988, 1989) and Corbae and Ouliaris (1988).

Unit Root Tests and the Real Exchange Rate

To test the PPP relationship, consider the following econometric model:

$$(1) \quad e(t)p^*(t) - rp(t) = d(t)$$

where $e(t)$ = won price of the foreign currency in (t), $p^*(t)$ = foreign price level in (t), $p(t)$ = Korean price level in (t), $d(t)$ is a stochastic disturbance which represents a deviation from PPP, and r is a constant.

Long-run PPP implies that $r = 1$ and $d(t)$ is stationary with mean zero. Note that e, p, and p^* are endogenous variables which are jointly determined; there is no obvious candidate for the left-hand side variable. To avoid the standard practice of estimating (1) by using instrumental variables, consider the reformulation of PPP in terms of the real exchange rate:

$$(2) \quad e(t)p^*(t)/p(t) = r + d_1(t)$$
$$r(t) = r + d_1(t)$$

where $d_1(t)$ is a stochastic disturbance and $r(t)$ is the real exchange rate = $e(t)p^*(t)/p(t)$.

In this formulation, long-run PPP holds if $d_1(t)$ is stationary; r is then the long-run value of the real exchange rate and $d_1(t)$ is the deviation of the real exchange rate from its long-run value.

The ARIMA model selection

If $d_1(t)$ is an indeterministic covariance stationary stochastic process, by the Wold decomposition theorem, $d_1(t)$ has an infinite order moving average representation which can be well approximated by a finite autoregressive representation under certain conditions.

If, for example, $d_1(t)$ is finite ARIMA (n, 0, 0), the underlying process for the real exchange rate movement is suggested by:

$$(3) \quad r(t) = a_0 + a_1 r(t-1) + \ldots + a_n r(t-n) + e_1(t)$$

where $e_1(t)$ is a serially uncorrelated stochastic disturbance with mean equal to zero.

Given this specification, long-run PPP requires that all characteristic roots of (3) lie within the unit circle. Because we can test only the relative version of PPP, the data place no restrictions on the estimated value of r. Using monthly data from International Financial Statistics, the real exchange rates for 6 of Korea's major trading partners--the U.S., Germany, Japan, India, the Philippines and Thailand--were constructed. The sample period is January 1973 to July 1987 (representing a period of flexible exchange rates).

The data series for the U.S. real exchange rate was constructed by multiplying the U.S. wholesale price index by the won price of the dollar and then dividing by the Korean wholesale price index. In the same way, we have obtained the real exchange rates for other countries.

Standard Box-Jenkins model selection procedures were used to characterize the nature of the $d_1(t)$ series. This Box-Jenkins modeling strategy consists of three stages (identification, estimation, and diagnostic checking). The maximum likelihood estimates of the "best" ARIMA models for each country are reported in Table 4-1.

Table 4-1. Maximum likelihood ARIMA estimates

$$r(t) = a_0 + \alpha_1 r(t-1) + \alpha_2 r(t-2) + \alpha_3 r(t-3) + e1(t)$$

January 1973-July 1987	a_0	a_1	a_2	a_3	MU[a]
U.S.	0.0235	0.9867 (0.0738)[b]	0.1838 (0.1041)	-0.1933 (0.0739)	1.0325
Germany	0.0433	1.2499 (0.0722)	-0.2858 (0.0725)		1.2065
Japan	0.0288	1.2216 (0.0731)	-0.2427 (0.0740)		1.3705
Philippines	0.0464	0.9662 (0.0166)			1.3765
India	0.0233	1.2605 (0.0722)	-0.2858 (0.0722)		0.9232
Thailand	0.0406	0.9630 (0.0190)			1.1011

[a]MU indicates mean level of the real exchange rate.

[b]The standard errors are in parentheses.

We are now in a position to determine whether the real exchange rates are stationary. Mann and Wald (1943) proved that the vector of least squares estimators for the nth-order stationary time series converges in distribution to a vector normal random variable. For the nonstationary time series, the story is different. The special case of nonstationary time series with multiple unit roots has been discussed by Dickey and Fuller (1979), Hasza and Fuller (1982), and Dickey, Hasza, and

Fuller (1984). In the presence of a single unit root, the standard Dickey-Fuller test is suggested by ARIMA representation.[1] The Dickey-Fuller test consists of rewriting equation (3) as:

$$(4)\quad r(t) = a_0 + b_1 r(t-1) + \sum_{i=2}^{n} b_i \mathrm{delr}(t+1-i) + e_1(t)$$

where: $b_1 = \sum_{i=1}^{n} a_i$; $b^i = -\sum_{j=i}^{n} a_{j+1}$; $\mathrm{delr}(t+1-i) = r(t+1-i) - r(t-1)$

Dickey and Fuller show that the confidence intervals under the null hypothesis that $b_1 = 1$ are larger than the standard confidence intervals under the null of no unit root. To reject the null of no unit root, Dickey and Fuller calculate that $\left(\frac{b_1 - 1}{\text{standard error}}\right)$ must be greater than:[2]

Significance Level

Obs.	0.01	0.05	0.10
100	-3.51	-2.89	-2.58
250	-3.46	-2.88	-2.57

Unit root test results for the real exchange rate for each country are reported in Table 4-2.

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[1]Given a stochastic difference equation, for example, $r(t) = a_0 + a_1 r(t-1) + a_2 r(t-2) + a_3 r(t-3) + e(t)$, if we suspect that there is a single unit root with the other roots less than 1, then the above stochastic difference equation can be rewritten in the following form: $r(t) = a_0 + b_1 r(t-1) + b_2 \mathrm{delr}(t-1) + b_3 \mathrm{delr}(t-2)$ where $b_1 = a_1 + a_2 + a_3$.

[2]The stability condition is simply that the absolute value of b_1 be less than unity.

Table 4-2. Dickey-Fuller form of ARIMA estimates

$$r(t) = a_0 + b_1 r(t-1) + b_2 \mathrm{delr}(t-1) + b_3 \mathrm{delr}(t-2) + e_1(t)$$

	a_0	b_1	b_2	b_3	t-stat[a]	R
U.S.	0.0284 (0.0147)[b]	0.9711 (0.0146)	0.0010 (0.0748)	0.1925 (0.0747)	-1.97	0.964
Germany	0.0408 (0.0204)	0.9652 (0.0171)	0.2649 (0.0734)		-2.03	0.951
Japan	0.0271 (0.0207)	0.9796 (0.0157)	0.2100 (0.0754)		-1.29	0.960
Philippines	0.0496 (0.0288)	0.9652 (0.0209)			-1.66	0.926
India	0.0327 (0.0132)	0.9619 (0.0145)	0.2620 (0.0725)		-2.61	0.963
Thailand	0.0463 (0.0218)	0.9562 (0.0198)			-2.19	0.932

[a]The t-statistic is for the hypothesis $b_1 = 1$.

[b]The standard errors are in parentheses.

Notice that these estimated parameters are in the stability set of the parameter space; the point estimate of the largest characteristic root always suggests convergence. However, by using the Dickey-Fuller confidence intervals under the null of a single unit root, we cannot reject the null at the 10% significance level for all countries but India. Even though we could not accept the random walk hypothesis for the real exchange rate for India, the point estimate for dominant root indicates that there is a great amount of persistence in any deviation from the PPP.

SURE Estimates

If we could not rule out any possible correlation in the error terms across equations, it is natural for us to consider Zellner's Seemingly Unrelated Regressions (SURE) estimates of the real exchange rate. By doing this, we can improve the precision of our estimates.

In performing the SURE estimations, the ARIMA representation for the real exchange rate was used: an AR(1) for the Philippines and Thailand an AR(2) for Germany, Japan, and India, and an AR(3) for the United States. The results are reported in Table 4-3; the column labeled 't-statistic' indicates the t-value for $b_1 = 1$.

From Table 4-3, we can now reject the null of a unit root for the U.S. as well as for India. It is surprising that, other than for Thailand, the Japanese-Korean real exchange rate is the most likely to be nonstationary.

Cointegration and Error Correction Models

If two economic variables are nonstationary, it is still possible that a linear combination of the two is stationary. Following Granger and Engle (1984), we know that two time series--$3(t)p^*(t)$ and $p(t)$--are cointegrated of order (d, b) if:

Table 4-3. Unit root tests for SURE model

$$r(t) = a_0 + b_1 r(t-1) + b_2 delr(t-1) + b_3 delr(t-2)$$

January 1973-July 1987	a_0	b_1	b_2	b_3	t-statistic[a]
U.S.	0.0364 (0.0107)[b]	0.9632 (0.0106)	0.1141 (0.0517)	0.0863 (0.0502)	-3.47
Germany	0.0340 (0.0151)	0.9709 (0.0125)	0.2795 (0.0526)		-2.32
Japan	0.0310 (0.0163)	0.9766 (0.0123)	0.2221 (0.0576)		-1.90
Philippines	0.0523 (0.0205)	0.9633 (0.0181)			-2.02
India	0.0308 (0.0092)	0.9641 (0.0200)	0.2636		-3.59
Thailand	0.0151 (0.0165)	0.9848 (0.0150)			-1.01

[a]The t-statistics are for the hypothesis $b_1 = 1$.

[b]The standard errors are in parentheses.

1) $e(t)p^*(t)$ and $p(t)$ are integrated of order d; thus, to have stationary stochastic processes, we have to difference both p(t) and $e(t)p^*(t)$ d times.

2) there exists a scalar r ($r \neq 0$) so that the series $e(t)p^*(t) - r\,p(t)$ is integrated of order d - b.

Campbell and Shiller (1987) argued that vector autoregressive representation is not appropriate in the presence of a cointegrating vector; instead, an error-correction model is also recommended. As Granger and Engle (1984) show, if p(t) and $e(t)p^*(t)$ are integrated of order 1, then it is generally true that $z(t) = e(t)p^*(t) - s\ p(t)$ will also be I(1). However, it is possible that $d(t) = e(t)p^*(t) - r\ p(t)$ is intergrated of order zero.

By using this information, we can construct the error correcting model. A linear representation of the econometric model is as follows:

(1) $e(t)p^*(t) - r\ p(t) = d(t)$

(5) $e(t)p^*(t) - s\ p(t) = z(t)$

Note that d(t) should be stationary because, by assumption, p(t) and $e(t)p^*(t)$ are cointegrated of order (1, 0); the residual of (1) is stationary without differencing. Note that this is an assumption implied by PPP; unless d(t) is stationary, long-run PPP cannot hold. On the other hand, z(t) is assumed to follow a random walk; if z(t) is stationary, prices and the exchange rate must be stationary. The stationarity of z(t) is violated by the observed movements in prices and the exchange rate.

To formulate the error-correcting model, let the d(t) series exhibit first-order serial correlation. An AR representation for d(t) and a z(t) series could be written as:

(6) $d(t) - \rho d(t-1) = e_2(t)$

(7) $z(t) - z(t-1) = e_3(t)$

where $e_2(t)$ and $e_3(t)$ are uncorrelated white noise disturbances and $0 < \rho < 1$.

Manipulating (1), (5), (6), and (7), we can derive the error correction representation.[3]

$$(8)\quad (1-L)e(t)p^*(t) = -s(1-\rho)/(s-r)\ d(t-1) + s/(s-r)\ e_2(t) -r/(s-r)\ e_3(t)$$

$$(9)\quad (1-L)\ p(t) = -(1-\rho)/(s-r)\ d(t-1) + 1/(s-r)\ e_2(t) - 1/(s-r)\ e_3(t)$$

Equations (8) and (9) show how exchange rates and/or prices $[e(t)p^*(t), p(t)]$ can be explained by the previous deviation--d(t-1)--from equilibrium. Notice that the error-correction model would be appropriate if there is a cointegrating vector which makes the linear combination of economic variables stable. But we can not exclude the possibility of no cointegrating vector.

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[3]Equations (1) and (6) can be combined to obtain: $(1-\rho L)e(t)p^* = r(1-\rho L)p(t) + e_2(t)$, where L denotes the lag operator. We can obtain the following equation, (A), by adding and subtracting $Le(t)p^*(t)$ and $r\ p(t-1)$.

$$(A)\quad (1-L)e(t)p^*(t) = r(1-L)p(t) + r(1-\rho)p(t-1) - (1-\rho)e(t-1)p^*(t-1) + e_2(t)$$

Equation (7) yields (B).

$$(B)\quad (1-L)e(t)p^*(t) = s(1-L)p(t) + e_3(t)$$

Solving (A) and (B) simultaneously yields (8) and (9).

Cointegration Tests

Engle and Granger (1987) argued that the estimated cointegrating vector is a consistent estimator in a large sample. Regressing $e(t)p^*(t)$ on $p(t)$, we obtain an estimate of r which is a consistent estimator provided that $d(t)$ is stationary. In the same way, the regression of $p(t)$ on $e(t)p^*(t)$ yields a consistent estimator of $1/r$.

To perform the cointegration tests, the residuals of this equilibrium regression should be checked for stationarity by using a Dickey-Fuller test; if $p(t)$ and $e(t)p^*(t)$ are cointegrated, the residuals must be stationary. The 'equilibrium' relationship was estimated as follows:

$$e(t)p^*(t) = r\ p(t) + d(t).$$

If $d(t)$ is stationary, a finite AR representation for $d(t)$ is possible. This AR representation for $d(t)$ could well be rewritten for a Dickey-Fuller test.

$$\text{Specifically:}\quad (1-L)\hat{d}(t) = \theta\hat{d}(t-1) + \sum_{i=1}^{n} (1-L)\hat{d}(t-i)$$

where the $\hat{d}(t)$ series is the estimated residual of (1). If the estimated residuals are stationary, the estimated value of θ will be significantly different from zero. Cointegration test results are reported in Table 4-4.

Table 4-4 indicates that the cointegration tests fail for all nations except for the case of Thailand. All the t-statistics except for Thailand's are sufficiently small that we can not reject the null hypothesis of no cointegrating vector at a 10% significance level.

Table 4-4. Cointegration test

January 1973–July 1987		t-statistic[a]
No lagged changes; $(1-L)d(T) = a_0 + \theta d(t-1)$		
United States	-0.0105 (0.0110)[b]	0.9545
Germany	0.0 (0.0148)	0.0
Japan	-0.005 (0.0134)	-0.073
Philippines	-0.0363 (0.0216)	-1.6805
India	-0.0425 (0.0221)	-1.92
Thailand	-0.0935 (0.0325)	-2.87
Four lags; $(1-L)d(t) = a_0 + \theta d(t-1) + \sum_{i=1}^{4} \delta_i (1-L)d(t-i)$		
United States	-0.0135 (0.0112)	-1.2053
Germany	0.0031 (0.0140)	0.2214
Japan	-0.0174 (0.0143)	-1.2167
Philippines	-0.0344 (0.0225)	-1.5288
India	-0.0578 (0.0226)	-2.5575
Thailand	-0.0147 (0.0364)	-4.05

[a]The t-statistic is for the hypothesis $\theta = 0$. To reject the null of no unit root, Dickey and Fuller show that the t-statistic should be greater than -2.58 (with 100 observation) at 10% significance level.

[b]The standard errors are in parentheses.

Notice, however, that cointegration tests for PPP between Korea and India are borderline insignificant at the 10% level. Given the point estimates, there is some evidence supportive of PPP; in general, however, it is hard to argue that long-run PPP holds for Korea.

Error correcting model

Given that the Thai and Korean price levels are cointegrated, it is possible to estimate the error-correcting model. Consider (10) and (11):

$$(10)\quad (1\text{-}L)e(t)p^{*}(t) = \underset{(0.0093)}{0.0298} - \underset{(0.0364)}{0.0712}\,[e(t\text{-}1)p^{*}(t\text{-}1) - rp(t\text{-}1)]$$

$$(11)\quad (1\text{-}L)p(t) = \underset{(0.0050)}{0.0307} + \underset{(0.0194)}{0.0227}\,[e(t\text{-}1)p^{*}(t\text{-}1) - rp(t\text{-}1)]$$

where r is the estimate of the long-run real exchange rate obtained from the equilibrium regression.

The Thailand price level multiplied by the won price of the baht declined in response to a positive deviation from PPP. The point estimate of the slope coefficient in (10) says that approximately 7% of the previous deviation from the equilibrium relationship was adjusted within one month.

Note that the Korea price level does not seem to be responsive to deviations from previous equilibrium relationship with Thailand; the point estimate of the adjustment coefficient for the Korean price level is well within a standard deviation from zero. This result would be expected if we consider that Thailand is the minor trade partner for Korea.

Consider the error-correcting models for the Korea major trade partners, the U.S. and Japan. Even though they failed the formal test for cointegration, the error-correcting representations are instructive.

Consider the error-correcting model for the U.S.:

$$(12)\quad (1\text{-}L)e(t)p^{*}(t) = \underset{(0.0047)}{0.0321} - \underset{(0.0098)}{0.0498}\ [e(t\text{-}1)p^{*}(t\text{-}1) - rp(t\text{-}1)$$

$$(13)\quad (1\text{-}L)p(t) = \underset{(0.0048)}{0.0303} - \underset{(0.0100)}{0.0368}\ [e(t\text{-}1)p^{*}(t\text{-}1) - rp(t\text{-}1)$$

In response to a positive deviation from PPP, the U.S. price level multiplied by the won price of the dollar decreased. The point estimate of the slope coefficient in (12) implies that about 5% of the previous deviation from the PPP was corrected within one month.

The Korean price level actually declined in response to a positive deviation from the PPP; the point estimate of the adjustment coefficient for the Korean price level is significantly different from zero.

Consider also the error-correcting model for Japan:

$$(14)\quad (1\text{-}L)e(t)p^{*}(t) = \underset{(0.0143)}{0.0533} - \underset{(0.0130)}{0.0092}\ [e(t\text{-}1)p^{*}(t\text{-}1) - rp(t\text{-}1)]$$

$$(15)\quad (1\text{-}L)p(t) = \underset{(0.0050)}{0.0306} - \underset{(0.0045)}{0.0065}\ [e(t\text{-}1)p^{*}(t\text{-}1) - rp(t\text{-}1)]$$

Contrary to the U.S., Japan's price level multiplied by the won price of the yen was not responsive to a positive deviation from the PPP. The point estimate of the slope coefficient in (14) is well within a standard deviation from zero.

