Japanese Foreign Direct Investments and the Effects on Japanese Economy[1] - An Econometric Approach -

By
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Abstract

This paper focuses the Japanese foreign direct investment behaviors and their effects on the balance of payments. An econometric model which we built enables us to analyzes these effects quantitatively. The model consists of the domestic sector and the international sector whose equations describe Japanese overseas activities and trade between Japanese foreign affiliates and domestic firms by industry. The equations of the international sector explain the displacement and associated effects of Japanese exports and boomerang effect due to the increased overseas production. Some simulation results tell us that an increase of Japanese FDI did not necessarily contribute to reducing the huge Japanese trade surplus in the 1980's, but suggest that the structural changes of overseas production in the 1990's may have had a great impact on the trade balance.

1. Introduction

In the 1980's, Japanese FDI increased a great deal. Statistics of the Bank of Japan show that Japanese FDI stock increased from US$ 19.6 billion at the end of 1980 to US $44 billion at the end of 1985. The discussions on Japanese FDI during that period had mostly been connected with Japanese trade friction between U.S. and Europe due to the huge trade surplus. Then the sharp appreciation of the Japanese yen after the Plaza Agreement in 1985 further spurred the increase of Japanese FDI in the latter half

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[1] This paper is the English summary of my book, Japanese Foreign Direct Investment - An Empirical Study Using a Multi-Sectoral Econometric Model - (Kaigai chokusetutoushi no Keizaigaku, Sobunnsha Publishing Inc., in Japanese), which was published last March. The final draft of the book was finished on December 1998 at the International Institute for Applied Analysis (IIASA). I would like to thank Dr. János Gacs, project leader of the Economic Transition and Integration, IIASA, for the critical and constructive comments on the former paper (Inaba and Morikawa (1995)) and giving me nice research environment. I am also grateful for the useful comments from Professor Mitsuo Saito (Kobe University in Japan, Emeritus) and Professor Kiyoshi Fujikawa (Konan University in Japan) as well as the anonymous referee and managing editor.

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of the 1980's. Many Japanese manufacturing companies began to seek offshore transplants to reduce production costs as well as to avoid the trade friction.

While Japanese FDI in the 1990's has been still below the level of 1990, Japanese foreign affiliates increased re-investment of their profit (earnings). Subsidiary earnings consist of FDI income remitted to Japan and re-investment. The subsidiary re-investment reached US$ 12.9 billion, accounting for 50.3% of the total subsidiary investment US$ 24.0 billion, which shows remarkable increase compared to the 1989 figure US$ 6.7 billion, accounting for 29% of US$ 23.8 billion.[2] Thus the high level of subsidiary re-investment in the 1990's further increased the subsidiary capital stocks as a production capacity in spite of the low figure of the FDI capital outflow from Japan. The amount of subsidiary sales in 1995 surpassed that of Japanese exports for the first time. The share of overseas production, subsidiary sale as percentage of domestic sales, expanded more than eight times from 1.6% in 1979 to 13.4% in 2000.[3] This change seems to have a great effect on the domestic economies of both, Japanese and the host countries as well as their foreign trade structures.

This paper focuses on the effects of Japanese FDI on the balance of trade. Does an increase of Japanese FDI reduce the trade surplus? If Japanese overseas production displaces Japanese exports or enhances Japanese re-imports from its foreign affiliates, Japanese trade surpluses will decrease. If Japanese exports of intermediary or capital goods to its foreign affiliates (associated exports) increases heavily, however, Japanese trade surpluses will not decrease. We needed to build a macro econometric model to analyze these effects quantitatively including the domestic repercussions. Our model consists of the domestic sector and the international sector which describes Japanese overseas activities and trade between Japanese foreign affiliates and domestic firms by industry. The equations of the international sector enable us to explicitly analyze the displacement and associated effects of Japanese exports and the boomerang effect caused by the increased overseas production. Furthermore, we attempted simulation analyses to determine how much of effect of Japanese FDI would have had during an earlier sample period if the yen exchange rate had appreciated, or an autonomous FDI increase had occurred.

Some interesting empirical studies on Japanese FDI have been made in recent years.[4] However, few of the previous works covering these issues in Japan have been carried out considering the domestic repercussion. We previously built a macro-econometric model which incorporates both the domestic and international sectors, and covers a sample period from 1974 to 1986 (Inaba-Morikawa(1993)). This paper presents the re-estimated results of the model in a prolonged estimation period(1974-1992).

The structure of this paper is as follows. Section 2 presents the main characteristics of our model, and explains the data used. The estimation results of the major equations are shown in section 3. Section 4 presents the simulation results of the

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[2] From the Statistics of the Ministry of International Trade and Industry(MITI), The 24th Survey of Overseas Japanese Companies.

[3] From the Statistics of MITI, The 30th Survey of Overseas Japanese Companies.

[4] See for instance Graham(1996).

model, and section 5 gives the conclusion.

2. The Model of Japanese Foreign Direct Investment

2.1 The Effects of FDI

Path-breaking empirical studies on the FDI-balance of payment relations were done by Reddaway(1967), and Hufbauer and Adler(1968)in the United Kingdom and in the United States respectively. Our model incorporates the main FDI - balance of payments relations, which they considered, as follows:

1. Exports of equipment, parts and components (associated exports)
   Overseas production enhances exports of capital goods and parts and components that are made in the home country. The magnitude of these exports depends upon the scale of production and the ratio of these exports to subsidiaries' total input. These effects are analyzed in the export equations for manufactured goods.

2. Export substitution and boomerang effect
   If subsidiary production creates a new market in the host country or in the rest of the world, it may have little influence on domestic production. If there is minimal market increase and subsidiary production replaces domestic Japanese production, the exports from the home country decrease, and in some cases the imports into the home country increase. Each effect is considered by the export functions for manufactured goods or by their import functions respectively.

3. Direct investment income
   Although direct investment income such as dividends, interest, and branch profits remitted to Japan reached \$4.8 billion in 1990, more than three-and-a-half times that of 1980, the ratio of FDI income remitted to Japanese FDI capital stock fell from 7.8% in 1980 to 3.1% in 1990.[5] Direct investment income itself is expected to increase rapidly through increased overseas production in the future.