Moreover, the Korean price level did not appear to be responsive to deviations from the real exchange rate movement, the point estimate of the adjustment coefficient for the Korean price level is well within a standard deviation from zero.

To see the adjustment between the exchange rate and the PPP in a different way, we have repeated the Engle and Granger (1987) procedure by using the foreign price level and the Korean price level divided by the won price of the foreign exchange.

The estimated error-correcting models for Thailand are:

$$(16) \quad (1-L)p^{*}(t) = \underset{(0.0020)}{0.0120} + \underset{(0.0157)}{0.0220} \, [p(t-1)/e(t-1) - (1/r)p^{*}(t-1)]$$

$$(17) \quad (1-L)p(t)/e(t) = \underset{(0.0041)}{0.0126} - \underset{(0.0323)}{0.0728} \, [p(t-1)/e(t-1) - (1/r)p^{*}(t-1)]$$

The point estimate of the slope coefficient for (16) shows that Thailand's price level did not seem to be responsive to a positive deviation from the previous equilibrium regression; the point estimate of the adjustment coefficient for the Thailand price level is well within a standard deviation from zero.

On the other hand, the Korean price level divided by the won price of the baht eliminated almost 7% of the deviation within one month.

The estimated error-correcting models for the U.S. are:

$$(18)\quad (1-L)p^*(t) = \underset{(0.0010)}{0.0095} + \underset{(0.0048)}{0.0226}\,[p(t-1)/e(t-1) - (1/r)p^*(t-1)]$$

$$(19)\quad (1-L)p(t)/e(t) = \underset{(0.0030)}{0.0090} + \underset{(0.0137)}{0.0057}\,[p(t-1)/e(t-1) - (1/r)p^*(t-1)]$$

The U.S. price level was adjusted to eliminate almost 2% of the deviation from PPP. On the contrary, the slope coefficient of (19) implies that the Korean price level divided by the won price of the dollar was not corrected to eliminate the previous deviation from the PPP.

The estimated error-correcting models for Japan are:

$$(20)\quad (1-L)p^*(t) = \underset{(0.0012)}{0.0042} + \underset{(0.0075)}{0.0325}\,[p(t-1)/e(t-1) - (1/r)p^*(t-1)]$$

$$(21)\quad (1-L)p(t)/e(t) = \underset{(0.0038)}{0.0013} + \underset{(0.9234)}{0.0095}\,[p(t-1)/e(t-1) - (1/r)p^*(t-1)]$$

Surprisingly, we have gotten the same result with the U.S. The Japanese price level moved in the correct direction in response to the previous deviation from PPP. The price level divided by the won price of the yen did not appear to adjust to a positive deviation from the equilibrium relationship.

Conclusions

Point estimates of ARIMA models of the real exchange rate for Korea and her major trading partners indicate convergence; this result is in accord with long-run PPP. However, by using Dickey-Fuller tests, we could not reject the null hypothesis of a single unit root for any nation except India. SURE estimates indicated that both the U.S. and Indian real exchange rates were convergent.

Engle and Granger (1987) argued that if there is an equilibrium relationship between economic variables, these time series might be cointegrated with each other. Cointegration tests for all nations but Thailand failed to indicate PPP. The overall impression is that PPP cannot be said to hold for the Korean economy.

CHAPTER V. VECTOR AUTOREGRESSIVE (VAR) REPRESENTATION ANALYSIS OF PPP IN THE KOREAN ECONOMY

In Chapter IV, we have seen that there is mixed evidence supporting Purchasing Power Parity (PPP). SURE estimations indicate that PPP "works" for U.S. vs. Korea but not for Japan vs. Korea. However, cointegration tests show that PPP fails for all three nations. The overall implication of Chapter IV is that PPP does not hold for the Korean economy.

In this chapter, we want to analyze why there are deviations from PPP. The theory of PPP states that 1) monetary shocks of any variety should not induce permanent deviations from PPP and 2) the relative productivity shocks may induce permanent deviations from PPP. To test this proposition, we focus on the Japanese/Korean and the U.S./Korean real exchange rates within a vector autoregression (VAR) framework. The critical point of the VAR method is that we do not have to distinguish endogenous variables from exogenous variables.

Data for the U.S., Korean, and Japanese industrial production indexes, money supplies (M1), prices (wholesale price index),[1] exchange rates, and interest rates have been collected from International Financial Statistics.

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[1]Only consumer and wholesale price indices are available on a monthly basis for all nations in the study. Wholesale price indices are generally thought to be more appropriate for constructing real exchange rates than are consumer prices. Note that export (or import) unit values are preferred for analyzing a nation's terms of trade.

Model Selection

The Choice of Variables in VAR

Traditional macro-econometric method has imposed priori restrictions on the relationships between economic variables (Sims, 1980a, b). To avoid this identification problem Sims has proposed to use VAR methodology alternatively. Furthermore, he has shown that different identification in the VAR system yields the different types of impulse responses which indicates the different policy implications (Sims, 1987).

Even though VAR analysis does not place any restriction on the relationships between economic variables, the VAR system has two limitations: the choice of variables and the number of lags.

The choice of variables was dictated by the PPP theory. Note that economic theory is a very useful guide for the choice of variables, in spite of the fact that VAR technique does not depend on a particular model specification suggested by the theory. The PPP theory states that 1) monetary shocks of any variety do matter in the short-run deviations from PPP and 2) the relative productivity shocks may induce the permanent deviation from PPP.

The theory of PPP implies that we may consider three variables in the VAR system; that is, the bilateral real exchange rate (ep^*/p), the relative money supply ratio between two countries, and the relative productivity shocks between two countries.

The validity of using the bilateral real exchange rate in the VAR system is that the PPP disparity implies the nonstationarity of the real exchange rate.

In addition to the three variables suggested by PPP, interest rate is included in the VAR system temporarily because the VAR system is so sensitive to omitted variables and interest rate may be important in the movement of the real exchange rate.[2]

To set the variables in the VAR system, the block causality test has been employed to validate three variables in the VAR system: real exchange rate, money supply ratio, and industrial production index ratio.[3]

The economic variables that form the VAR system are as follows:

Notation:

$R(t) = e(t)p^*(t)/p(t)$; $e(t)$; nominal exchange rate

$p^*(t)$; foreign price level

$p(t)$; domestic price level

$R(t)$; bilateral real exchange rate

$delr(t) = R(t) - R(t-1)$

$m(t) = M^*(t)/M(t)$; $m(t)$; relative money supply ratio

$M^*(t)$; foreign money supply

$M(t)$; domestic money supply

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[2]Sims (1972) argued that the causality runs from money to income. That is, the money stock is causally prior, in Granger's sense. In the presence of the interest rate in the VAR system, the above argument would not be true. Along this line of argument, see Sims (1980a, b).

[3]Theory suggests that the real exchange rate can be affected by real government purchases and (in a non-Ricardian Equivalence environment) taxes. Unfortunately, the use of monthly data precludes us from obtaining good measures of government spending or taxes. For the same reason, the Index of Industrial Production--rather than Gross National Product--was used to measure "output."

$delm(t) = [M^*(t)/M(t) - M^*(t-1)/M(t-1)]$

$y(t) = Y(t)/Y(t)$; $Y^*(t)$; foreign industrial production index

$Y(t)$; domestic industrial production index

$dely(t) = [Y^*(t)/Y(t) - Y^*(t-1)/Y(t-1)]$

$ipc(t) = i(t) - i^*(t) - [e(t+1) - e(t)]/e(t)$;

$i^*(t)$; foreign interest rate

$i(t)$; domestic interest rate

$delipc(t) = ipc(t) - ipc(t-1)$.

The VAR system we may consider is as follows:

$$\begin{bmatrix} a_{11}(l) & a_{12}(l) & a_{13}(l) & a_{14}(l) \\ a_{21}(l) & a_{22}(l) & a_{23}(l) & a_{24}(l) \\ a_{31}(l) & a_{32}(l) & a_{33}(l) & a_{34}(l) \\ a_{41}(l) & a_{42}(l) & a_{43}(l) & a_{44}(l) \end{bmatrix} \begin{bmatrix} delm(t) \\ dely(t) \\ delr(t) \\ delipc(t) \end{bmatrix} = \begin{bmatrix} e_1(t) \\ e_2(t) \\ e_3(t) \\ e_4(t) \end{bmatrix}$$

where: a_{ij} = polinomials in the lag operator l; and e_k = white noise stochastic disturbancs (k = 1, 2, 3, 4).

The above VAR system contains 4 variables: the relative money supply ratio differential, the relative productivity ratio differential, the real exchange rate differential, and the interest rate differential. (Using the interest rate parity condition, we have defined the interest rate differential.[4]) By taking the first order differencing of the

[4]We used several formulations for the interest rate differential. Let i(t) and i*(t) represent the Korean and foreign short-term rate, respectively. The specifications: i(t)-i*(t); i(t)-i*(t)+[e(t+1)/e(t) -1]; and i(t)-i*(t)+[e(t+1)/e(t)-1] were used as measures of the interest rate differential for both the U.S./Korean and Japanese/Korean cases.

variables, we can keep the assumption that the arguments of the VAR system are wide-sense stationary.

All series are monthly and cover the period of January 1973 to July 1987. The system also contains a constant and 11 seasonal dummy variables.

The block causality test was done to select the appropriate variables in VAR. The Granger-Sims causality test is multivariate-generalized in this test. The null hypothesis for doing this test is that, in the set of variables delm, dely, delr, delipc, lags of delipc do not affect the first three. Two systems for delm, dely, and delr are estimated. The restricted one excludes the lags of delipc, while the unrestricted one includes them.

Consider the U.S. vs. Korean VAR system. Twelve lags were specified for this system--a constant and 11 seasonal dummies were included in the system. A statistical test was performed to see the block exogeneity. The chi-square, $x^2(df = 36) = 27.77$ with 36 restrictions, indicated that the null hypothesis could not be rejected at a high significance level (83%).

The implication of this test result is that the joint movements of the real exchange rate, the relative productivity shock, and the relative money supply shock are independent of the interest rate shock. This result allows us to set three variables (delm, dely, and delr) in the U.S. vs. Korea VAR system.

We have also considered the Japan vs. Korea system--12 lags were specified and a constant with 11 seasonal dummies was included in the VAR system. A block exogeneity test was done for this system. The chi-square, $x^2(df = 36) = 31.84$ with 36 restrictions, indicated that the null hypothesis could not be rejected at a high significance level (66%). This result convinced us to set 3 variables (delm, dely, and delr) in the Japan vs. Korea VAR system.

As the theory suggested, we will consider 3 variables in two VAR systems (U.S. vs. Korea and Japan vs. Korea).

The choice of lags in VAR

We are now left with the choice of lag length. The testing procedure in choosing the appropriate lag length is the likelihood ratio: $(t-c)\,[\log\det\Sigma_R - \log\det\Sigma_u]$, where Σ_R and Σ_u are the restricted and unrestricted covariance matrices, and t is the number of observations. Following Sims (1980a, b), we have considered correcting c to improve the small sample properties. This concept was applied to the block causality test in the previous section.

Consider the U.S. vs. Korea VAR system with 3 variables. We have also considered a constant and 11 seasonal dummies as explanatory variables in the system.

A statistical test was done to choose the lag length in the VAR system. Twelve lag length specifications against 18 lag length specifications were tested by using the Sims modified likelihood ratio test. The chi-square, $x^2(df = 54) = 31.74$ with 54 restrictions indicated that the 12 lags specification could not be rejected at a high significance level (99%).

To confirm that the 12 lags specification is compatible with the U.S. vs. Korea system, we have done the statistical lag length test again. That is, the 6 lag-length specification was tested against the 12 lag-length specification. The chi-square, x^2(df =54) = 111.82, indicated that the 6 lags specification could be rejected at a 5% significance level.

The statistical lag length tests imply that the 12 lags specification is appropriate in the U.S. vs. Korea system.

For the Japan vs. Korea case we have performed a statistical lag length test again. First, a 12 lags specification test was done against an 18 lags specification. The chi-square, x^2(df = 54) = 40.70 with 54 restrictions, showed that the 12 lag-length specification could not be rejected at a high significance level (90%). Once more, the 6 lag-length specification test against a 12 lag-length was performed. The resulting chi-square, x^2(df =54) = 106.72 with 54 restrictions, showed that the 6 lag-length specification could be rejected at a 5% significance level.

The lag-length test for both systems (U.S. vs. Korea and Japan vs. Korea) showed that the 12 lags specification is appropriate for both VAR systems.

Estimated VAR

In the previous section, we have set the three variables for both systems with 12 lags: a constant and 11 seasonal dummies are included as explanatory variables in both systems. The estimated VAR (U.S. vs. Korea) is reported in Table 5-1.

Table 5-1. Estimated vector autoregression (U.S. vs. Korea)

Equation	Variable	1	2	3	4	5	6	7	8	9
delm	delm	-0.181[b]	-0.041	-0.061	0.057	-0.106[a]	0.089	0.063	0.059[a]	-0.127[a]
	dely	-0.172[a]	-0.152[a]	-0.206[a]	-0.074	0.101	0.070	0.31[b]	0.180[a]	-0.085
	delr	-0.074[a]	-0.147[b]	-0.055	-0.076[a]	0.038	-0.019[b]	0.062	-0.069	0.029
	seasonals	-0.015[b]	0.013[b]	0.016[b]	0.002	0.001	0.005[a]	0.0	-0.020[b]	0.012[b]
delg	delm	-0.081[a]	0.076[a]	0.051[a]	0.17[b]	0.212[b]	0.062	-0.049	-0.035	-0.151[b]
	dely	-0.194[b]	0.083	0.060	-0.034	-0.051	0.083[a]	0.023	0.167[b]	0.067
	delr	-0.069[a]	0.028	-0.031	-0.057[a]	0.040	-0.132[b]	-0.033	0.035	-0.074[a]
	seasonals	0.001[b]	-0.007[a]	0.001	0.003	-0.006[a]	0.002	-0.003	-0.011[b]	0.0
delr	delm	0.11	0.07	0.032	0.090	0.245[b]	0.005	0.030	0.185[a]	-0.075
	delr	0.114	0.143	0.001	0.223[a]	-0.026	0.138	0.211[a]	-0.047[b]	-0.040[b]
	delr	-0.039	0.057	0.046	0.042	0.009	0.132[a]	0.170[a]	-0.062	0.106[a]
	seasonals	0.0	0.006	0.108[a]	0.006	0.001[a]	0.005	-0.008[a]	-0.003	0.007[a]

Note: The sample period is 1974:2 to 1987:7 (162 observations). a indicates a t-statistic between 1 and 2 in absolute value. b Indicates a t-statistic greater than 2. The lags in seasonals, especially, are in the order of -11 to 0 instead of 1 to 12.

Table 5-1. (Continued)

Equation	Variable	10	11	12	Durbin-Watson	R^2	SE(X10)
delm	delm	-0.001	-0.079	0.002	2.12	0.697	0.12
	dely	0.180[a]	0.297[b]	0.200[a]			
	delr	0.040	0.082	0.151[b]			
	seasonals	-0.01[b]	-0.016[b]	0.007[a]			
delg	delm	0.018	0.089[a]	0.028	2.11	0.569	0.085
	dely	0.157[b]	0.146[a]	-0.263[b]			
	delr	0.146[b]	0.122[b]	0.055[a]			
	seasonals	0.0	-0.002	0.009[b]			
delr	delm	-0.173[a]	-0.315[b]	-0.060	1.97	0.413	0.15
	delr	-0.022	0.015	-0.117			
	delr	-0.120[a]	-0.151[a]	-0.163[a]			
	seasonals	-0.003	0.0	0.013[b]			

A three-equation system was estimated by using OLS, equation by equation. The volatility of the relative money supply ratio, as measured by the etimated standard error, is higher than that of the relative productivity ratio. The real exchange rate shows the highest volatility among the 3 variables.

Most of the parameters in autoregressive system are not significant, as we would expect from an over-parameterized model. The estimated coefficients on successive lags tend to oscillate in each system. Because of both the near multicollinearity in each equation and the complicated cross-equation feedbacks, the autoregressive coefficients are very difficult to interpret. The vector-moving, average representation, which is more comprehensible and equivalent to VAR, will be considered in the following section. As will be seen in the next section, in contrast to the VAR system, the responses to typical random shocks are relatively smooth; we can elicit a reasonable economic interpretation.

The dynamic interrelationships among the variables are specified in Table 5-2.

In equation delm (the U.S. vs. Korea relative money supply ratio), given delr and dely, all of the own lags of a delm are not important in explaining the movement of a delm at a 5% significance level. On the other hand, given delm and delr, the zero coefficients of all lags in dely can not be rejected at a 5% significance level, which implies that past values of relative productivity shock do matter in the movement of the relative money supply ratio in the presence of the past own lags of the relative money supply ratio and the past lags of the real exchange

Table 5-2. F-statistics for tests in which all lags of designated variables have zero coefficients (U.S. vs. Korea)

	Variable		
Equation	delm	dely	delr
delm	1.8213 (0.053)[a]	2.34 (0.01)	1.98 (0.03)
dely	2.67 (0.003)	3.477 (0.0002)	2.875 (0.0016)
delr	1.63 (0.09)	0.76 (0.69)	1.787 (0.058)

[a]Numbers in parentheses indicate approximate marginal significance levels.

rate. Given delm and dely, the stochastic process of the relative money supply ratio could be affected by the real exchange rate movement at a 5% significance level.

In equation dely, all of the lagged variables are important in the movement of the relative productivity shock at a 5% significance level. In equation of delr, a 5% significance level, no variable matters in the movement of the real exchange, given the other two variables. But at a 10% significance level, given dely and delr, the lagged values of the relative money supply ratio could affect the real exchange rate deviation from its long-run level. In this sense, any variety of the relative money supply shock does matter in the real exchange nonstationarity. As we have come to expect, the real exchange rate movement is affected by its own lags.

Note that this kind of statistical causal relationship can be misleading since OLS results are fairly robust in the VAR. To capture the refined causal relationships between variables, impulse responses and error decomposition will be introduced in section 3.

We are now in a position to consider the Japan vs. Korea VAR system. Table 5-3 shows the estimated VAR system (Japan vs. Korea).

Like the U.S. vs. Korea VAR system, the estimated VAR (Japan vs. Korea) indicates that the estimated coefficients on successive lags are oscilated in each OLS equation. The highest volatility, as indicated by estimated standard error in each equation, is with the real exchange rate. The variability in relative monetary shocks is more than that of relative productivity shocks. These observations have the same conclusions with the U.S. vs. Korea VAR system.

Granger causality tests have been performed in the Japan vs. Korea VAR system. It is striking that movements in the money supply and the real exchange rate appear to be completely autonomous; movements in these variables are not even explained by their own past as shown in Table 5-4.

In equation delm, given 2 variables, no variable explains the movement in the relative money supply ratio. Strikingly, the lagged values of the relative money supply shock do not cause the movement of themselves in the presence of lagged real exchange rate and lagged productivity shock.

In equation dely, given dely and delr, the relative money supply shock is very important in the stochastic process of relative productivity shock at a 5% significance level. Unlike the relative money

Table 5-3. Estimated vector autoregression (Japan vs. Korea)

Equation	Variable	1	2	3	4	5	6	7	8	9
delm	delm	-0.055[b]	0.038	-0.120[a]	0.007	-0.095[a]	0.110[a]	-0.142	-0.004	-0.120[a]
	delg	-0.441[b]	-0.137	-0.05	-0.046	0.289[a]	0.013	0.221[a]	0.054	-0.120
	delr	0.038	-0.016[b]	-0.001	-0.087[a]	0.017	0.015	0.003	0.038	0.003
	seasonals	-0.004	0.027[b]	-0.001[a]	0.001	-0.004	-0.01[a]	-0.008[a]	-0.021[b]	-0.001[a]
delg	delm	-0.029	0.061[a]	0.018	0.076[b]	0.127[b]	0.047[a]	-0.090[b]	-0.033	-0.105[b]
	delg	-0.093[a]	0.093[a]	0.079	0.086[a]	-0.104[a]	0.127[a]	0.184[b]	0.286[b]	0.112[a]
	delr	-0.02	-0.05[a]	0.026[a]	-0.042[a]	0.358[a]	-0.004	-0.05[b]	0.068[b]	-0.047[a]
	seasonals	-0.002	0.0	-0.003	0.002	-0.001	-0.001	-0.006[a]	-0.048[a]	0.002
delr	delm	0.008	-0.065	0.72	0.060	-0.22[a]	-0.117	0.114	0.181[a]	0.067
	dely	-0.013	0.035	-0.470[a]	0.050	0.226	0.282[a]	0.145	-0.592[a]	0.254
	delr	0.202[b]	-0.09	0.116[a]	0.106[a]	0.046	0.0	-0.042	0.013	-0.007
	seasonals	-0.004	0.012	0.009	0.010	-0.014[a]	-0.008	0.011	0.009	0.013[a]

Note: The sample period is 1974:2 to 1987:7 (162 observations). a indicates a t-statistic between 1 and 2 in absolute value. b indicates a t-statistic greater than 2. The lags in seasonals, especially, are in the order of -11 to 0 instead of 1 to 12.

Table 5-3. (Continued)

Equation	Variable	10	11	12	Durbin-Watson	R^2	SE(X10)
delm	delm	-0.077	0.051	0.227[b]	2.10	0.597	0.191
	delg	0.157	0.266[a]	0.074			
	delr	0.028	-0.002	0.135[b]			
	seasonals	-0.006	-0.002	-0.015[a]			
delg	delm	-0.025	0.033	-0.037	2.10	0.60	0.081
	delg	0.1[a]	0.157[b]	-0.238[b]			
	delr	0.019	0.004	0.007[b]			
	seasonals	-0.001	0.008[b]	0.007			
delr	delm	-0.010	-0.220[a]	-0.009	1.957	0.3	0.303
	dely	0.238	0.482	-0.016			
	delr	-0.149[a]	0.044	-0.002			
	seasonals	-0.011	-0.003	0.011			

Table 5-4. F-statistics for tests in which all lags of the designated variable have zero coefficients (Japan vs. Korea)

Equation	Variable		
	delm	dely	delr
delm	1.494 (0.136)[a]	1.140 (0.335)	0.924 (0.526)
dely	3.543 (0.0002)	5.59 (0.0)	1.84 (0.05)
delr	0.800 (0.64)	1.02 (0.44)	1.03 (0.43)

[a]Numbers in parentheses indicate approximate marginal significance levels.

supply ratio, in the presence of delm and delr, the own lagged values of relative productivity shock explain the movement of themselves at a 5% significance level. Given delm and dely, real exchange rate shock does matter in the movement of the relative productivity shock at a 10% significance level.

In equation delr, surprisingly, given two variables, no variable causes the real exchange rate deviation from its long-run level. This Granger test suggests that there may be a third factor that influences the movement of the real exchange rate.

Unlike the U.S. vs. Korea system, we can not find any factor to influence the movement of real exchange rate at even a 10% significance level. Note that for the U.S. vs. Korea system, money does matter for the nonstationarity of the real exchange rate at a 10% significance level.

The System's Response to Typical Random Shocks-- (Impulse Responses and Variance Decomposition)

The impulse response function, or moving average representation, is suggested as an alternative descriptive device of the VAR system[5] because autoregressive systems are very difficult to describe succinctly; there are complex patterns of cross-equation feedbacks. Furthermore, the estimated lagged coefficients tend to oscillate. In contrast to the VAR estimation, the impulse response function may yield the reasonable economic interpretation.

Given the VAR system, the typical random shocks are positive residuals of one standard deviation unit in each equation.[6] For example, the residual in the money supply ratio (M^*/M) is referred to

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[5]By Wold's decomposition theorem, a finite stationary autoregressive representation can be inverted to an infinite moving average representation. This result can be extended to a multivariate autoregressive representation. For more details, see Fuller (1976).

[6]Given a finite order vector autoregressive representation, $a(l)y(t) = u(t)$, where $y(t)$ is an n x 1 vector, $a(l)$ is an n x n matrix of polynomials in the backward-shift operator, l, i.e., $a(l) = a_0 - a_1 l - a_a - \ldots - a_g l^m$, and $u(t)$ is an (n x 1) vector of random disturbances, each of which is independent and identically distributed with zero mean and finite variance, but they are contemporaneously correlated. By the Wold decomposition theorem, moving average representation, $y(t) = \sum_{s=0}^{\infty} G(s)u(t-s)$ where $G(s)$ is an (n x n) matrix of parameters. Then, $y(t)$ can be written as $y(t) = \sum_{s=0}^{\infty} G(s)T^{-1}Tu(t-s)$, where T is a matrix to the variance-covariance matrix of $e(t) = Tu(t)$, the identity matrix. The i, jth component, $c_{ij}(s)$, of $G(s)T^{-1}$ is response of y_i to an innovation or exogenous shock of one standard deviation in y_j. Sims (1980a, b) argued that $e(t)$ is the driving force in the system.

as the money supply ratio innovation in the sense that it can not be predicted from past values of variables in the system.

Note that the residuals (residual vector) in the VAR system are contemporaneously correlated across equations and that they are uncorrelated with the past residuals. To capture the distinct pattern of movement of the variables in the system, the orthogonalization of disturbances in the system may be useful. But, unfortunately, there is no unique, best way for doing this.[7]

To do this orthogonalization, we have triangularized the system, with variables ordered as (M^*/M), (Y^*/Y), (ep^*/p).[8] With this triangularization, (M^*/M) innovation is assumed to disturb all the other variables of the system instantly, to the extent of the strength of the contemporaneous correlation of other residuals with the (M^*/M). In the same way, the innovation in (Y^*/Y) is assumed to disturb only the real exchange rate, while the (ep^*/p) residual is only allowed to affect the variable (ep^*/p) in the initial period. Notice that this ordering makes it most likely that real and nominal variables will affect the real exchange rate. Reversing the ordering of money and productivity does not affect the results reported below.

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[7]Given moving average representation, $y(t) = \sum_{s=0}^{\infty} G(s)T^{-1}TU(t-s)$, the matrix T is not a unique one for orthogonalization.

[8]The ordering of the variables is based on the theory: Money is causally prior to income, money causes the real exchange rate in the short run and permanent real shock causes the permanent deviations from PPP. Furthermore, we have done the possible reordering of the variables, but it turned out that there is no significant change in statistical sense.

The charts at the end of this chapter display the impulse responses to a typical random shock in the system (see Figures 5-1 through 5-24).[9]

For the U.S. vs. Korea case, the interpretation of the system's response to typical random shock is as follows. U.S. money innovations have different effects on the money supply ratio, the productivity ratio, and the real exchange rate (see Figures 5-4, 5-5, and 5-6). The relative money supply ratio (M^*/M) shows small fluctuations, returning to normal after one year. The shape of the responses of the relative productivity ratio is different from that of the relative money supply ratio. The productivity ratio (Y^*/Y) is higher than the normal for eight months, except for the second month after a shock occurs in U.S. money supply. The overall effect of U.S. money innovation has a positive effect on U.S. productivity, except for the period from eighth to eleventh month. This effect is consistent with the view that money affects income in the short-run. The real exchange rate (ep^*/p) is higher than the normal level during the nine months after a shock in U.S. money supply. This result is contrary to the macroeconomic approach to the exchange rate determination. According to the macroeconomic view, with sticky prices, monetary expansion in the U.S. should induce the decrease in the won price of the dollar, which results in the reduction in eP^*. That is, U.S. monetary shock may make a U.S. good competitive over a Korean good. But, the impulse response of the real exchange rate to a shock in money indicates that U.S. monetary innovation may cause the competitiveness of

[9]The vertical axis of Figures 5-1 through 5-24 represents the fractions of standard deviations.

U.S. goods to deteriorate relative to Korean goods. The implication of this result is that there would be exchange rate stabilization in Korea. Even though responses of the real exchange rate to typical random shocks in U.S. money attains a negative peak after one year, it dampens out after that period. The real exchange rate deviation from its long-run level is persistent during ten months after a shock in U.S. money.

The shock in U.S. productivity causes the big fluctuations in both the real exchange rate and the relative money supply ratio (see Figures 5-7 and 5-9), while it causes the relatively smooth fluctuation in the relative productivity ratio (see Figure 5-8). For the first 5 months, there is a relative monetary contraction in the U.S. to one standard deviation shock in U.S. productivity, while U.S. monetary expansion occurs after this period for about 4 months. After one year, the impulse responses of the money supply ratio converge to the normal level. The overall effect of the U.S. productivity shock on the relative productivity ratio is positive, as we predicted. Contrary to the monetary shock to a real exchange rate movement, the responses of the real exchange rate to a shock in U.S. productivity shows the complex patterns during the first ten months. After this period, the real exchange rate is higher than the normal level for about six months, eventually dampening out to the normal level. This fact may illustrate the importance of the real factor in explaining the real exchange movement. This is consistent with Hsieh's view for the real exchange determination within the Ricardian framework.

The impulse response of the real exchange rate, the relative money supply ratio, and the relative productivity ratio to a random shock in the real exchange rate movement are as follows (see Figures 5-10, 5-11, and 5-12).

The responses of the relative money supply ratio shows the mirror images in its fluctuations during the one and one-half year. During the first six months, there is a U.S. monetary contraction. This contraction is compatible with the response of the real exchange rate to a shock in U.S. money. Note that U.S. monetary innovation causes the real exchange rate to rise, which implies that the U.S. loses the competitiveness over Korea. So, it is natural for U.S. to reduce money supply in the presence of the rise in the real exchange rate. By doing that, the U.S. good can retain its competitiveness over the Korean good.

The shock in the real exchange rate has a complicated effect on the income level, returning to the normal level after one year. Surprisingly, it has a positive peak effect on the income level at one year, while it has a negative peak effect at the seventh month. For the ten months, except the third and sixth months, after a shock, the positive real exchange rate shock has reduced the income level. The economic interpretation of this result is that the rise in the real exchange causes U.S. competitiveness over Korea to deteriorate, which results in the reduction of the U.S. income relative to Korean income.

The real exchange rate movement to its own shock exhibits relative smoothness from the second month to the sixth month. After this period, the movement shows large fluctuations until one year. Eventually, it returns to the normal level.

Consider the Japanese vs. Korean impulse responses to typical random shocks. Contrary to the case of the U.S. vs. Korea system, the response of the bilateral real exchange rate movement to a random shock in Japanese money supply is negative for the first four months, while both the movement of the relative money supply ratio and that of the relative productivity ratio move in almost the same direction with that of the U.S. vs. Korea system (see Figures 5-16, 5-17 and 5-18). The real exchange rate movement for the first four months is in accord with the macroeconomic view with sticky prices. The macroeconomic approach to exchange rate determination states that a money supply increase in Japan reduces the own price of the yen. If price is sticky in the Japanese economy relative to the exchange rate, then ep^* (foreign price level in terms of domestic currency unit) will decrease. If we interpret the real exchange rate as the terms of trade, then the lower level of the real exchange rate makes the Japanese economy more competitive than the Korean economy. The convergence pattern of the Japan vs. Korea real exchange rate is more complicated than that of the U.S. vs. Korea real exchange rate. Even though the real exchange rate (Japan vs. Korea) converges to its normal level, it fluctuates more than that of the U.S. vs. Korea real exchange rate.

The adjustment pattern of 3 variables (real exchange rate, money supply ratio, and productivity ratio) to a random shock in Japanese productivity is strikingly different from the U.S. vs. Korea system (see Figures 5-19, 5-20, and 5-21).

As was seen in the U.S. vs. Korea system, for the first five months, the relative monetary contraction in Japan may be induced by the relative productivity shock in Japan. The response of the relative money supply in Japan has almost the same shape as that in the U.S. The relative income adjustment pattern in Japan to its own shock is more persistent than that of the U.S. vs. Korea system. But the pattern returns to its normal level.

Unlike the U.S. vs. Korea system, the real exchange rate is not sensitive to the positive productivity shock in Japan for the first three months. The overall effect of the relative productivity shock on the real exchange rate is positive, which implies that the relative productivity shock may cause the real exchange rate to rise. Thus, the relative productivity shock in Japan may make the Japanese economy less competitive. It is economically nonsensical. My own guess is that the productivity shock may induce the relative monetary fluctuation, which is transferred to the real exchange rate movement.

The one standard deviation shock in the real exchange rate gives rise to the different shape of the impulse responses from the U.S. vs. Korea system (see Figures 5-22, 5-23, and 5-24). Unlike the U.S. vs. Korea system, the relative Japanese monetary contraction occurs because of the shock in the real exchange rate after three months. After six months, the impulse responses of the relative money supply ratio have the same pattern as that of the U.S. vs. Korea system. The dampening speed of the real exchange rate is more speedy than that of the U.S. vs. Korea system. For the first seven months, except for the third month after a shock in the real exchange rate, the movement of the real exchange rate is above the normal level. It converges to its normal level from below the normal.

The relative income in Japan is so sensitive to the random shock in the real exchange rate that it fluctuates more than that of the U.S. vs. Korea case. It may reflect the different Japanese economic philosophy from that of the United States. The real exchange rate movement to its own shock shows a different pattern to that of the U.S. vs. Japan system. In the Japan vs. Korea system, the real exchange rate movement converges to its normal level from below the normal level, while the U.S. vs. Korea real exchange rate converges to its normal level from above the normal level.

To locate the main channels of influence in the system, the decomposition of the variance of the variable has been executed.[10] Table 5-5 represents the variance decomposition of the variables for the U.S. vs. Korea system.

If a variable's own innovations account for all of its variance, we say this variable is an exogenous stochastic variable. In a dynamic macro-economic model, there is an intrinsic sampling error in estimates of the model. Taking into account this sampling error, a variable that

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[10]Given $y(t) = \sum_{s=0}^{\infty} C_s e(t-s)$, where $C(s) = G(s)T^{-1}$ and $e(t) = Tu(t)$. For linear model, the coefficients in C are interpreted as responses to innovation. The variance-covariance matrix of $y(t) - E[y(t)| y(t-k), y(t-k-1), \ldots]$, the k period-ahead forecast of y is given by $V_k = \sum_{s=0}^{k-1} C(s)\mathrm{var}(e(t))C(s)'$.

Table 5-5. Variance decomposition: Proportions of forecast error k months ahead produced by each innovation (U.S. vs. Korea)

Forecast error in	K	Triangular innovation in S.E.	delm	dely	delr
delm	1	0.0101	1.00	0.00	0.00
	3	0.0105	0.95	0.02	0.03
	6	0.0109	0.93	0.03	0.04
	9	0.0114	0.87	0.06	0.07
	12	0.0121	0.84	0.09	0.07
	36	0.0127	0.81	0.1	0.09
dely	1	0.0071	0.04	0.96	0.00
	3	0.0076	0.08	0.90	0.02
	6	0.0079	0.14	0.83	0.03
	9	0.0085	0.14	0.75	0.11
	12	0.0094	0.20	0.64	0.18
	36	0.0098	0.20	0.62	0.18
delr	1	0.0127	0.01	0.01	0.99
	3	0.0128	0.01	0.01	0.98
	6	0.0132	0.02	0.02	0.93
	9	0.0138	0.03	0.03	0.90
	12	0.0145	0.03	0.03	0.85
	36	0.0150	0.13	0.05	0.82

was strictly exogenous would have entries of almost 1.00 in its diagonal cell in the table, with almost all zeros in all other cells in its row of the table.

For the U.S. vs. Korea system, both the money supply ratio and the real exchange rate have more than 80% of their variance accounted for by own innovations at all the time horizons shown.

On the contrary, the variance of the relative productivity ratio is caused by its own innovation of about 60%. This result implies that the movements of the relative money supply ratio and the real exchange rate are caused by their own innovations, respectively; that is, they are an exogenous stochastic process, compared to the relative productivity ratio.

The innovation in the real exchange rate accounts for the variance of the relative money supply ratio by 9% at all time horizons, which indicates that there is a small feedback from the real exchange rate to the relative money supply ratio.

The relative productivity ratio has about 20%, and 18% of its variance accounted for by the relative monetary innovations and the real exchange rate shock, respectively. This result is suggestive of important feedbacks from money and the real exchange rate into production.