4. Outflow of long term capital
   As we mentioned in the previous chapter, Japanese long-term capital outflow through FDI increased remarkably in the 1980's. If subsidiary investment is financed from parent companies or from other companies in Japan, long-term capital outflow from Japan takes place. The direct investment capital outflow equation in this model explains the determinants of this outflow.

Graham(1996) made a comprehensive survey on these issues, and himself did research on the FDI-trade relations by using gravity model, which helps to remove simultaneity bias in regression analysis. But he even did not make distinction between export

[5] From Statistics of the Bank of Japan

displacement and associate exports, which we considered.

2.2 Introduction of the Effect of FDI on Our Model

Table 1 shows the industry classification of our model. Other industry is taken as exogenous. This classification follows a special industrial grouping included in the "Annual Report on National Accounts." [6] Figure 1 shows a flow chart of this model. This model shows both the estimate of the Japanese FDI activities and the modeling of Japanese FDI in association with the production of Japanese companies' foreign affiliates. After FDI stock and sales of foreign affiliates are determined endogenously, sales in both the host and the third countries (local sales and the exports to the third countries) which may be competitive with Japanese exports, are also determined, because the exports of the foreign affiliates to Japan are also endogenously determined in the model. Furthermore, imports of foreign affiliates from Japan which consist of the share of total inputs for their production, are determined. Thus we can consider the effects of Japanese FDI on the balance of trade which includes the displacement of exports, the associated exports, and re-imports due to the increased overseas production. This model has 195 equations and identities.

2.3 Data for the Model

The data of the domestic variables, and the exports and imports of the international sector are mainly based on the System of National Accounts (SNA). Due to the limited availability of data, the sample period of the international sector begins from 1974. Estimation of the world trade volume by industry is made from OECD statistics (excluding estimation for Japan). The world export prices (excluding Japan) are the weighted averages of six developed countries' price indexes: export price indexes are used for Germany, France, and Italy, whereas producers prices are used for the US, UK, and Canada.

The time series of Japanese foreign direct investment statistics are usually prepared on three different bases. The Bank of Japan provides data according to the balance of payments statistics. These data are available by host area, but not by industry. The data of the Ministry of Finance are based on the amounts of its investment notifications/approvals, which provide the estimates of planned investments reported by Japanese companies by industry and host country, regardless of whether these investments are realized or not. The statistics from these sources differ considerably and do not provide any measurements of overseas production or re-investment of subsidiaries. The Ministry of International Trade and Industry (MITI) provides the subsidiary investment position and the amounts of import-export trade between subsidiaries and parent companies every three years by industry and host area.[7]

[6] The Economic Planning Agency (EPA) of Japan provides this report every year.

[7] Data on import-export trade between subsidiaries and parents companies are available every year from 1986.

The statistics are based on the data collected by the survey of Japanese companies, and

Table1: Industry Classification

Agriculture, forestry & fisheries	1	
Mining	2	
Manufacturing		
Light Manufacturing	3	(pulp, paper, ceramics, food, textile, other manufacturing)
Chemicals	4	(chemicals, petroleum, coal industry)
Metal Industry	5	(primary metals, metal products)
Machinery	6	(general, electrical, transportation, precision machinery)
Wholesale & retail trade	7	
Other Industry	8	(services, other industries)