The real exchange rate movement is caused by the relative monetary shock of about 13%, while the relative productivity shock explains the variance of the real exchange by 5% at all time horizons. This is compatible with the previous result. Given the relative productivity ratio and the real exchange rate, monetary shock does matter in the real exchange rate nonstationarity at a 10% significance level.

Table 5-6 shows the variance decomposition of the variable for the Japan vs. Korea system.

Both the relative money supply ratio and the real exchange rate have more than 88% of their respective variance accounted for by their own innovation at all time horizons shown. The degree of the exogeneity of both has been strengthened, compared to the U.S. vs. Korea system.

The innovation in the relative money supply in Japan explains the variance of the relative productivity ratio by 24%, and the real exchange rate shock caused the variability of the relative productivity by 11%.

Table 5-6. Variance decomposition: Proportions of forecast error k months ahead produced by each innovation (Japan vs. Korea)

Forecast error in	K	Triangular innovation in S.E.	delm	dely	delr
delm	1	0.0160	1.00	0.00	0.00
	3	0.0164	0.97	0.03	0.00
	6	0.0170	0.94	0.04	0.03
	9	0.0173	0.92	0.05	0.03
	12	0.0176	0.91	0.06	0.03
	36	0.0187	0.88	0.06	0.06
dely	1	0.0068	0.10	0.90	0.00
	3	0.0072	0.13	0.83	0.04
	6	0.0077	0.19	0.74	0.07
	9	0.0084	0.22	0.68	0.10
	12	0.0091	0.24	0.65	0.10
	36	0.0098	0.24	0.65	0.11
delr	1	0.0254	0.01	0.00	0.99
	3	0.0260	0.01	0.00	0.99
	6	0.0270	0.03	0.01	0.96
	9	0.0275	0.04	0.03	0.93
	12	0.0280	0.05	0.04	0.91
	36	0.0286	0.06	0.06	0.88

This result implies that there is a stronger feedback of money into the income than that of the real exchange rate.

The shock in the real exchange rate has accounted for the variability of itself very much (88%), which is consistent with the previous section--the real exchange rate movement is not caused by anything at a high signifiance level.

Tables 5-5 and 5-6 display the forecast standard errors over various forecasting horizons, provided that the sampling error in the estimated coefficients is ignored.[11] Of course, in a dynamic econometric model, actual forecast errors will be substantially larger because the statistical estimates are imperfect.

We see that all the standard errors of the variables (U.S. vs. Korea and Japan vs. Korea) rise steadily as the forecasting horizon lengthens. The striking element is that the forecast standard error in the real exchange rate (Japan vs. Korea) is larger than that of the U.S. vs. Korea system by almost two times. This may indicate that the real exchange movement for the Japan vs. Korea system is more nonstationary than that of the U.S. vs. Korea system. This result is consistent with the previous chapter; in the seemingly Unrelated Regression Model (with ARIMA model), the nonstationarity of the real exchange rate (U.S. vs. Korea) is not rejected.

The Validity for Generating the Confidence Intervals for Impulse Responses and Variance Decompositions

Runkle (1987) has questioned the statistical significance of variance decompositions and impulse response functions for unrestricted

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[11]The standard errors are computed from the same MARS used in computing Tables 5 and 6. The tables use the formula for the t-step-ahead expected squared forecast error in variable i:

$$S^2(i,t) = \sum_{i=1}^{p} \sum_{v=0}^{t-1} a_{ij}(v)^2 S_i^2$$

where there are p variables in the system, $S_j^2 = s^2(j,1)$ is the variance of the j^{th} innovation, and $a_{ij}(v)$ is the coefficient on the v^{th} lag of the j^{th} innovation in the MAR equation for variable i (Sims, 1980a, b).

vector autoregressions. His argument is that reporting impulse response functions or variance decompositions is tantamount to using regression coefficients without t-statistics. Runkle showed that the standard statistics estimated by using unrestricted vector autoregressions (VARs)--impulse response functions and variance decompositions--are very imprecise estimates of their population counterparts. That is, the economic interpretation based on this kind of statistical result is very suspicious.

To examine the importance of reporting confidence intervals for variance decompositions and impulse response functions, let's follow Runkle's simple example:

Suppose that y_t has the univariate AR representation $y_t = a\, y_{t-1} + e_t$, where $a < 1$ and e_t is white noise. Then we have a moving average representation, $y_t = \frac{1}{(1-aL)} e_t$, where L is the lag operator. The response of y_{t+k} to a shock in e_t is a^k. By applying standard asymptotic theory, we know that if $t^{1/2}(\hat{a}-a)$ is distributed as $N(o,S^2V^{-1})$, then $t^{1/2}(g(\hat{a}) - g(a))$ is distributed as $N(o,S^2GV^{-1}G')$, where S^2 is the variance of e_t, V is the probability limit of y'y/t, and G=dg(a)/da. Hence, a standard-deviation confidence interval for the k^{th} term in the impulse response function is

$$\hat{a}^k \pm 2k\, \hat{a}^{k-1}(\hat{S}^2(y'y)^{-1})^{1/2}.$$

Note that the size of the confidence interval has grown dramatically relative to the size of the coefficient, whereas, the future impulse response (the current shock e_t multiplied by a^k) goes to 0. This confidence interval says that the asymptotic t-statistic of the k^{th} term in the impulse response function goes to 0 at the rate a/k. This univariate AR case can be extended to the vector cases which demonstrates the importance of generating the confidence interval for variance decompositions and impulse responses.

Runkle (1987) has suggested two different methods to generate the confidence intervals for variance decompositions: by using a normal approximation to the distribution of the parameters of the variance decomposition and by using Efron's (1982) bootstrap method to generate the empirical confidence intervals.[1]

Block Causality Test

In Section 1, we have employed the block causality test to select the model (the number of variables). A block causality test includes the concept that the lags of one set of variables do not enter into the equations for the remaining variables as its null hypothesis. Granger-Sims causality tests are generalized in this text.

In this section, we examine the block exogeneity of the variables in the system, By doing so, we may confirm the result in the previous section.

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[1]See Sims (1987), who has used a full Bayesian Monte Carlo methodology in forming the distribution theory, for more details.

Consider the U.S. vs. Korea system: The block exogeneity for both the real exchange rate and the relative productivity ratio is not passed at a 5% significance level. That is, the movements of both the relative productivity ratio and the real exchange rate are not independent of the relative monetary shock in the U.S. The implication is that money does matter in the movement of both.

The block causality test is passed for the relative money supply ratio and the real exchange rate at a 5% significance level. The movements of both the relative money supply ratio and the real exchange rate are independent of the relative productivity shock in the U.S. This result is consistent with the previous result that money does matter in the movement of the real exchange in the presence of the lagged values of the real exchange rate and the relative productivity ratio.

The block causality test was done for the relative money supply ratio and the relative productivity ratio. The movement of the real exchange rate is very important in explaining the movements of the relative money supply ratio and the relative productivity ratio at a 5% significance level.

Consider the Japan vs. Korea system. The block causality test for the relative productivity ratio and the real exchange rate is not passed at a 5% significance level. The relative monetary shoc- in Japan is very important in the movement of the relative productivity ratio and the real exchange rate.

The block exogeneity of the relative money supply and the real exchange rate has passed at a 5% significance level. This result implies that both the movement of the real exchange rate and that of the relative money supply ratio is not affected by the relative productivity shock in Japan.

Contrary to the U.S. vs. Korea system, the block exogeneity test of the relative money supply ratio and relative productivity ratio is passed. The real exchange movement is not important for the movement for the relative money supply ratio and the relative productivity ratio in Japan.

Long-Run Neutrality of Money

For the U.S. vs. Korea case, movements in the real exchange rate are not explained by productivity shocks at conventional significance levels (the marginal significance level is 0.69). In contrast, the marginal significance level for the relative money supply shocks is 9%; thus, there is some evidence that money supply shocks--but not productivity (or interest rate shocks)--affect the real exchange rate between the U.S. and Korea.

The Korean vs. Japanese results are that movements in the money supply ratio and the real exchange rate appear to be completely autonomous; movements in these variables are not even explained by their own past.

Note that the standard money neutrality proposition is that money should not cause changes in relative prices in the long-run. The question is that money really does matter in the nonstationarity of the U.S. vs. Korea real exchange rate movement.

To investigate the long-run neutrality of money for the bilateral real exchange rate movement (U.S. vs. Korea), we set up the hypothesis as follows:

$$\begin{aligned} delr(t) = \alpha_0 &+ \alpha_1 \, delm(t-1) + \alpha_2 \, delm(t-2) + \ldots + \alpha_{12} \, delm(t-12) \\ &+ \beta_1 \, dely(t-1) + \beta_2 \, dely(-2) + \ldots + \beta_{12} \, dely(t-12) \\ &+ \gamma_1 \, delr(t-1) + \ldots + \gamma_{12} \, delr(t-12) \end{aligned}$$

Ho (null hypothesis); $\alpha_1 + \alpha_2 + \ldots + \alpha_{12} = 0$

Ha (alternative hypothesis); $\alpha_1 + \alpha_2 + \ldots + \alpha_{12} \neq 0$

F-statistic, $F(1, 125) = .256$, ind-cated that the null hypothesis could not be rejected at a high significance level (66%). This test result implies that money really does not matter for the movement of the U.S. vs. Korea real exchange rate in the long-run. This is consistent with the standard PPP theory: monetary shocks may induce temporary deviations from PPP, given the long-run neutrality of money, these deviations should eventually be eliminated. Real disturbances, on the other hand, can induce permanent chages in the real exchange rate.

Conclusions

To analyze the PPP disparity, the VAR system (3 variables and 12 lags) has been employed.

For the U.S. vs. Korea system, the relative monetary shock is important for the nonstationarity of the real exchange rate movement, while we can not find any factor to explain the nonstationarity of the real exchange movement in the Japan vs. Korea system. This result is confirmed by the impulse response, the variance decomposition, and the block causality test in both systems. Finally, we have tested the long-run neutrality of money for the bilateral real exchange rate movement (U.S. vs. Korea). Test results show that the relative monetary shocks do not cause the U.S. vs. Korea real exchange rate movement in the long-run. This is consistent with the theory of PPP.

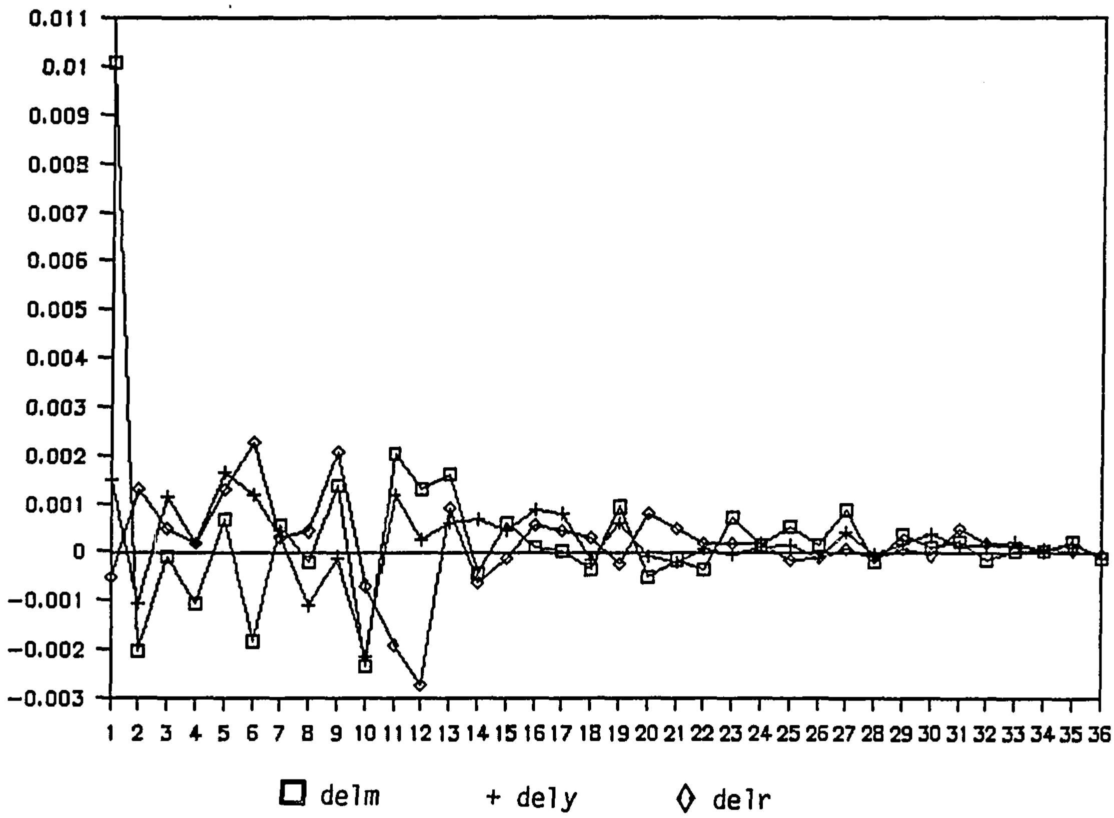

Figure 5-1. Responses of delm, dely, and delr to a shock in delm (U.S. vs. Korea)

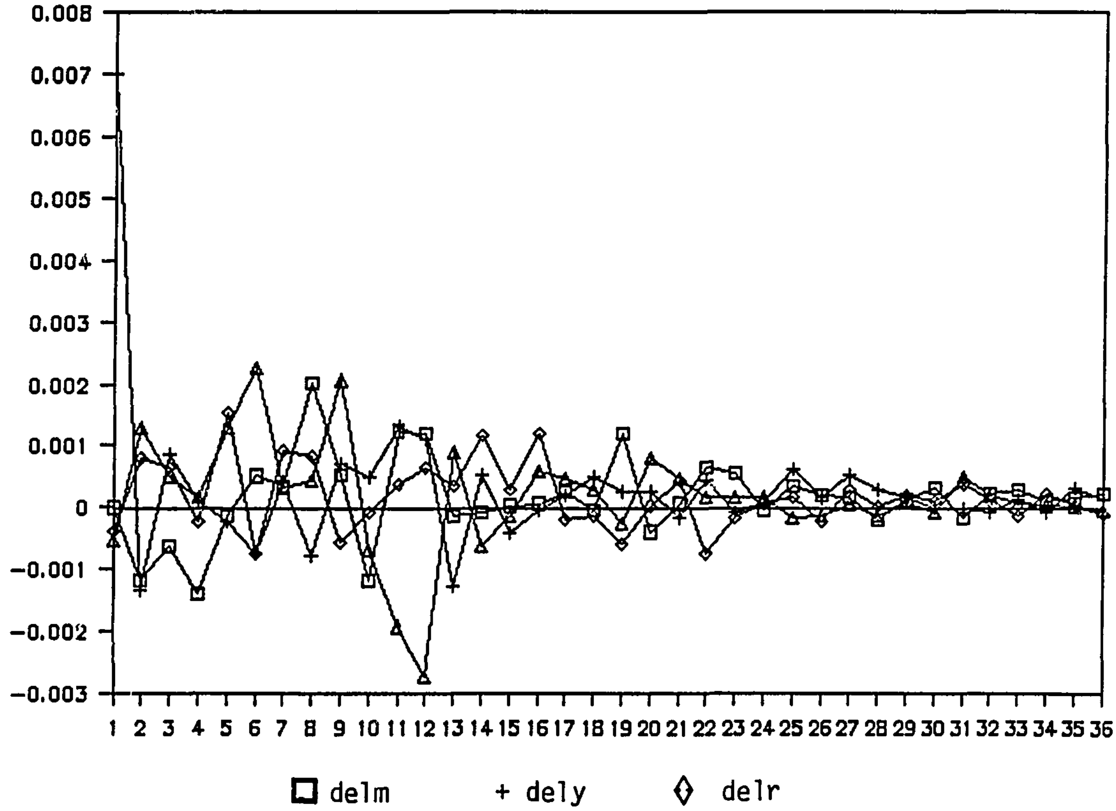

Figure 5-2. Responses of delm, dely, and delr to a shock in dely (U.S. vs. Korea)

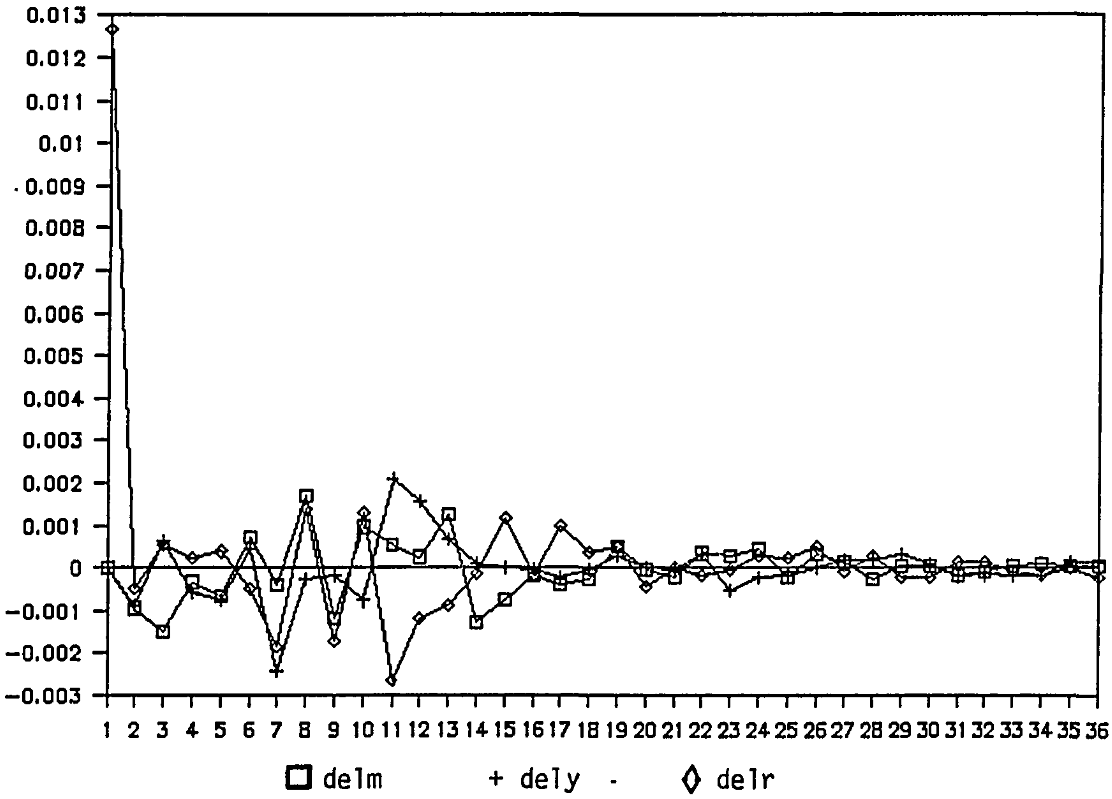

Figure 5-3. Responses of delm, dely, and delr to a shock in delr (U.S. vs. Korea)