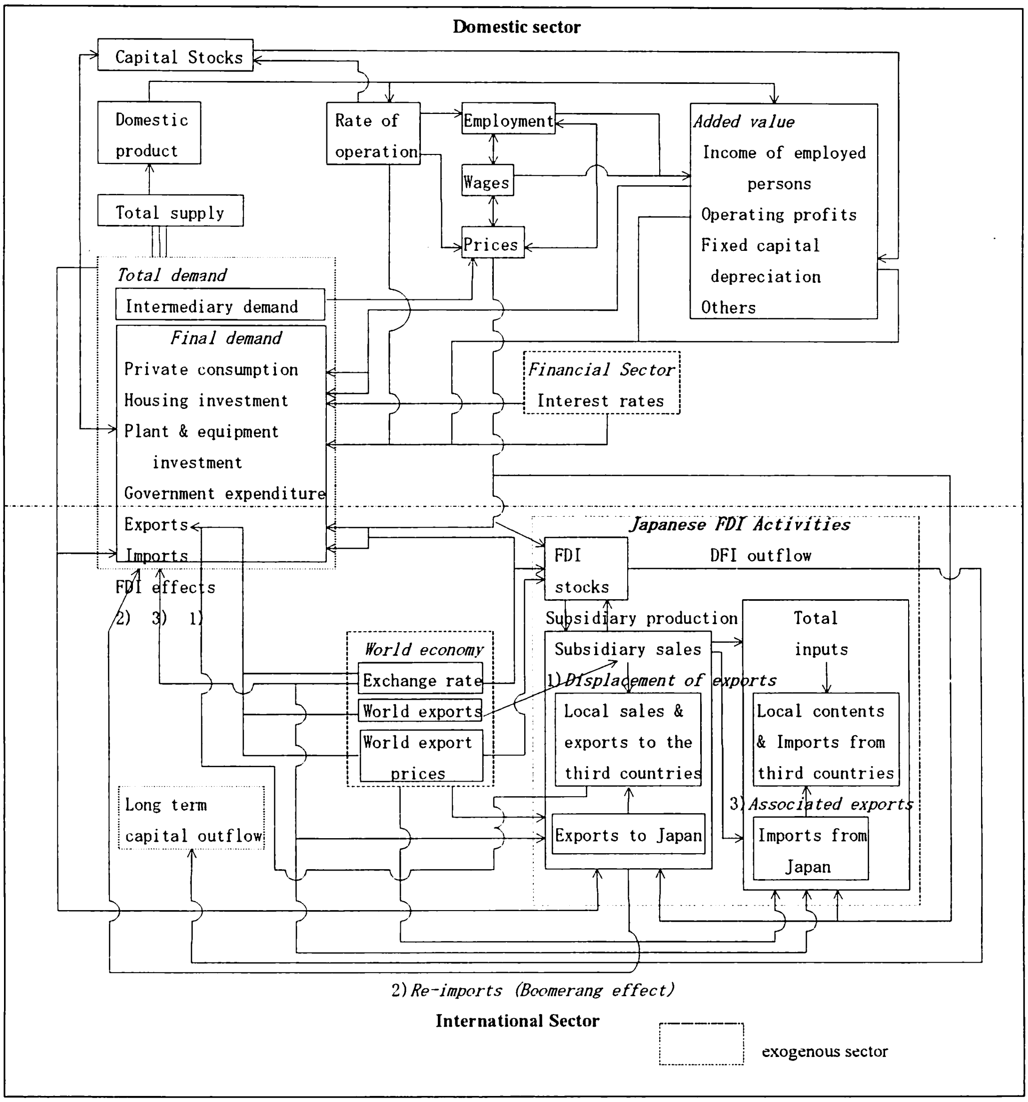

Figure 1: Japanese FDI Activities Within the Framework of Macro-Econometric Model

also every year provide data on subsidiary sales, subsidiary earnings, subsidiary employment and so on. These data are subject to changes between the years covered, however, and are not available before 1972. The MITI direct investment data are adjusted by other information from the Tokyo Keizai Databank to make sure coverage of the number of firms are more accurate, and these revised data are used in estimations of FDI equations and the related equations. In the following section, we explain the estimation results of the main equations of our model. It should be noted that all the structural equations are estimated by the ordinary least squares (OLS) methods. Since some of the equations have a lagged dependent variable as a regressor, the OLS estimators are not consistent. All the conclusions are subject to qualifications by more appropriate estimation method. However, statistics for the reliability of the coefficients by OLS are robust and stable. We do not think that other estimation method such as instrumental variable is needed. The other issue to be considered is that the sample period is a little bit old. We will discuss it at the conclusion.

3. Estimation Results of Main Equations

3.1 FDI Functions

3.1.1. Determinant of FDI

The decisions on FDI are supposed to depend upon the behavior of the parent company. In our model, the classification of industries in which we considered the FDI functions is based on what kind of goods the industries are producing in the host countries. Industries are classified into three groups according to Japanese direct investment behavior; namely, (a) development of natural resources, (b) manufacturing, and (c) wholesale and retail trade.

(a) Development of natural resources

Since the Japanese economy consumes far more natural resources; i.e., agricultural products, timber, seafood, minerals, etc., than it produces, it seeks a stable supply condition. In some cases domestic firms invest abroad to develop their supplies.

(b) Manufacturing

As for direct investment behaviors in manufacturing, the so-called profit motive is essential for the Japanese companies to start overseas production. Profit motive, used in a broad sense, consists of the following factors: (1) profit differential, (2)market growth factors, (3)production cost factors, and (4)institutional factors.

(1) Profit differential (Kojima(1978))

If foreign profit rates exceed domestic profit rates, parent companies invest abroad in the hope that they will generate more profit by overseas production than by domestic production.

(2) Market growth factors (Scaperlanda and Maurer(1969))
If the domestic product in the industry concerned shrinks, or if the overseas market is expected to grow faster than the domestic market, parent companies seek for a business opportunity abroad to keep their market shares.

(3) Production cost factor (Ballassa and Norland[1988], Julius[1990]).
The appreciation of the yen exchange rate forces the ratio of the domestic production cost to the overseas production cost to increase. Parent companies in some industries decide to move some parts of their production facilities from their home countries to countries where relative production costs are lower.

(4)Institutional factors.
The enormous trade imbalance of competitive goods has forced parent companies to reduce their exports in favor of overseas production. For example, the voluntary restraint of Japanese auto export was carried out in the 1980's. Another factor is the drastic deregulation of international capital transactions, a move which was taken several times by the Japanese government in the 1980's. These acts have been big incentives for Japanese firms to invest abroad.

(c) Wholesale and retail trade.
Much of the export of foreign affiliates to Japan and their imports from Japan have been made through overseas trading companies. These companies play a very important role in the import-export trade between parent companies and their foreign affiliates. We considered this in the FDI of the wholesale and retail trade industry (Results are not included here).

3.1.2. Specifications of the FDI Functions

We will now explain the concrete specification of FDI functions of the model. Except for wholesale and retail trade, all dependent variables of the estimated equations are the increase of logarithm of fixed capital stocks of subsidiaries (DIK(i)), namely $Ln(\mathrm{DIK(i)})-Ln(\mathrm{DIK(i)}_{-1})$, or $Ln(\mathrm{DIK(i)}/\ \mathrm{DIK(i)}_{-1})$.[8] The suffix of parentheses indicates industry in Table 1 (i=1,2,...,8).

(a) Development of natural resources

In the FDI function of Japanese agriculture, forestry and fisheries, we used the growth rate of real world exports of light manufacturing as a market factor because we thought that FDI is partly associated with the FDI to types of light manufacturing such as food processing, pulp production, etc. (see Table 2). The FDI of agriculture,

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[8] As already shown in 2.3, DFI capital outflow data of Ministry of Finance does not include re-investment of subsidiaries. The formula of growth of subsidiary capital stocks $\mathrm{DIK(i)}/\mathrm{DIK(i)}_{-1}$, enables us to consider the change of both subsidiary re-investment and Japanese FDI capital outflow, since $\mathrm{DIK(i)} = \mathrm{DIK(i)}_{-1}$ + subsidiary re-investment + Japanese FDI capital outflow + stock valuation adjustment – depreciation allowance.

Table 2: FDI Function: Development of Natural Resources

Method: OLS, (t values in the parentheses)

	sample period	market factor	supply constraint factor			competitive factor	stock adjustment factor	const		R^2 /D.W
			domestic factor	natural resource price	*dummy* [from-to=1]				*dummy* [from-to=1]	
Agriculture, forestry and fisheries	1979 -92	0.139[1)] (2.96)	4.436[2)] (3.97)			-0.698[3)] (-5.05)		-0.777 (-3.91)		0.85 /2.58
Mining	1976 -92	0.156[4)] (2.99)		0.107[5)] (2.36)	0.406[6)] (2.87)		-0.122 (-4.73)	1.265 (5.72)	-0.214[6)] (-7.90)	0.83 /1.32

1) using the growth rate of the real world trade (excluding Japan) in light manufacturing relative to the previous year

2) using the domestic operation ratio of previous year

3) using relative import price of the previous year

4) using the mean of real domestic product and real imports of one and two years before

5) using the rate of change of major natural resource price of two years before

6) using a dummy[1989-92=1] × a log of the rate of change of major natural resource price in two years before

7) using a dummy[1989-92=1]

forestry and fisheries is made to develop natural resources, and foreign affiliates which belong to light manufacturing industries use natural resources as inputs for their production, which is partially exported to Japan. The domestic supply relative to domestic product as a resource constraint factor, and relative import price also explain the FDI of agriculture, forestry, and fisheries.

In the FDI function of mining, we used the ratio of relative import price increase as a resource constraint factor. Japan has imported most of the crude materials it needs. So, we assumed that Japanese companies would set up offshore plants in mining industry when Japan confronts increases in import prices in order to secure a more stable supply. The domestic operations ratio and the lagged subsidiary capital stocks explain the FDI of mining as well.

(b) Manufacturing

As shown above , the following four factors explain the FDI equations of manufacturing, which play a major role in this model.

Ln(DIK(i)/ DIK(i)$_{-1}$) = f(profit differential of the industry concerned ,
market growth factors of the industry concerned,
production cost factors of the industry concerned,
institutional factor)

As for profit differential, we used profit rate of Japanese affiliates, or the relative ratio of domestic profit rate to profit rate of Japanese affiliates. The domestic operations ratio or relative ratio of domestic operations rate to Japanese affiliates' operations rate is used as a proxy of market factor. The yen's exchange rate, relative export price, and the rate of domestic wage increase are used as proxies of production cost factors. In the FDI function of chemicals, import price of mining (dollar base) is added as an explanatory variable, considering the effect of the price change of mining on the production cost. Institutional factors consist of dummy variables, which show the de-regulation of foreign capital outflow at the beginning of the 1980's (dummy=1 after 1980, dummy=0 before 1980), and voluntary exports restraint indicator (exports divided by domestic product minus exports).

Table 3 shows the estimation results. Profit differential is significant only in chemical industry. Market growth factors are highly significant in every manufacturing industry. As for production cost factors, we adopted relative export price in metal industry and machinery, and the reciprocal of yen's exchange rate in light manufacturing. The production cost factors in chemicals consist of the rate of domestic wage increase, and import price of mining. While a dummy variable as an institutional factor is insignificant in every industry, voluntary export restraint indicator is somewhat significant in metal industry and machinery. Dummy variables such as constant dummy and coefficient dummy are added to consider the structural changes of the parameters in the 1980's and in the late 1980's.

(c) Wholesale and retail trade.

In the equation for the wholesale and retail trade industry, dependent variable is logarithm of FDI increase, namely $Ln(\mathrm{DIK}(7) - \mathrm{DIK}(7)_{-1})$. We chose the sum of total exports and imports of Japan as an explanatory variable. This was done because we thought that the wholesale and retail trade industry plays an important role in the activities of all industries as shown in Table 4. The dummy variable, which indicates the structural change in the late 1980's, is added in the estimation (Results are not reproduced here).

3.1.3 The Equation of Japanese FDI Capital Outflow

After explaining the capital stocks of the subsidiaries in the model, we can explain Japanese FDI capital stocks with the participation ratio of Japanese firms taken into account, and we can then explain the Japanese FDI capital outflow as the increase of the stocks (see Figure 1). We only estimated the Japanese macro FDI by capital outflow (which is based on the balance of payments), and not by industry.[9]

Japanese FDI capital outflow =f(the increase of the all industries' capital stocks of the subsidiaries held by Japanese firms)

[9] As we explained in 2.3, the Bank of Japan provides only the aggregated time series data of FDI capital outflow based on the balance of payments. The FDI income is also endogenous variable in this model. Unfortunately, we have not seen any established theory on the determinants of this variable. Some historical evidences in Japan made us to specify this equation as follows:

FDI income = f(the all industries' capital stocks of the subsidiaries held by Japanese firms, the relative ratio of subsidiary profit to domestic profit rate of all industries).

The FDI income here is a macro variable based on balance of payments.

Table 3: FDI Functions: Manufacturing Method: OLS, (t values in the parentheses)

	sample period	profit differential	market factor: relative operation ratio	market factor: domestic operation ratio	cost factor: relative export price	cost factor: exchange rate	institutional factor (voluntary restraint indicator)	stock adjustment	*const*	R^2 /D.W
Light manufacturing	1979		0.153[1]			0.248[2]		-0.262	3.762	0.93
	-92		(4.06)			(3.90)		(-8.33)	(7.70)	/2.33
dummy[1989-92=1]						-0.056[7]		0.029[8]		
						(-4.61)		(7.05)		
Chemicals	1981		0.414[3]		0.561[3),4)]	1.059[5]			0.681	0.88
	-92		(8,75)		(4.52)	(1.98)			(5.82)	/2.50
Metal	1978	0.147[2]	0.239[3]		0.244[2]		-0.245		0.744	0.94
industry	-92	(4.00)	(4.79)		(3.44)		(-3.61)		(1.95)	/3.10
dummy[1988-92=1]							0.041[9]			
							(2.18)			
Machinery	1982			-1.832[6]	0.550[3]		0.405[6]		4.994	0.95
	-92			(-6.09)	(2.91)		(2.08)		(4.02)	/2.04
dummy[1988-92=1]					-0.032[10]		0.088[9]			
					(-7.63)		(2.08)			

1) using the average value of the variable of 1 year and 2 years before
2) using the weighted average of the values in present and the previous year
3) using the value of the variable in the previous year
4) using the rate of change of primary commodity's price
5) using the rate of wage increase in chemicals
6) using the weighted average variable of 1 year and 2 years before
7) using a dummy[1989-92=1] × a log of reciprocal of yen's exchange rate
8) using a dummy[1989-92=1] × a log of subsidiary capital stock in the previous year
9) using a dummy[1988-92=1] × a log of commodities' exports divided by gross domestic product plus commodities' imports minus commodities' exports of the industry concerned
10) using a dummy[1988-92=1] × a log of relative export price index of the commodity concerned