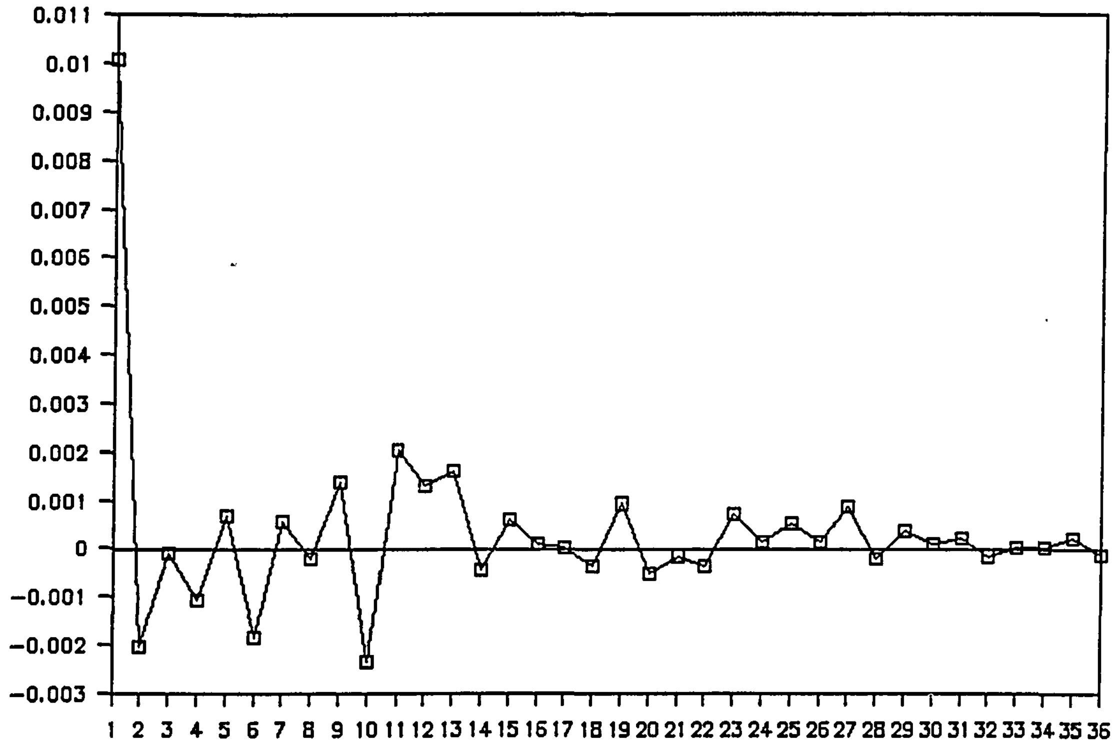

Figure 5-4. Responses of delm to a shock in delm (U.S. vs. Korea)

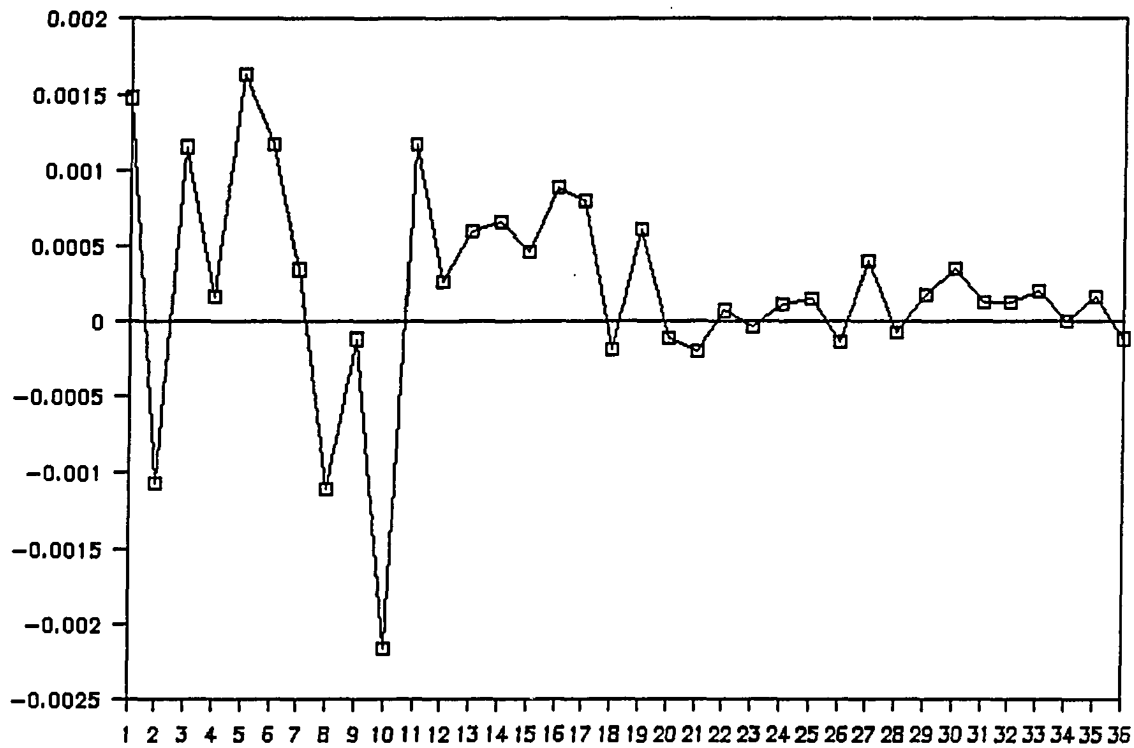

Figure 5-5. Responses of delg to a shock in delm (U.S. vs. Korea)

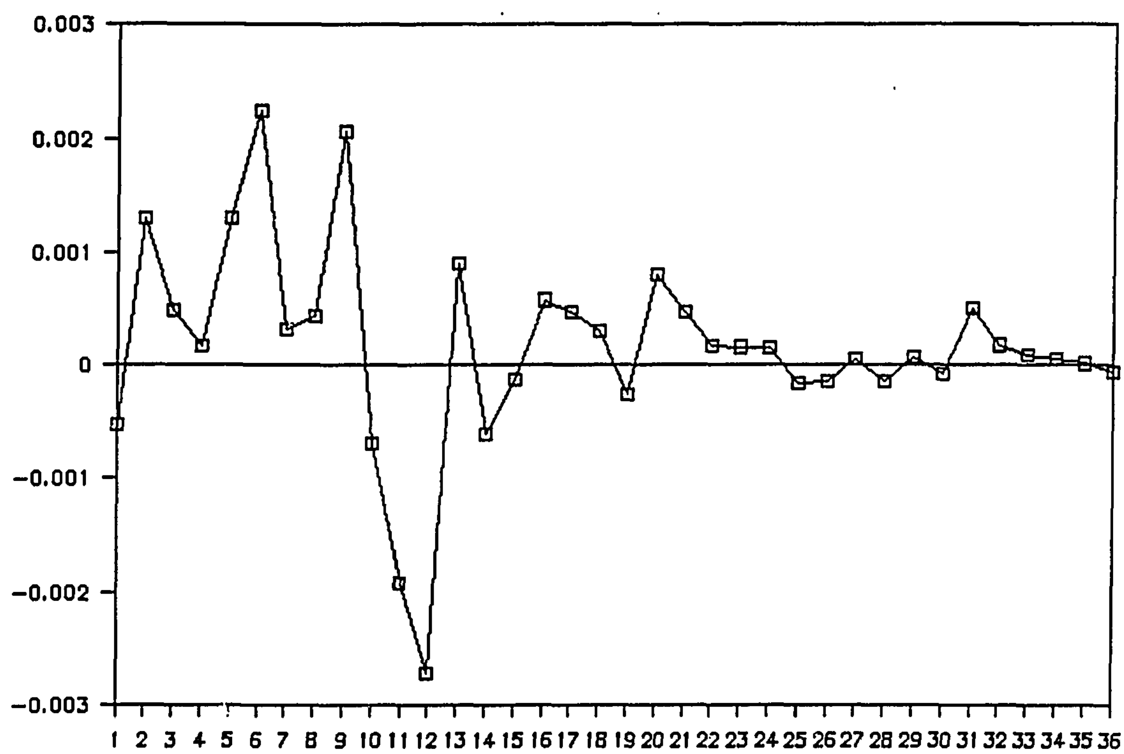

Figure 5-6. Responses of delr to a shock in delm (U.S. vs. Korea)

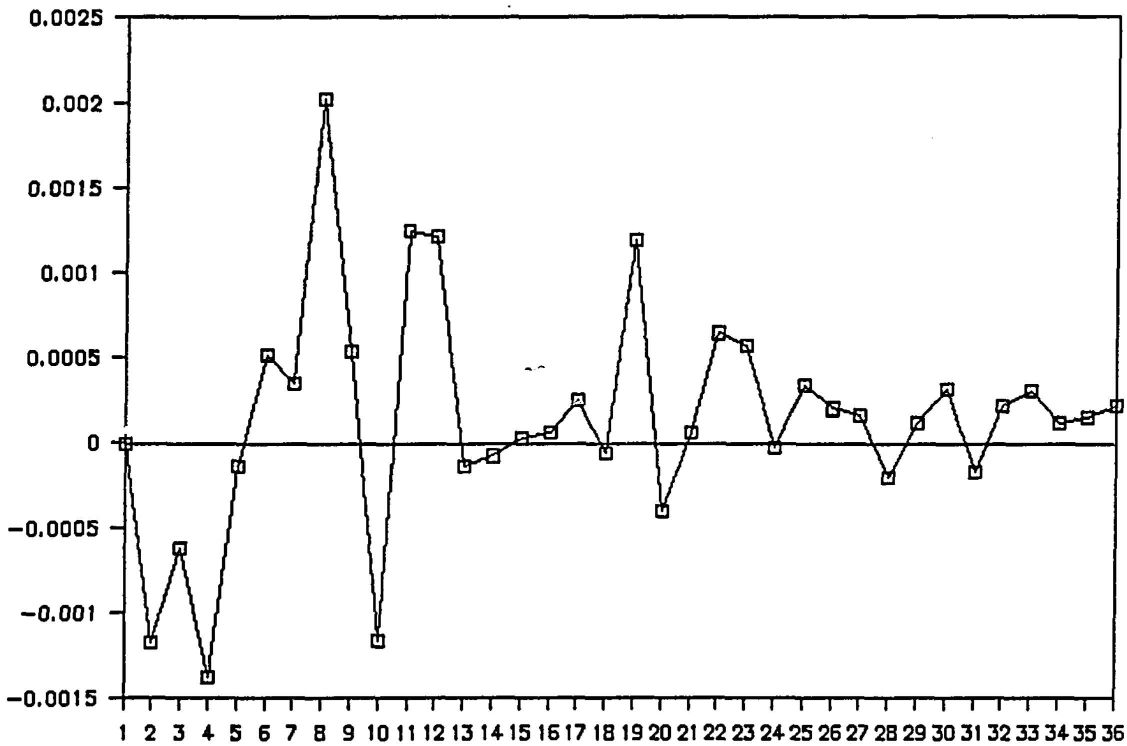

Figure 5-7. Responses of delm to a shock in dely (U.S. vs. Korea)

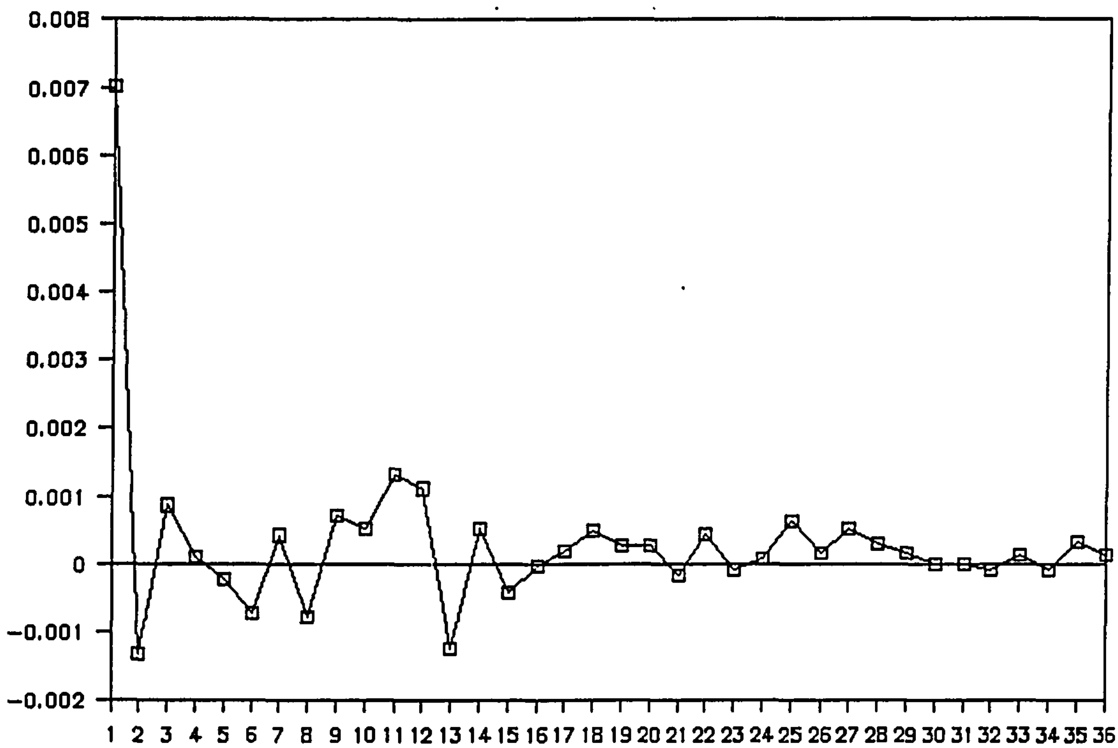

Figure 5-8. Responses of dely to a shock in dely (U.S. vs. Korea)

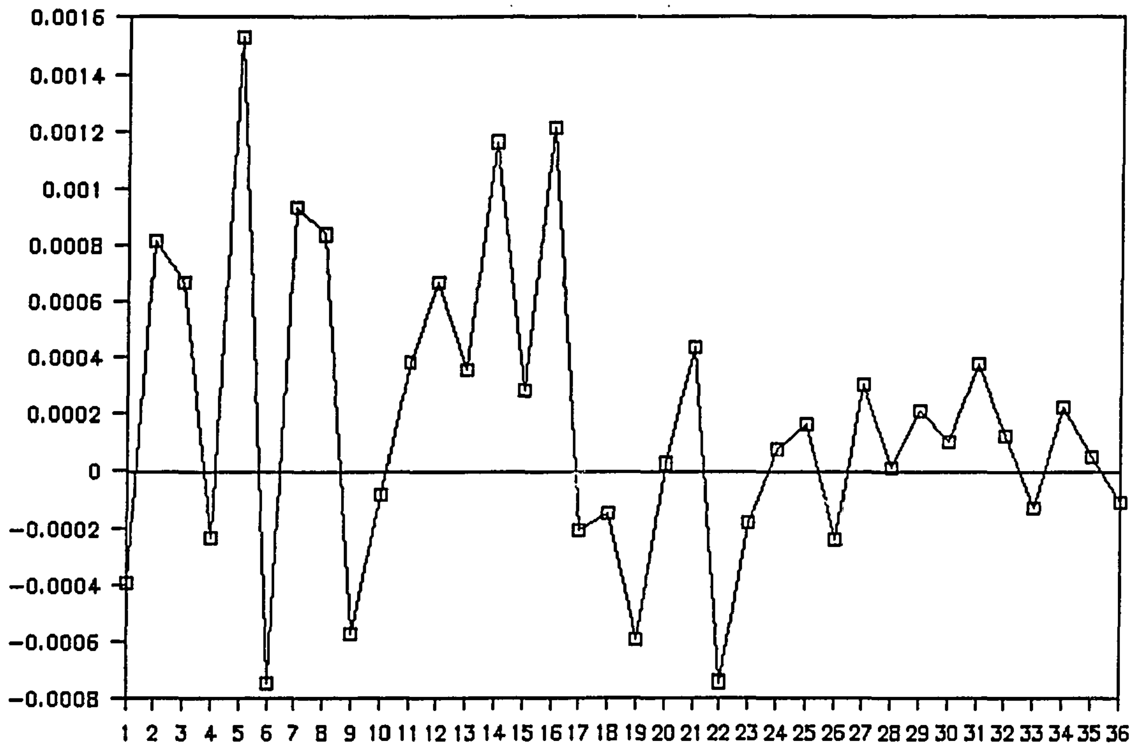

Figure 5-9. Responses of delr to a shock in dely (U.S. vs. Korea)

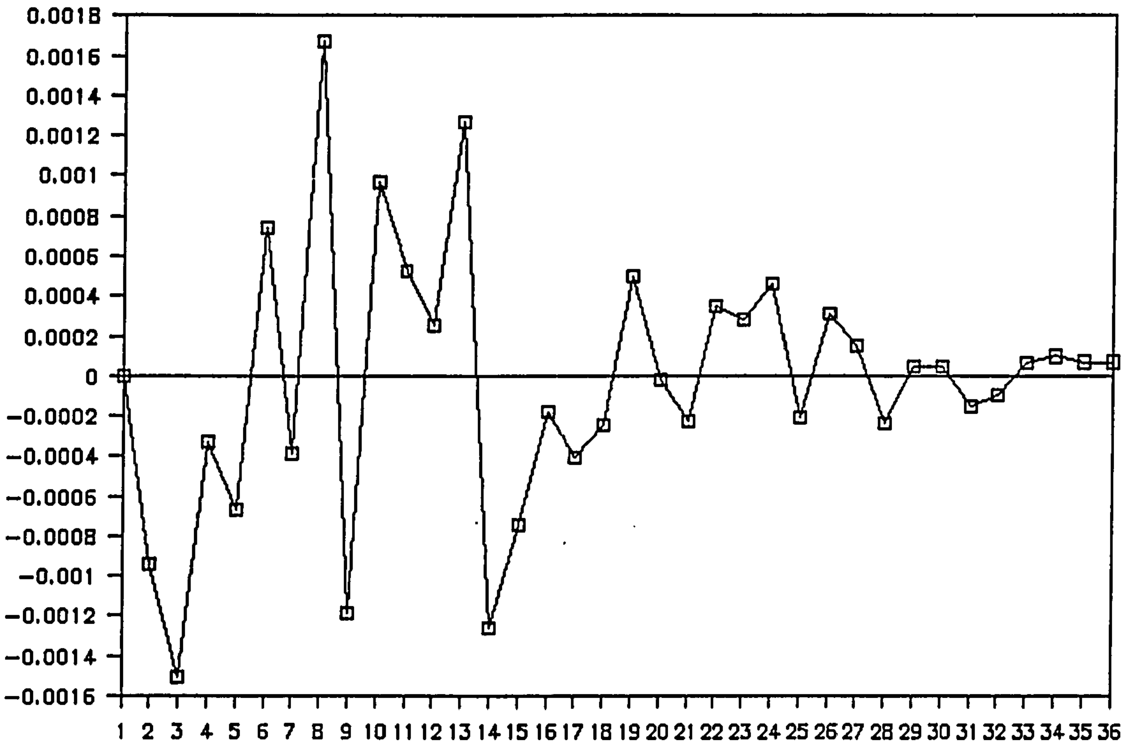

Figure 5-10. Responses of delm to a shock in delr (U.S. vs. Korea)

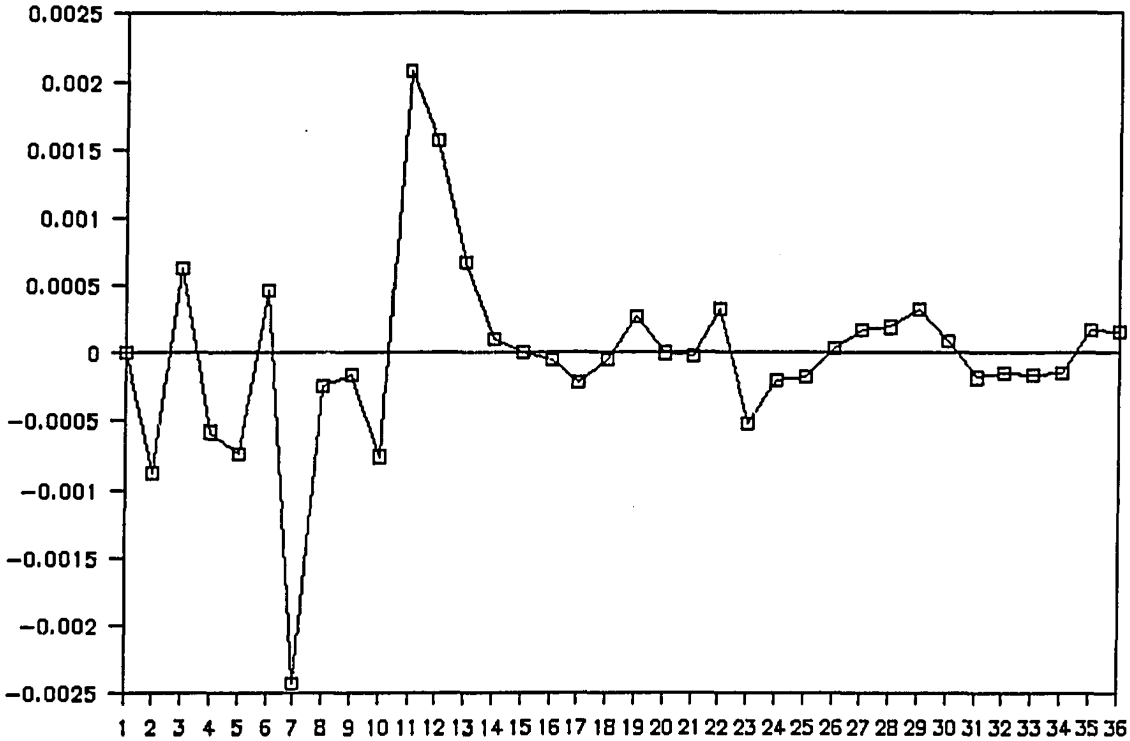

Figure 5-11. Responses of dely to a shock in delr (U.S. vs. Korea)

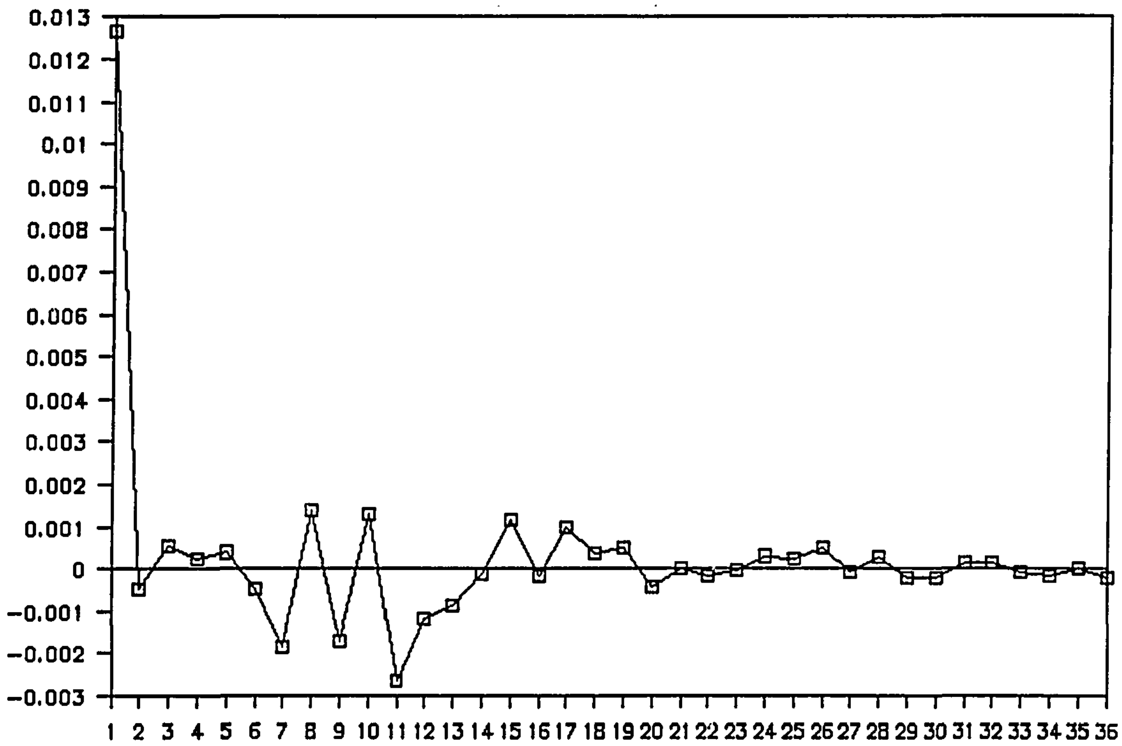

Figure 5-12. Responses of delr to a shock in delr (U.S. vs. Korea)

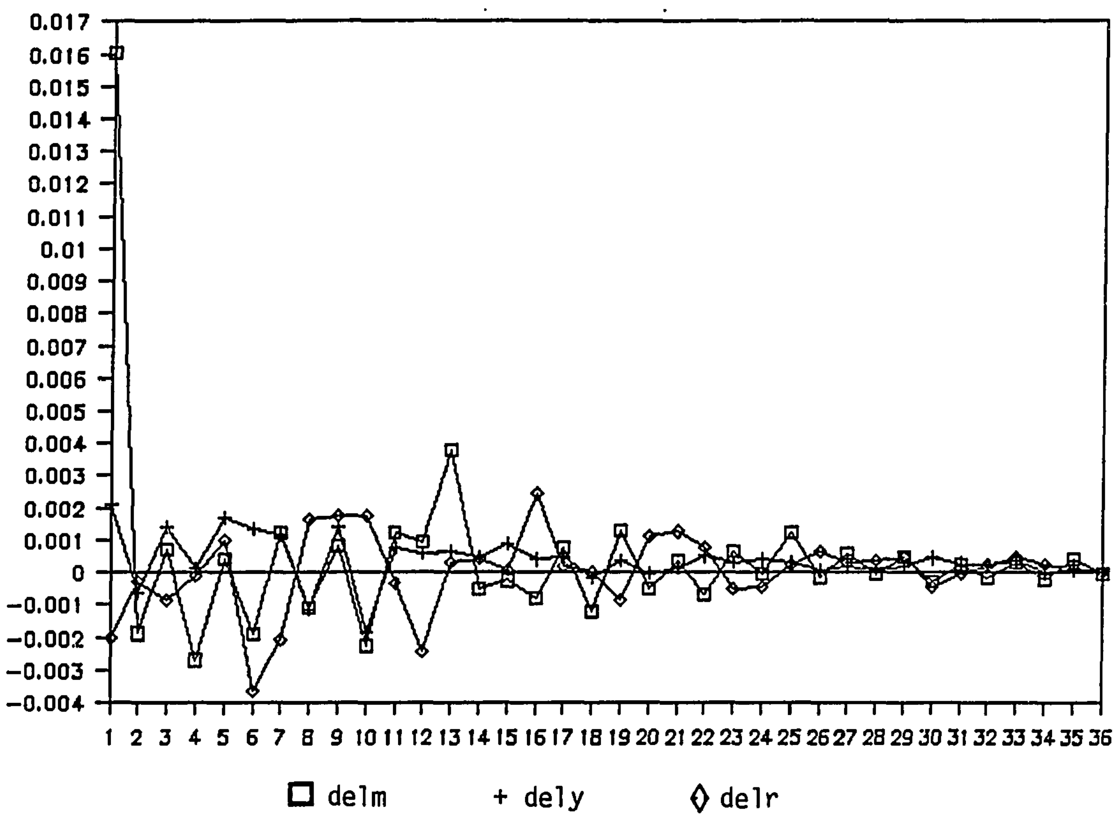

Figure 5-13. Responses of delm, dely, and delr to a shock in delm (Japan vs. Korea)

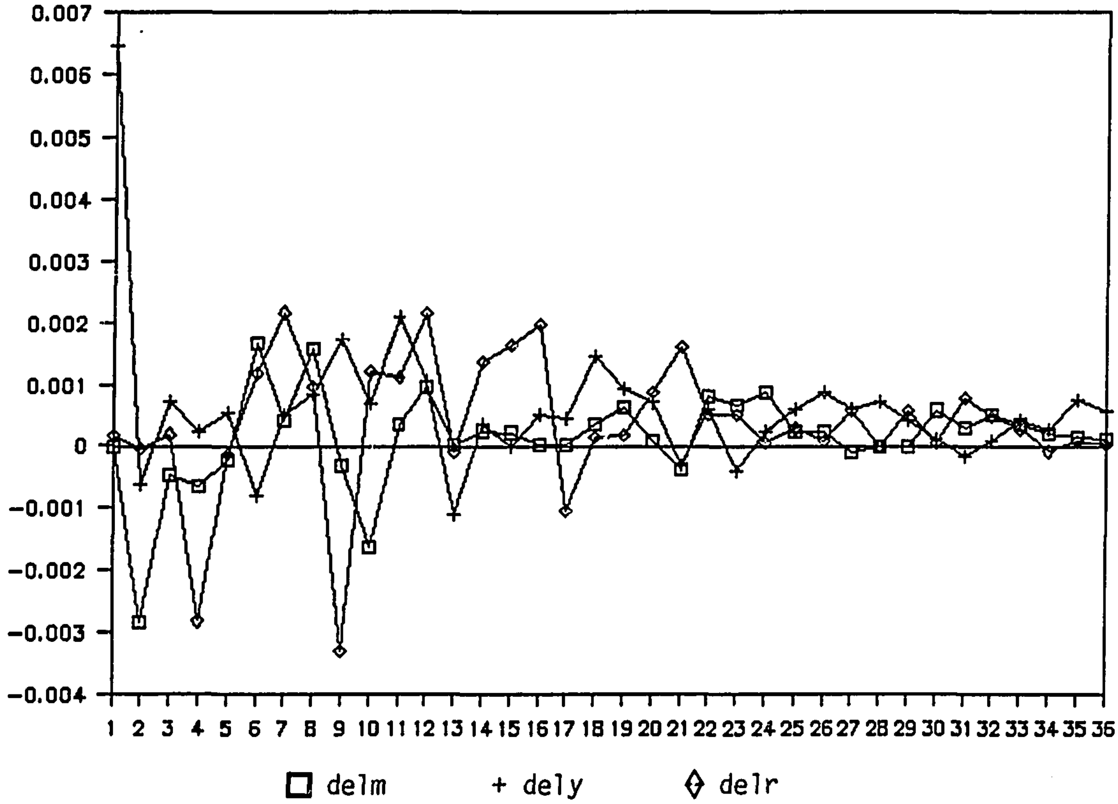

Figure 5-14. Responses of delm, dely, and delr to a shock in dely (Japan vs. Korea)

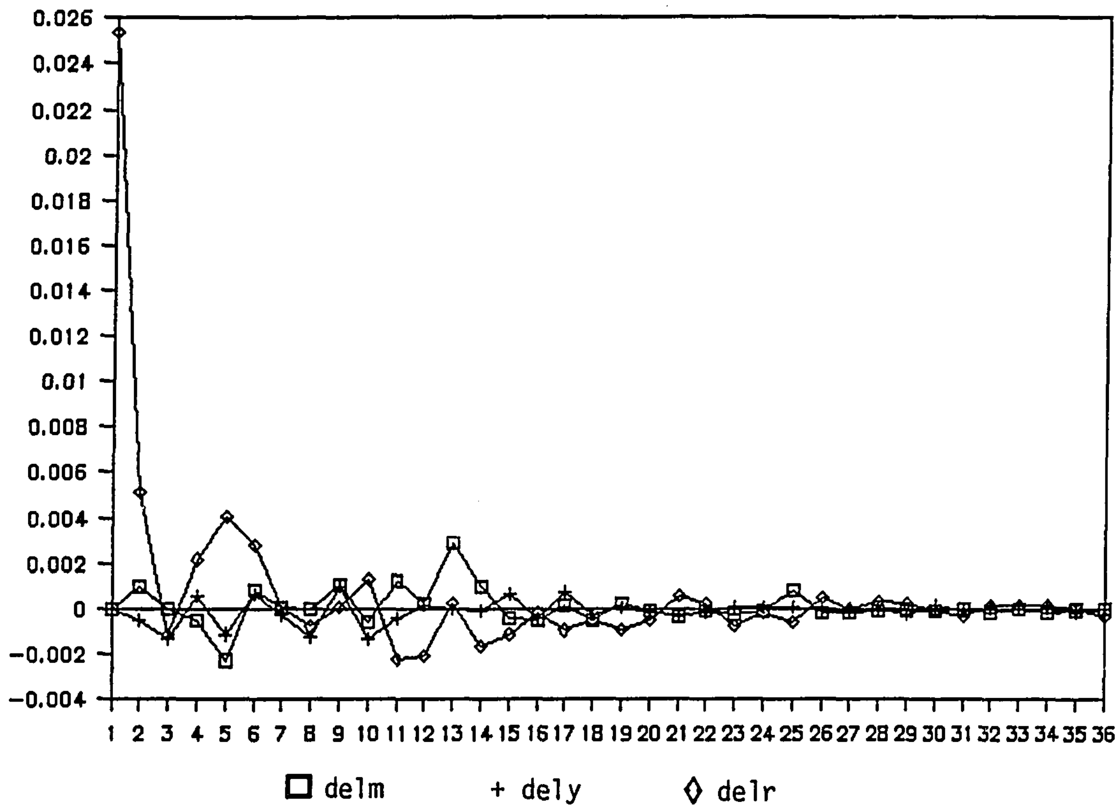

Figure 5-15. Responses of delm, dely, and delr to a shock in delr (Japan vs. Korea)

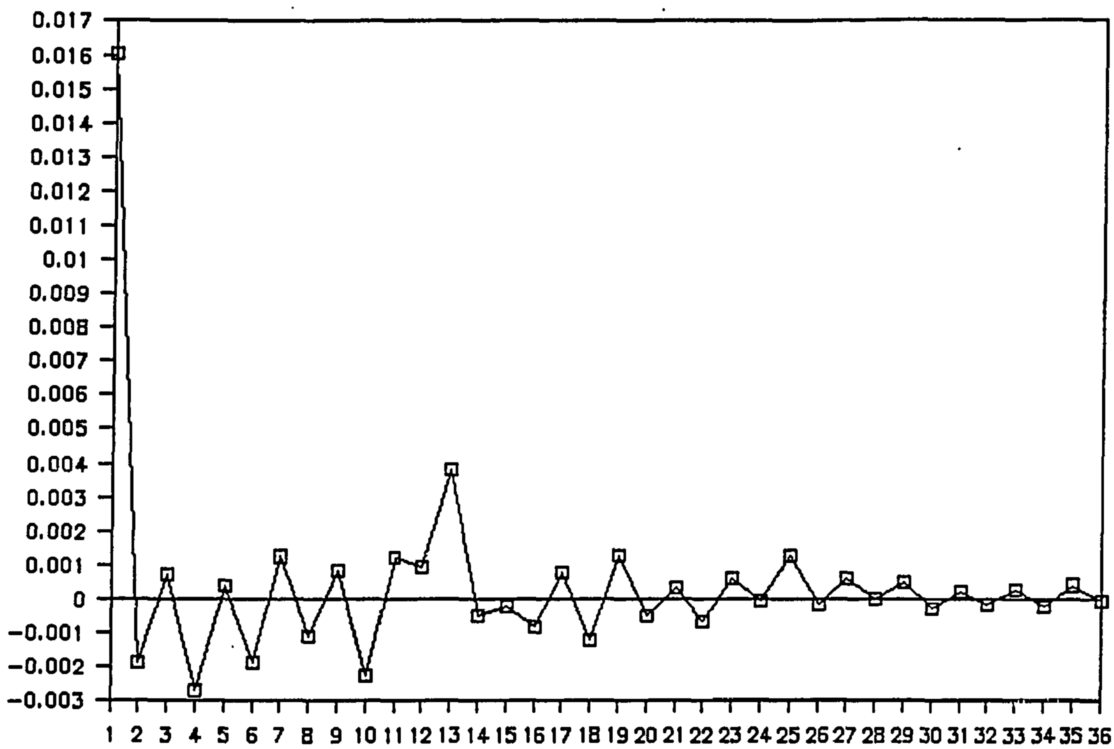

Figure 5-16. Responses of delm to a shock in delm (Japan vs. Korea)