Table4: Subsidiary Sales by Industry
(billion yen, % share to the total in the parentheses)

	Subsidiary sales		Subsidiary exports to Japan		Subsidiary imports from Japan	
	1980	1986	1980	1986	1980	1986
Agriculture forestry & fisheries	136.5 (0.3)	99.8 (0.2)	70.9 (0.5)	50.0 (0.8)	51.7 (0.05)	0.2 (0.0)
Mining	634.5 (1.6)	327.5 (0.7)	383.8 (2.6)	171.3 (2.6)	14.4 (0.01)	0.2 (0.0)
Manufacturing	6984.2 (17.1)	10648.5 (23.5)	682.5 (4.6)	890.1 (13.7)	487.4 (4.6)	630.8 (3.6)
Wholesale and retail trade	32952.8 (80.6)	32743.5 (72.1)	13557.1 (92.1)	5331.9 (81.9)	10005.1 (95.0)	16418.3 (95.0)
Other industry	188.9 (0.5)	156.5 (3.4)	20.7 (0.1)	64.7 (1.0)	355.9 (0.3)	238.9 (1.4)
Total	40896.7 (100.0)	45383.9 (100.0)	14714.9 (100.0)	6507.9 (100.0)	10534.6 (100.0)	17288.5 (100.0)

Source: The Ministry of International Trade and Industry, The 1st and 3rd Survey of Overseas Business Activities

3.2 Subsidiary Sales Functions

Subsidiary sales are used as a proxy of subsidiary production value.[10] We see few previous empirical works on overseas production.[11] Whether demand side or supply side mainly explains overseas production, depends on the industry concerned and host area. Since we have not seen any established theories or empirical works on these issues yet, we set the hypothesis that both demand factors and supply factors would influence overseas production. The following equation is a reduced form which is derived from subsidiary sales demand function and subsidiary sales supply function.

Subsidiary sales (DIS(i))
= f{(real world exports excluding Japan of the industry concerned (WT(i)), subsidiary profit rate divided by subsidiary sales (RDIR(i)), subsidiary capital stock of the industry concerned at the beginning of term ($DIK(i)_{-1}$)} (3-1)

Demand prices for subsidiary sales (demand function) are supposed to depend upon the producer price of the industry concerned (DIP(i)) and the development of the world market of the industry concerned. We used WT(i) as a proxy of world market.

Demand prices = f(DIP(i), WT(i)) (3-2)

Supply prices of subsidiary sales (supply function) are supposed to depend upon producer price, production capacity as a supply shift factor, and production cost factor. Because of lack of reliable data on production cost, we used subsidiary profit rate divided by subsidiary sales (RDIR(i)), which is justified by the following relations:

Average cost = (subsidiary sales – subsidiary profit)/ subsidiary sales
= 1 – subsidiary profit / subsidiary sales (RDIR(i))

As a supply shift factor, we used subsidiary capital stock of the industry concerned at the beginning of term ($DIK(i)_{-1}$).

Supply prices = f((DIP(i)), 1- RDIR(i), $DIK(i)_{-1}$) (3-3)

Thus, (3-2), (3-3) lead to (3-1) and the following equation.

DIP(i) = f(WT(i), RDIR(i), $DIK(i)_{-1}$) (3-4)

Since the price data in (3-4) is not available, we estimated only the subsidiary sales

[10] While MITI provides data on overseas production every year from 1986, it is not so reliable as subsidiary sales because of its low coverage.

[11] Shinjo (1988) and EPA (1996a) estimated the coefficients of the equations which explained the ratio of subsidiary sales to domestic production.

functions in (3-1). Lagged dependent variable ($DIS(i)_{-1}$))is added in the estimation as a dynamic factor. So (3-1) becomes

$$DIS(i) = f(WT(i), RDIR(i), DIK(i)-1, DIS(i)_{-1}) \qquad (3\text{-}5)$$

Considering that subsidiary sales of some industries can be influenced by input demand of other industries, each lagged value of subsidiary sales of light manufacturing and that of chemicals explains subsidiary sales of agriculture, forestry, and fisheries, and subsidiary sales of mining respectively. Subsidiary sales of the wholesale and retail trade industry also explain that of each industries as an accelerator. On the other hand, the subsidiary sales of wholesale and retail trade industry are explained by the sum of world trade of primary and manufacturing goods. A linear logarithmic form is used in the estimation except for subsidiary profit, as shown in Table 5.

The estimated results in Table 5 show that both demand factors and supply factors explain subsidiary sale except for the wholesale and retail industry, and chemicals. The estimated coefficients of demand factors are significant except for chemicals. Among supply factors the subsidiary profit rate is significant only in light manufacturing and machinery. In light manufacturing, a dummy variable, which shows structural change in the 1980's, is added. The estimated coefficients indicating production capacity are statistically significant in all industries except for the wholesale and retail trade industry. The estimated coefficients of subsidiary sales of wholesale and retail trade industry as an accelerator satisfy the sign condition and are statistically significant in chemicals, metal industry, and machinery (see the column of subsidiary sales of related industry in Table 5). It is interesting to note that the estimated coefficient indicating world manufacturing exports in the equation of wholesale and retail trade industry shows high elasticity. This means that the increase of world trade of manufactured goods enhances the activity of Japanese foreign affiliates in the wholesale and retail trade industry, thus accelerating the activity of manufacturing industries, particularly in light manufacturing and machinery.