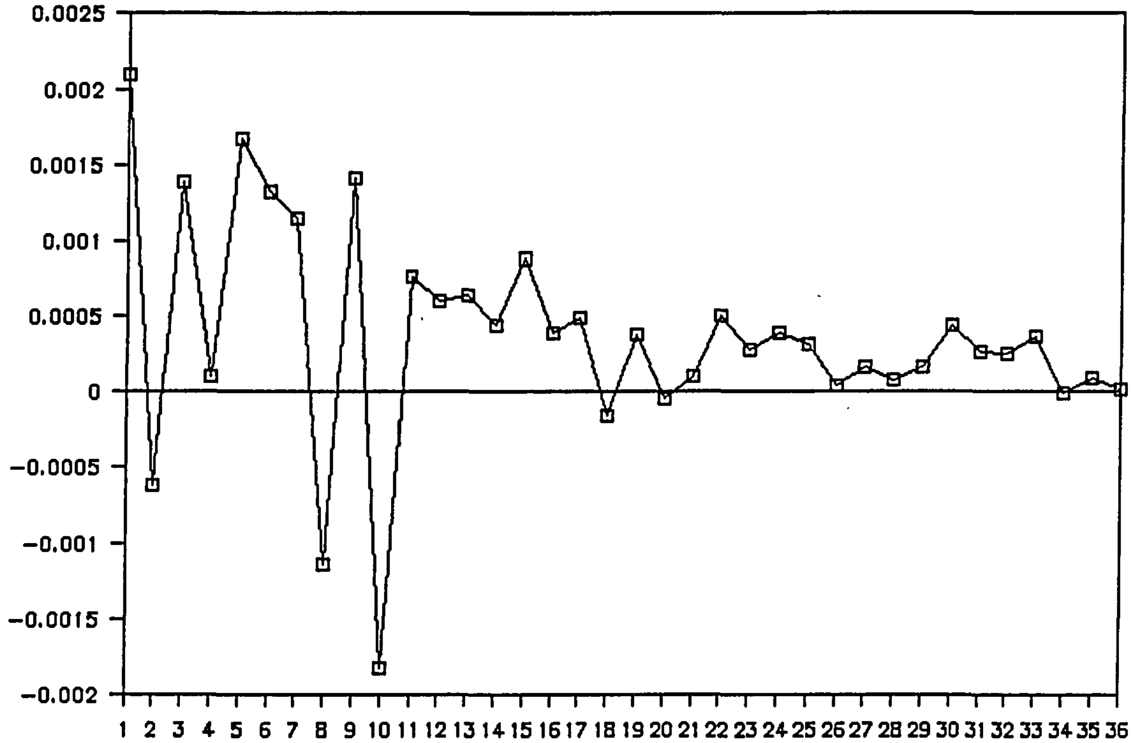

Figure 5-17. Responses of dely to a shock in delm (Japan vs. Korea)

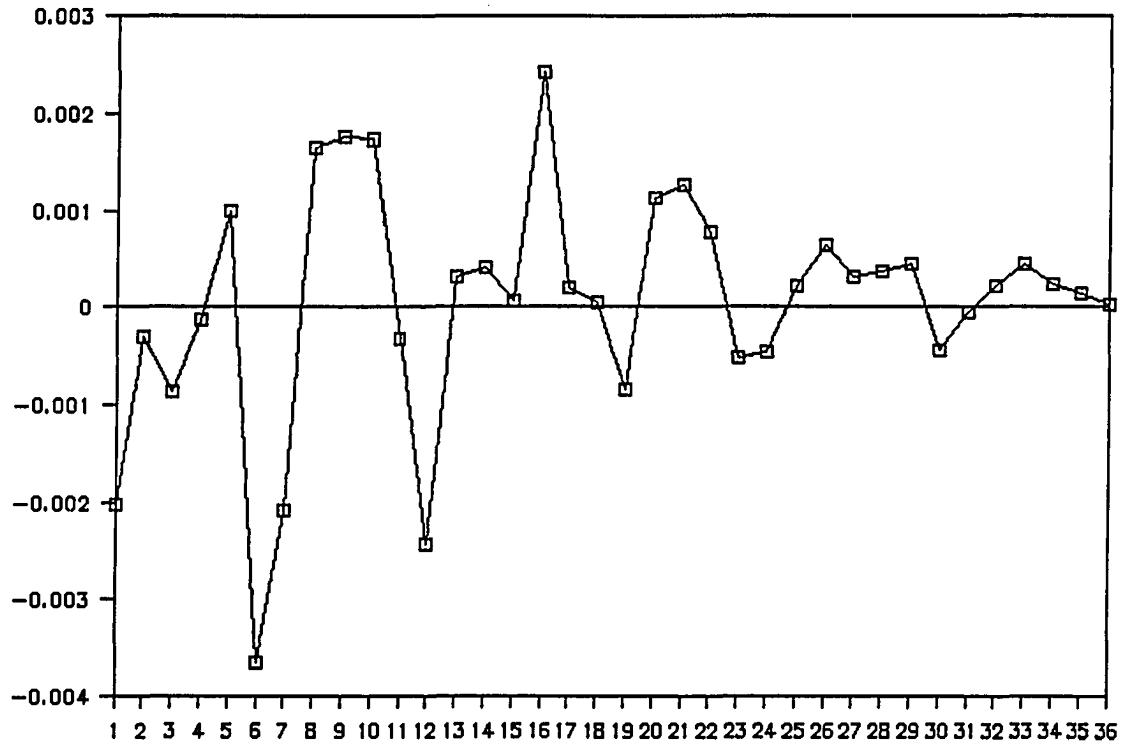

Figure 5-18. Responses of delr to a shock in delm (Japan vs. Korea)

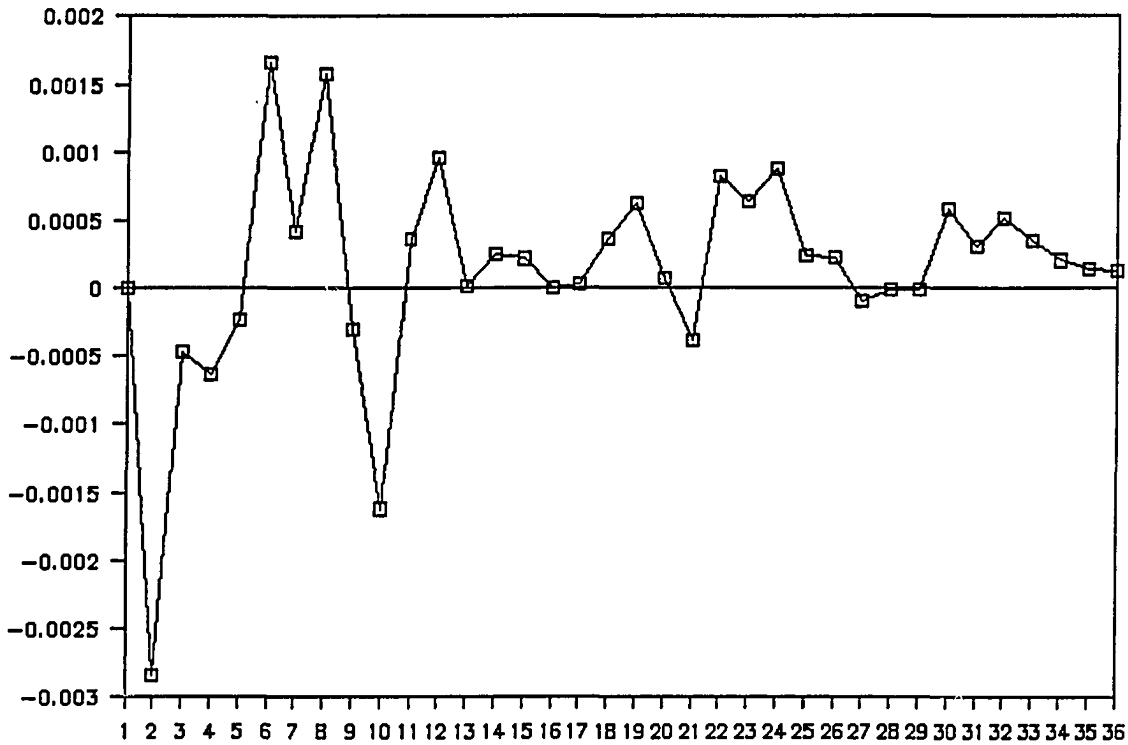

Figure 5-19. Responses of delm to a shock in dely (Japan vs. Korea)

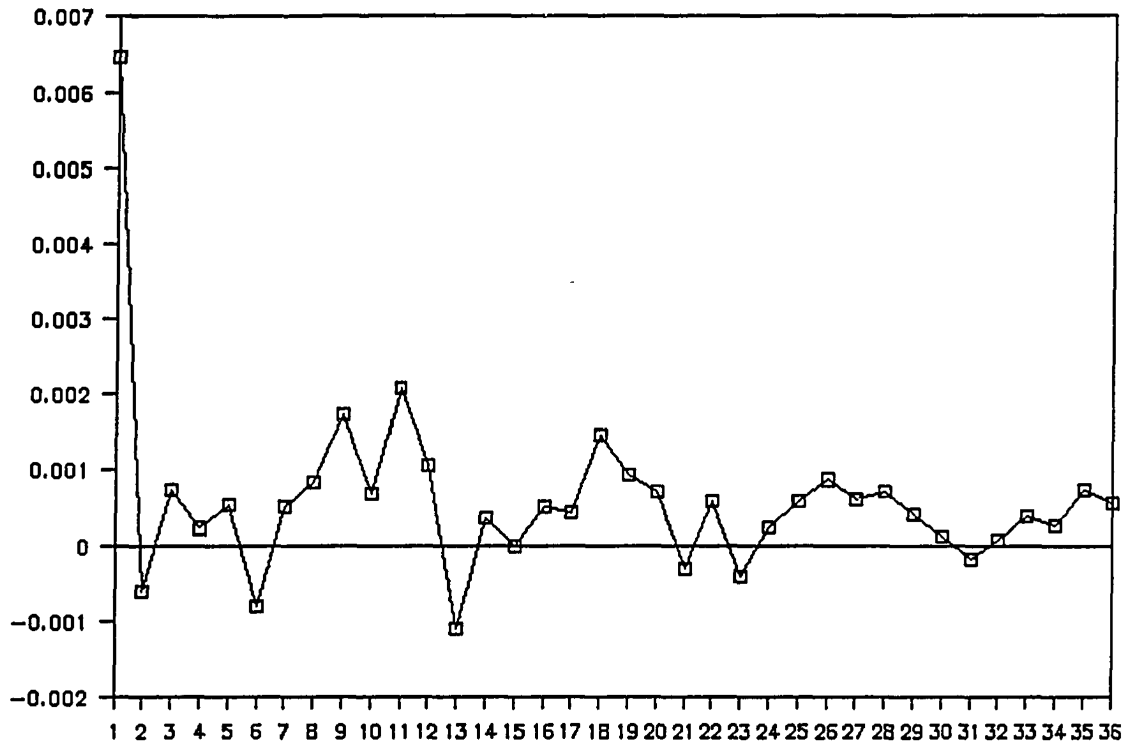

Figure 5-20. Responses of dely to a shock in dely (Japan vs. Korea)

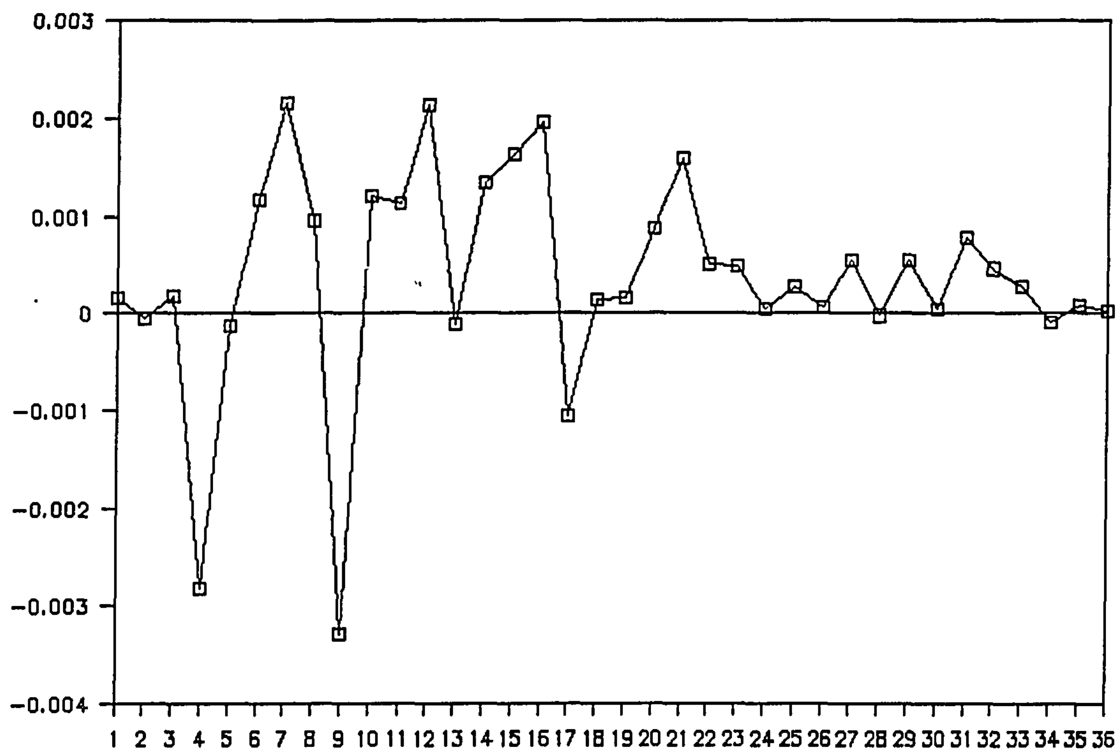

Figure 5-21. Responses of delr to a shock in dely (Japan vs. Korea)

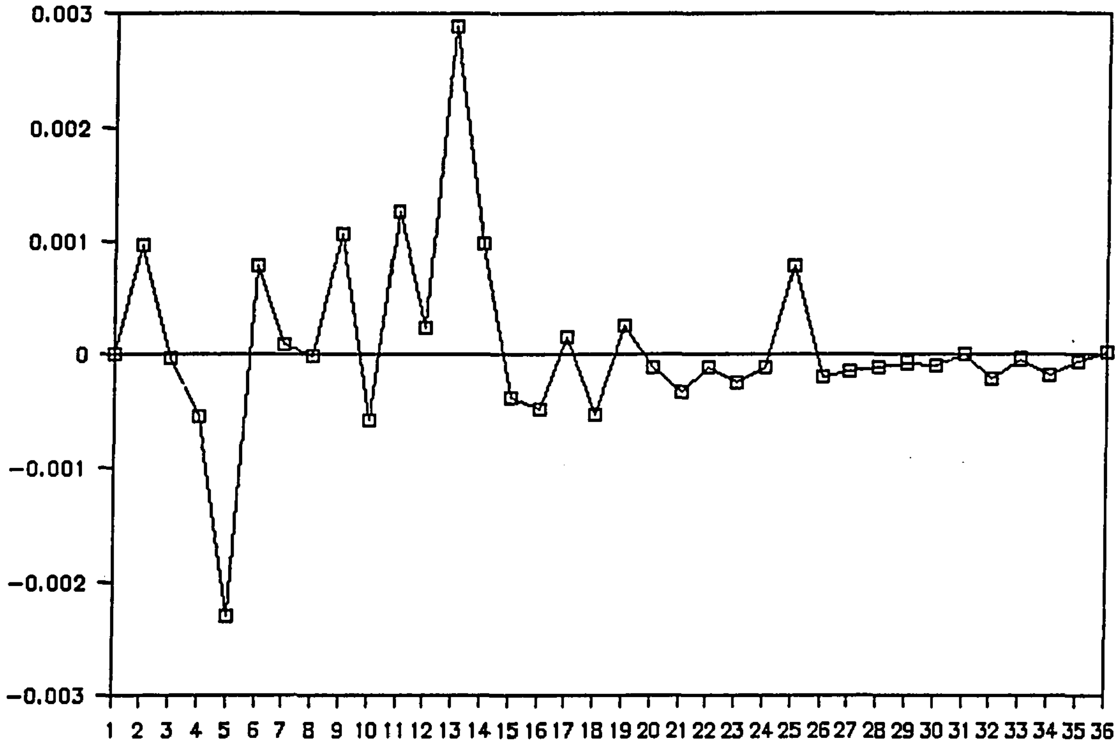

Figure 5-22. Responses of delm to a shock in delr (Japan vs. Korea)