3.3 Export Functions Including the FDI Effects

Export functions are generally explained by relative export prices adjusted by foreign exchange rate to world export price, the amount of world trade, and so on. As we discussed earlier, the effects of displacement and associated exports are introduced in the equations. The effect of associated exports is measured by the subsidiary imports from Japan. On the other hand, the effect of export displacement is the share of the subsidiary sales in the host and third countries, which may compete with the Japanese exports and displace them. We assumed that the displacement effect appeared when the growth rate of the subsidiary sales in the host and third countries exceeded that of the world markets for the Japanese exports. Therefore, the general form of the estimated equations is considered as follows:

Table 5: Subsidiary Sales Functions Method: OLS (t values in the parentheses)

		Demand factor		Supply factor				Dynamic factor				const		
		Real world exports		Subsidiary earnings (profit rate)		Subsidiary capital stock		Subsidiary sales of the previous year		Subsidiary sales of related industry				R^2 /D.W
					dummy from-to=1		dummy from-to=1		dummy from-to=1		dummy from-to=1		dummy from-to=1	
Agriculture,	1977-	2.085 1)				0.801 2)	0.498 5)			0.288	0.083 6)	-32.79	0.872 7)	0.90
forestry &	92	(6.73)				(1.44)	(2.54)			-1.68	(2.37)	(-6.63)	(4.82)	/2.34
Mining	1977-	1.673	-0.045 8)			0.635 2)				0.666	0.188 9)	-21.64	1.033 10)	0.87
	92	(3.73)	(-2.08)			(3.45)				-2.95	(3.32)	(-3.62)	(5.01)	/2.03
Light	1976-	0.408 3)		5.411 1)	-4.975 11)	0.071	0.154 12)					-1.593		0.98
manufacturing	92	(3.65)		(5.37)	(-2.84)	(0.35)	(6.09)					(-1.89)		/2.57
Chemicals	1979-					0.218 1)	0.090 13)	0.514	-0.148 14)	0.609		-3.56		0.97
	92					(1.41)	(3.25)	(2.98)	(-2.84)	(2.47)		(-2.89)		/2.22
Metal industry	1979-	1.886 1)				0.413 2)				0.791	-0.059 15)	-25.09		0.88
	92	(2.03)				(2.11)				(4.68)	(-2.86)	(-2.52)		/1.89
Machinery	1976-	3.539 4)		3.187		0.234				0.204		-42.82		0.99
	92	(4.65)		(5.84)		(2.24)				(2.03)		(-4.86)		/1.98
Wholesale & retail	1980-	0.817 1)	0.011 16)							0.421		-3.572		0.99
trade	92	(1.64)	(2.02)							(4.32)		(-0.58)		/2.18

1) using the average value of variable in the present and previous year
2) using the variable of 3 years before
3) using the weighted average of the variable in the present and previous year
4) using the average value of the variable in the present year, previous year, and 2 years before
5) using a dummy[1987-92=1] × a log of subsidiary capital stock divided by world export price index in 3 years before
6) using a dummy[1987-92=1] × a log of subsidiary sales in light manufacturing divided by world price index in light manufacturing
7) using a dummy[1985=1]
8) using a dummy[1981-92=1] × a log of real world export in the previous year
9) using a dummy[1989-92=1] × a log of subsidiary sales of chemicals divided by world export price index of chemicals
10) using a dummy[1984-86=1]
11) using a dummy[1981-92=1] × a log of the average value of subsidiary earnings divided by subsidiary sales in the present and previous year
12) using a dummy[1981-92=1] × a log of subsidiary capital stock divided by world export price index in the previous year
13) using a dummy[1984-92=1] × a log of subsidiary capital stock divided by world export price index in the previous year
14) using a dummy[1986-92=1] × a log of the weighted average of subsidiary capital stock divided by world export price index in the present and previous year
15) using a dummy[1984-92=1] × a log of subsidiary sales of wholesale and retail trade divided by world export price index of the industry concerned
16) using a dummy[1988-92=1] × a log of weighted average of all commodities' real world exports in the previous and 2 years before

(The export of Japanese firms - the subsidiary import from Japan)
=f{the world export volume of the industry concerned,
relative export price of the industry concerned,
(the growth of subsidiary sales in the host and third countries
/ the growth of the world export volume of the industry concerned)}

Linear logarithmic forms are used in all parts of the estimation. The commodities of primary industries are treated as exogenous because their export shares were very small. Furthermore, we did not consider the effects of FDI directly in the equations for the wholesale and retail trade industry. The industry's export was represented by the sum of the exports of all the other manufacturing industries. The estimated results in Table 6 are satisfactory as a whole. However, the estimated parameters of the effect of the export displacement are insignificant except for machinery.

Table 6 : Export Functions Including FDI Effect (real, yen based)
Method: OLS, (*t* values in the parentheses

	sample period	Real world exports	dummy from-to=1	Relative export price	dummy from-to=1	Export displacement effect	lag of dependent variable	const	$\bar{R}^2$ / D.W
Light	1975	0.535[1]	-0.221[3]	-0.513		-0.079		1.463	0.76
Manufacturing	-92	(2.69)	(-2.23)	(-2.38)		(-0.58)		(0.60)	/2.07
Chemicals	1978	0.756[2]		-0.897		-0.119	0.769	-12.82	0.98
	-92	(4.74)		(-4.39)		(-1.91)	(5.88)	(-4.34)	/2.79
Metal	1979	0.857[2]		-1.250	0.028[4]	-0.162		-8.778	0.93
industry	-92	(2.32)		(-9.50)	(8.40)	(-1.58)		(-2.15)	/2.25
Machinery	1976	0.793		-0.764		-0.219	0.618	-11.27	0.98
	-92	(2.10)		(-2.68)		(-2.13)	(4.04)	(-2.29)	/1.76

1) using the weighted average of the variable in the present and previous year
2) using the variable in the previous year
3) using a dummy[1981-92=1] × a log of reciprocal of yen's exchange rate
4) using a dummy[1986-92=1] × a log of relative export price

3.4 Import Function Including the Effects of FDI

The effects of Japanese foreign affiliates' production on Japanese imports are considered in the import functions of the manufacturing industry by commodities. The subsidiaries export their production goods to Japan, and this is referred to as the subsidiary exports to Japan. The following two types of import functions were estimated in manufacturing. Linear logarithmic forms are used in the estimation.

Type 1
(Imports - subsidiary exports to Japan)
=f(total domestic supply of the industry concerned,
relative import price of the industry concerned)

Type 2
Imports = f(total domestic supply of the industry concerned,
relative import price of the industry concerned,
subsidiary exports to Japan)

For imports of the commodities of primary industry we did not consider the effects of FDI in the estimated equations, but used ordinary import functions. Instead of the relative import price, the rate of increase of primary commodity price is used as a speculative factor in the estimation of import function of mining. Neither did we consider the effects of FDI directly for the import of the wholesale and retail trade industry, which we represented by the sum of commodities traded by all the other industries, but not by wholesale and retail trade industry itself. The estimated results in Table 7 show that in manufacturing type 1 of import function is adopted except for chemicals. We see both price and income effects are significant in all industries.

Table 7: Import Functions Including FDI Effect (real, yen based)
Method: OLS, (*t* vales in the parentheses)

	Sample period	Domestic total supply	dummy from-to=1	Relative import price	dummy from-to=1	Re-import effect	lag of dependent variable	const	dummy from-to=1	$\bar{R}^2$ /D.W
Agriculture etc	1971	1.832[1]	-0.007[3]	-0.222				-10.08		0.91
	-92	(5.76)	(-2.59)	(-3.42)				(-3.66)		/2.33
Mining	1973	0.464	-0.016[4]	0.129[5]				6.036		0.80
	-92	(2.59)	(-3.08)	(2.15)				(4.33)		/2.03
*Light**	1974	1.596		-0.655			0.262	-12.07		0.96
Manufacturing	-92	(3.88)		(-2.26)			(1.94)	(-3.06)		/1.14
Chemicals	1976	1.301		-0.402		0.087		-6.079		0.98
	-92	(5.69)		(-2.89)		(6.29)		(-2.50)		/1.92
Metal *	1977	2.207		-0.390[1]				-6.590	0.519[6]	0.93
industry	-92	(6.45)		(-2.00)				(-4.52)	(6.94)	/1.45
Machinery *	1974	0.772[1]		-0.772[2]	-1.039[7]			-1.089		0.93
	-92	(5.55)		(-5.67)	(-2.01)			(-0.69)		/1.76

1) using the value of the variable in the previous year
2) using the weighted average value of the variables in the previous year and 2 years before
3) using a dummy[1988-92=1] × a log of the average value of the real domestic supply in the present and previous year
4) using a dummy[1991-92=1] × a log of real domestic product
5) using a log of the weighted average of growth rate of mineral commodities' price index relative to the previous one in the present and previous year
6) using a dummy[1981-92]
7) using a dummy[1986-92] × a log of relative import price in the previous year

3.5 Subsidiary Imports from Japan

The subsidiary inputs are divided into two categories based on where the goods purchased come from: subsidiary imports from Japan, and local purchases and subsidiary imports from the third countries (see Figure 1).[12] The former is determined in the structural equation, and the latter is then determined as a residual. Just like an export function, subsidiary imports from Japan are explained by subsidiary sales as an income factor and relative export price as a price factor. The estimation was taken only for the commodities of manufacturing industries.

Subsidiary imports from Japan by each country's commodities
= f(subsidiary sales of the industry concerned,
relative export price of the industry concerned) (3-6)

In (3-6),all the subsidiary imports from Japan were assumed to have come only from the parent companies, which were supposed to belong to the same industry as the subsidiaries. The subsidiary imports from Japan for a certain industry were not just imported from the same industry but also from different industries in Japan. So it may

[12] We treat the ratio of subsidiary inputs to sales as given.

thus be better to incorporate the inter-industry trade between the subsidiaries and the companies in Japan. However good information on it is not available. If the aggregation level is high enough such as that in Table 1, we thought the assumption in (3-6) could be applied.

The estimation results in Table 8 show that all the equations are well represented, and the income effects are significant. The effects of price are significant in all industries except for machinery. The dummy variables, which indicate structural changes of the coefficients, are significant in light manufacturing and machinery.

3.6 Subsidiary Exports to Japan

The sales of Japanese foreign affiliates are divided into two parts; namely, subsidiary exports to Japan, and subsidiary sales in host countries or to third countries. The former means imports into Japan from Japanese subsidiaries and the latter means exports and sales which may compete with Japanese exports. The latter is determined as a residual: subsidiary local sales and sales to third countries = total subsidiary sales - subsidiary exports to Japan. The subsidiary exports to Japan, which means re-imports by overseas production, is explained by the income factor, total Japanese domestic supply, and relative price factor; i.e., the ratios of the domestic price to the world prices as proxy variables of the competitiveness between domestic companies and subsidiaries. The general form of equations of the subsidiary exports to Japan is as follows (Linear logarithmic forms are used in the estimations).

Subsidiary exports to Japan by each industry's commodity
=f(real domestic total supply of the industry concerned, relative ratio of domestic price to world price of the industry concerned)

The estimated results in Table 9 show that all subsidiary exports to Japan are well represented, and the estimated coefficients, denoting the income and price effects, are mostly statistically significant. A value of lagged subsidiary exports is added as an adjustment factor in light manufacturing and machinery.

4. Some Simulation Analyses of the Model

4.1 Final Test of the Model and Its Dynamic Properties

4.1.1 Final Test of the Model

Simulation analyses for the model consisting of the structural equations explained above, other equations, and identities are performed here. Table 10 shows the results of final test performance of main variables in the term of absolute average percentage error ratio, covering 11 annual periods beginning in 1982. Looking at the domestic sector first, all macro variables are very well explained, their average error ratio

Table 8 :Subsidiary Imports from Japan (real, yen based)
Method: OLS (*t* vales in the parentheses)

	Sample period	Subsidiary sales	dummy from-to=1	Relative export price	dummy from-to=1	const]	$\bar{R}^2$ ／D.W
Light manufacturing	1978 -92	0.529[1] (3.35)		-1.462[2] (-1.51)	-0.046[3] (-1.40)	-7.528 (-1.40)	0.79 /2.10
Chemicals	1977 -92	0.826 (20.1)		-0.854[2] (-2.56)		-7.349 (-4.23)	0.97 /2.05
Metal industry	1978 -92	0.765 (2.98)		-0.848 (-3.45)		-6.348 (-2.93)	0.73 /1.43
Machinery	1975 -92	0.976 (27.8)	-0.226[4] (-1.96)	-0.050 (-0.21)	-0.481[5] (-1.86)	-3.223 (-3.18)	0.96 /1.26