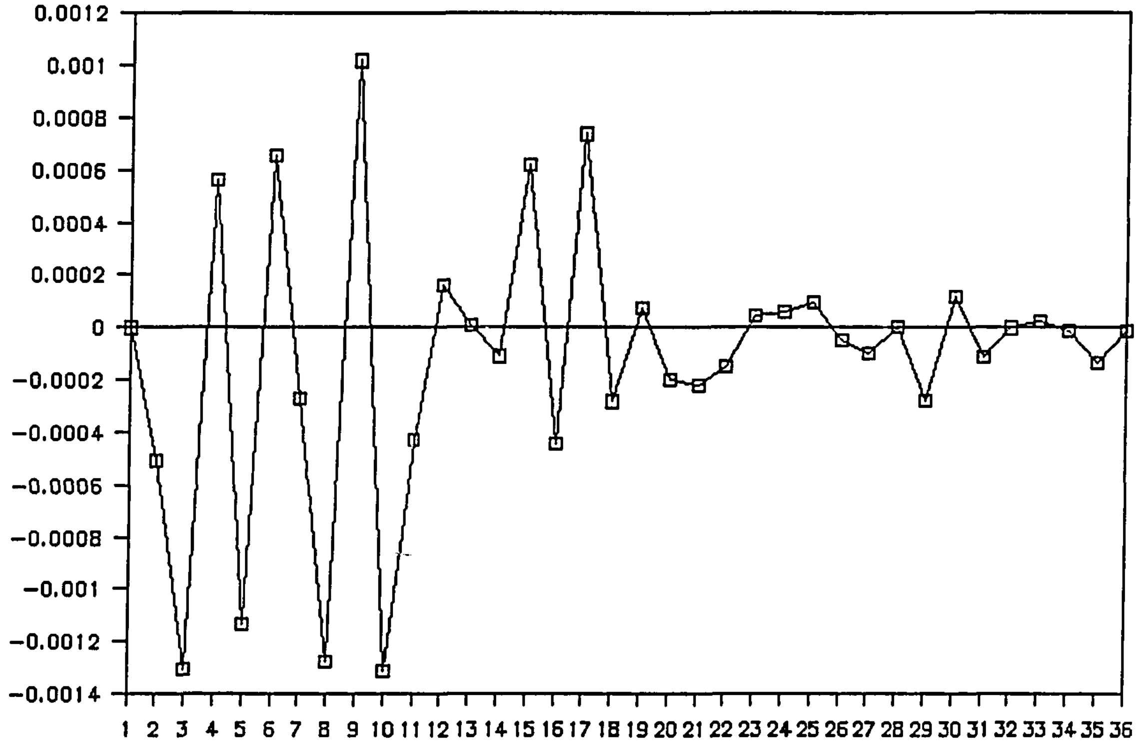

Figure 5-23. Responses of dely to a shock in delr (Japan vs. Korea)

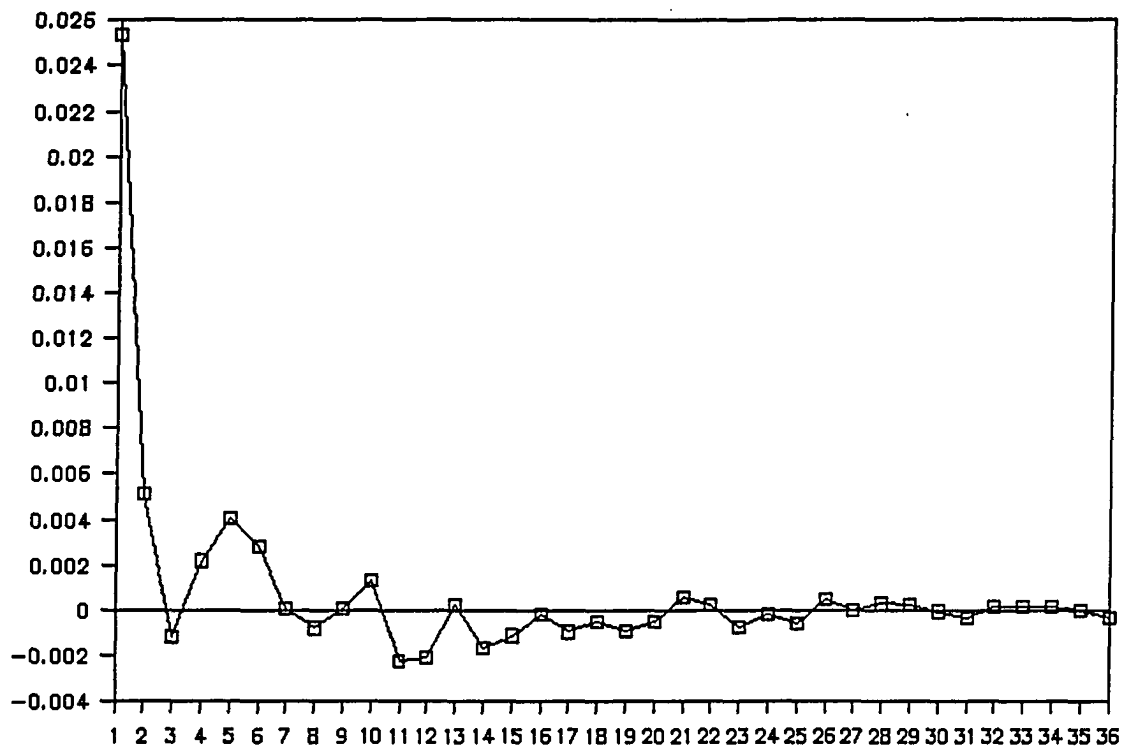

Figure 5-24. Responses of delr to a shock in delr (Japan vs. Korea)

CHAPTER VI. SUMMARY AND CONCLUSIONS

Korea is representative of the growing economies with strong trading ties to other Pacific Rim nations--specifically to the United States and to Japan. So, the study of the PPP performance in the Korean economy was very impressive.

The standard ARIMA models of the real exchange rate for Korea and her major trading partners were favorable to the long-run PPP. However, using unit root and cointegration tests, we found that there was little evidence supporting the PPP hypothesis for the Pacific Rim: 1) by using Dickey-Fuller tests, we could not reject the null hypothesis of a single unit root for any nation except India, 2) SURE estimates indicated that both the U.S. and Indian real exchange rate were convergent, and 3) cointegration tests for all nations but Thailand failed to indicate PPP.

The overall impression was that PPP can not be said to hold for the Korean economy. Furthermore, these results are consistent with those for the Western nations and Japan; there exist shocks to the real exchange rate that are not self-correcting.

The theory suggests that permanent real economic shocks can induce permanent changes in the real exchange rate. Money supply shocks, however, are generally deemed to be neutral in the long run. Thus, the theory suggests that monetary shocks of any variety may induce temporary but not permanent changes in the real exchange rate.

To ascertain the theory we employed the vector autoregressive (VAR) analysis. We also focused on the U.S. vs. Korea and the Japan vs. Korea

VAR systems. By using vector autoregressions, we found mixed support for the theory. Real shocks (as measured by interest rates or industrial production) did not appear to cause movements in the real exchange rates. For the U.S. vs. Korea system, money shocks did Granger-cause the real exchange rate at the 10% significance level. On the other hand, money shocks did not Granger-cause the real exchange rate at the 5% significance level for the Japan vs. Korea system. In support of the standard claim, money shocks did not cause permanent changes in the real exchange rate.

For further research in this area, we may consider the other real shocks (for example, government spending) to support the theory of PPP.

BIBLIOGRAPHY

Backus, David. "The Canadian-U.S. Exchange Rate: Evidence from a Vector Autoregression." The Review of Economics and Statistics 68 (1986): 628-37.

Balassa, B. "The Purchasing Power Parity Doctrine: A Reappraisal?" Journal of Political Economy 72 (June 1964): 584-96.

The Bank of Korea. National Income in Korea. Seoul: Author, 1982.

The Bank of Korea. Economic Statistics Yearbook. Seoul: Author, 1982, 1988, 2 citations.

The Bank of Korea. Monthly Bulletin. Seoul: Author, June 1989.

Bayard, Thomas O. and Soo-Gil Young (eds). Economic Relations between the United States and Korea: Conflict or Cooperation? Washington, D.C.: Institute for International Economics, 1989.

Bhagwati, J. N. "Why Are Services Cheaper in the Poor Countries?" The Economic Journal 94 (June 1984): 279-86.

Blanchard, Oliver Jean. Comment. Journal of Business and Economic Statistics 5 (4) (October 1987): 449-451.

Branson, W. and D. Henderson. "The Specification and Influence of Asset Market." In Handbook of International Economics, eds. P. Kenen and R. Jones, 749-805. Amsterdam: North Holland, 1984.

Campbell, John Y. and Robert J. Shiller. "Cointegration and Tests of Present Value Models." Journal of Political Economy 95 (1987): 1062-88.

Cassel, G. "Abnormal Deviations in International Exchanges." The Economic Journal 26 (December 1916): 413-15.

Corbae, Dean and Sam Ouliaris. "Cointegration and Tests of Purchasing Power Parity." The Review of Economics and Statistics 70(3) (August 1989): 508-11.

Daniel, Betty. "Optimal Purchasing Power Parity Deviations." International Economic Review 27 (June 1986): 483-510.

Davutyan, Nurhan and John Pippenger. "Purchasing Power Parity Did Not Collapse During the 1970s." American Economic Review 75 (December 1985): 1151-158.

Dickey, D. A. and W. A. Fuller. "Distribution of the Estimators for Autoregressive Time Series with a Unit Root." Journal of the American Statistical Association 24 (1979): 427-31.

Dickey, D. A., D. P. Hasza, and W. A. Fuller. "Testing for Unit Roots in Seasonal Time Series." Journal of the American Statistical Association 79 (1984): 355-67.

Dixit, A. and J. Stiglitz. "Monopolistic Competition and Optimum Product Diversity." American Economic Review 67 (June 1977): 297-308.

Dornbush, Rudiger. "Expectations and Exchange Rate Dynamics." Journal of Political Economy 84 (December 1976): 1161-76.

Dornbush, Rudiger. "Exchange Rate Economics: Where Do We Stand?" Brookings Papers on Economics Activity, No. 1, 1980, 143-85.

Dornbush, Rudiger. "The Purchasing Power Parity." NBER Working Paper 1591, March 1985.

Dornbush, Rudiger. "Exchange Rates and Prices." American Economic Review 77(3) (March 1987): 93-106.

Dornbush, Rudiger. "Doubts About the McKinnon Standard." Journal of Economic Perspectives 2(1) (Winter 1988a): 105-12.

Dornbush, Rudiger. "Real Exchange Rates and Macroeconomics: A Selective Survey." NBER Working Paper No. 2775, 1988b.

Dornbush, Rudiger. "Korean International Macroeconomic Policy; Discussion." In Economic Relations between the United States and Korea: Conflict or Cooperation?, eds. Thomas O. Bayard and Soo-Gil Young, 43-76. Washington, D.C.: Institute for International Economics, 1989.

Dornbush, Rudiger and Dwight Jaffee. "Purchasing Power Parity and Exchange Rate Problems Introduction." Journal of International Economics 8 (1978): 157-61.

Dornbush, R., S. Fischer, and P. Samuelson. "Comparative Advantage, Trade and Payments in a Ricardian Model with a Continuum of Goods." American Economic Review 67(5) (December 1977): 823-39.

Edison, Hali J. "Purchasing Power Parity in the Long Run: A Test of Dollar/Pound Exchange Rate (1890-1978)." Journal of Money, Credit, and Banking 19(3) (August 1987): 376-87.

Edwards, Sebastian. "Real and Monetary Determinants of Real Exchange Rate Behavior: Theory and Evidence from Developing Countries." NBER Working Paper No. 2721, 1988.

Einzig, Paul. The History of Foreign Exchange. London: Macmillan & Co., Ltd., 1962.

Enders, Walter. "ARIMA and Cointegration Tests of PPP Under Fixed and Flexible Exchange Rate Regimes." The Review of Economics and Statistics 70(3) (August 1988): 504-08.

Enders, Walter. "Unit Roots and the Real Exchange Rate Before World War I: The Case of Britain and the USA." Journal of International Money and Finance 8 (1989): 59-73.

Enders, Walter and E. Harvey Lapan. International Economics. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1987.

Enders, Walter and E. Harvey Lapan. "Stability, Random Disturbances and the Exchange Rate Regime." Southern Economic Journal 46 (1979): 49-70.

Engle, Robert and C. W. J. Granger. "Cointegration and Error Correction: Representation, Estimation, and Testing." Econometrica 55 (March 1987): 251-76.

Frenkel, J. A. "Flexible Exchange Rates, Prices, and the Role of News: Lessons from the 1970s." Journal of Political Economy 89 (August 1981): 665-705.

Frenkel, Jeffrey A. "International Capital Mobility and Crowding Out in the U.S. Economy: Imperfect Integration of Financial Markets Or of Goods Markets?" NBER Working Paper 1773. Cambridge, Massachusetts: National Bureau of Economic Research, 1985.

Fuller, Wayne A. Introduction to Statistical Time Series. New York: John Wiley and Sons, Inc., 1976.

Granger, C. W. and Robert Engle. "Dynamic Model Specification with Equilibrium Constraints: Co-Integration and Error Correction." Mimeo, Department of Economics, San Diego, California, 1984.

Hakkio, Craig S. "A Re-examination of Purchasing Power Parity." Journal of International Economics 17 (1984): 265-77.

Hasza, H. B. and W. A. Fu-ler. "Testing for Nonstationary Parameter Specifications in Seasonal Time Series Models." The Annals of Statistics 10 (1982): 1209-16.

Hong, Won-Tack. Factor Supply and Factor Intensity of Trade in Korea. Seoul, Korea: Korea Development Institute, 1976.

Hong, Won-Tack and Anne O. Krueger, eds. Trade and Development in Korea. Seoul, Korea: Korea Development Institute, 1975.

Hsieh, D. "The Determinants of the Real Exchange Rate." Journal of International Economics 12 (May 1982): 335-62.

Isard, P. "How Far Can We Push the Law of One Price?" American Economic Review 67 (December 1977): 942-48.

Kim, Chuk-Kyo, ed. Planning Model and Macroeconomic Policy Issues. Seoul, Korea: Korea Development Institute, 1977.

Kim, Kwang-Suk and Joom-Kyung Park. Sources of Economic Growth in Korea: 1963-1982. Seoul, Korea: Korea Development Institute, 1985.

Kim, Mahn-Je and Sung-Tae Ro. "Korean International Macroeconomic Policy." In Economic Relations between the United States and Korea: Conflict or Cooperation?, eds. Thomas O. Bayard and Soo-Gil Young, 43-76. Washington, D.C.: Institute for International Economics, 1989.

Kravis, I. and Ray Lipsey. "Price Behavior in the Light of Balance of Payments Theories." Journal of International Economics 8 (May 1978): 193-246.

Krugman, P. "Purchasing Power Parity and Exchange Rates." Journal of International Economics 8 (August 1978): 397-407.

Kuzmets, Paul W. Economic Growth and Structure in the Republic of Korea. New Haven: Yale University Press: 1977.

Lapan, Harvey and Walter Enders. "Random Disturbances and the Choice of Exchange Regimes in an Intergenerational Model." Journal of International Economics 10 (1980): 263-83.

Litterman, Robert B. and Laurence Weiss. "Money, Real Interest Rates, and Output: A Reinterpretation of Postwar U.S. Data." Econometrica 53 (January 1985): 129-56.

Mann, H. B. and A. Wald. "On the Stastical Treatment of Linear Stochastic Difference Equations." Econometrica 11 (1943): 173-220.

McKinnon, Ronald I. "Monetary and Exchange Rate Policies for International Financial Stability: A Proposal." Journal of Economic Perspectives 2(1) (Winter 1988): 83-103.

Meese, Richard A. a-d Kenneth J. Singleton. "On Unit Roots and the Empirical Modelling of Exchange Rates." The Journal of Finance 37(4) (September 1982): 1029-35.

Mussa, Michael L. "Empirical Regularities of the Exchange Rate and Theories of the Foreign Exchange Market." In Policies for Employment, Prices, and Exchange Rates, Carnegie Rochester Conference Series 11, eds. K. Brunner and A. Meltzer, 9-58. Amsterdam: North Holland, 1979.

Mussa, Michael L. "The Exchange Rate, the Balance of Payments and Monetary and Fiscal Policy Under a Regime of Controlled Floating." Scandinavian Journal of Economics 78 (May 1976): 229-48.

Ohanian, Lee E. "The Spurious Effects of Unit Roots on Vector Auto-Regressions: A Monte Carlo Study." Journal of Econometrics 39 (1988): 251-66.

The Republic of Korea, Economic Planning Board. Korea Statistical Yearbook. Seoul: Author, 1988.

The Republic of Korea, Economic Planning Board. Major Statistics of Korean Economy. Seoul: Author, 1982.

The Republic of Korea, Ministry of Trade and Industry. Free and Fair Trade: Korea's Record and Commitment. Seoul, Author, 1989.

Runkle, David E. "Vector Autoregressions and Reality." Journal of Business and Economic Statistics 5(4) (October 1987): 439-442.

Runkle, David E. "Reply." Journal of Business and Economic Statistics 5(4) (October 1987): 454.

Samuelson, P. A. "Analytical Notes on International Real Income Comparisons." Economic Journal 84 (September 1974): 595-608.

Samuelson, P. A. "Theoretical Notes on Trade Problems." Review of Economics and Statistics 46 (May 1964): 145-54.

Sargent, Thomas J. "Autoregression, Expectations, and Advice." American Economic Review 74 (May 1984): 408-15.

Sargent, Thomas J. "Estimating Vector Autoregressions Using Methods Not Based on Explicit Economic Theories." Federal Reserve Bank of Minneapolis Quarterly Review 3 (Summer 1979): 8-15.

Sargent, Thomas J. "Interpreting Economic Time Series." Journal of Political Economy 89 (April 1981): 213-48.

Sims, Christopher A. "Money, Income and Causality." American Economic Review 62 (1972): 540-52.

Sims, Christopher A. "Macroeconomic and Reality." Econometrica 48 (January 1980a): 1-48.

Sims, Christopher A. "Comparison of Interwar and Postwar Business Cycles: Monetarism Reconsidered." American Economic Review 70 (May 1980b): 250-57.

Sims, Christopher A. "Are Forecasting Models Usable for Policy Analysis?" Federal Reserve Bank of Minneapolis Quarterly Review 10 (Spring 1987a): 2-16.

Sims, Christopher A. "Comment." Journal of Business and Economic Statistics 5(4) (October 1987b): 443-449.

Watson, Mark W. "Comment." Journal of Business and Economic Statistics 5(4) (October 1987): 451-453.

Williamson, John. "Korean International Macroeconomic Policy; Discussion." In Economic Relations between the United States and Korea: Conflict or Cooperation?, eds. Thomas O. Bayard and Soo-Gil Young, 43-76. Washington, D.C.: Institute for International Economics, 1989.

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