1) using the weighted average value of the variable in the previous year and 2 years before
2) using the average of the variable in the previous year and 2 years before
3) using a dummy[1986-92=1] × a log of the average value of relative export price
4) using a dummy[1988-92=1] × a log of the value of subsidiary sales divided by yen's exchange rate and export price index
5) using a dummy[1988-92=1] × a log of the value of relative export price index

Table 9 : Subsidiary Exports to Japan (real, yen based)
Method: OLS (t values in the parentheses)

	Sample period	Real domestic total supply	Relative import price	lag of dependent variable	const	$\bar{R}^2$ ／D.W
Light manufacturing	1980 -92	1.998[1] (5.97)		0.219 (2.01)	-17.82 (-5.52)	0.97 /1.79
Chemicals	1976 -92	2.564[1] (2.28)	5.651[3] (0.30)		5.252 (0.30)	0.89 /2.04
Metal industry	1978 -92	2.266[2] (3.52)	8.683[4] (4.76)		-59.13 (-8.09)	0.86 /1.89
Machinery	1979 -92	1.157[1] (3.55)	1.163[1] (3.55)	0.531 (3.55)	-3.904 (-2.89)	0.96 /2.79

1) using the value in the previous year
2) using the weighted average value of the variable in the previous year and 2 years before
3) using the average value of the variable in the previous year and 2 years before
4) using the weighted average value of the variable in the previous year, and 2 years and 3 years before

being less than 3%. The average error ratios of real exports are also less than 8% except for the wholesale and retail trade industry. As for the real imports, the average error ratios are less than 10% except for the metal industry. Though some of the variables indicating the subsidiary activities show somewhat large error ratios because of their sharp fluctuation, the results of the final test seem to be reasonable as a whole. The solutions of the final test are used as a base line solution in the following simulations.

4.1.2 Dynamic Properties of the Model

The dynamic properties of the model are examined by multiplier analysis, sustained change simulation with 1 trillion yen increase of real government investment expenditures during 1982-86. As shown in Table 11, the multiplier of this model is compared with those of other major multi-sectoral econometric models in Japan: the Economic Planning Agency (1996b) (EPA), Kinoshita and others (1982), and Shishido and others (1989). Apart from our model, no model contains the equations which describe Japanese FDI and overseas production. The multiplier of our model peaks at the level of 1.47 in the second year and its change is comparable to that of EPA, whose sample period is almost the same as ours. The comparison of the figures of our model and EPA with those in Kinoshita and Shishido, whose sample period starts from 1960's, makes us realize that the multiplier in the 1980's and 1990's has become lower than that in the 1960's and 1970's.

Table10 : Final Test of the Model
The result of final test (1982-92) : absolute average percentage error %

	Macro variables		
Domestic sector (yen base)	real value	nominal value	deflator
Private consumption	1.8	1.5	0.6
Non-residential investment	2.6	2.6	0.6
Gross national expenditure	1.3	1.6	1.3
International Sector (balance of payments base)			
FDI capital outflow	-	24.3	-
FDI income	-	6.0	-

	Industrial sector						
	agriculture, forestry & fisheries	*mining*	*light manufacturing*	*chemicals*	*metal industry*	*machinery*	*Wholesale & retail trade*
International sector							
Real exports (yen base)	—	—	2.9	1.9	7.1	4.1	6.3*
Real imports (yen base)	3.7	5.6	6.7	3.8	13.8	8.8	8.3*
Subsidiary capital stocks	3.5	5.9	2.7	6.8	5.1	2.6	5.6
Subsidiary sales	9.5	14.3	4.6	8.5	10.3	6.4	5.8
Domestic sector							
Real gross product	3.1	4.4	2.6	2.7	4.2	1.8	4.5
Real non residential Investment	1.7	7.8	8.4	4.6	5.7	6.7	6.0
Producer's price	2.1	3.0	2.0	2.7	2.3	1.7	3.1
Employee's compensation per worker	1.7	3.0	1.8	2.8	2.1	1.7	2.7
Number of employee	1.4	1.9	2.2	2.8	2.9	2.4	6.2

4.2 10% Appreciation of the Yen Value Against the Dollar

4.2.1 The Appreciated Yen's Impact on the Subsidiary Activities

Some economists say that the yen's appreciation after the Plaza Agreement stimulated Japanese overseas production, which in turn contributed to substitution of Japanese exports and reductions in the huge trade surplus. To verify their argument, a simulation of the yen's appreciation was performed. While changes of foreign exchange rates

Table11 : Dynamic Properties of the Model[1)]

	Sample Period and data	1st year	2nd year	3rd year	4th year	5th year
Our model	1974-92 annual	1. 44	1. 47	1. 33	1. 17	1. 10
EPA[2)]	1975-92 semi-annual	1. 30	1. 45	1. 24	1. 28	1. 39
Kinoshita	1963-76 annual	2. 19	2. 49	2. 41	2. 21	1. 98
Shishido	1961-85 annual	2. 00	2. 45	2. 31	2. 12	2. 17

1) difference from the base line solution of real national expenditure

2) average value of the multiplier in the first half year and that in the second half year

affect the FDI behavior of Japanese firms, Japanese FDI also affects yen exchange rates through the accumulation of Japanese foreign assets. We treated yen exchange rates as exogenous, and did not consider the latter effect in this model. We assumed that the yen value against the dollar was 10% more than the actual value during the five years in the 1982-86 period.

The appreciation of yen exchange rate increases the Japanese FDI and subsequently the subsidiary production, as we can see in Table 12. The subsidiary capital stocks of chemicals and machinery industry increase at a particularly high rate (20.1% point and 16.4% point in the fifth year respectively). While subsidiary sales increases at a slower pace than FDI increase because of the gestation period of production, its increase is strong in chemical industry (6.1% point increase in the fifth year). Looking at the difference, wholesale and retail trade industry shows the largest increase in both subsidiary capital stocks (US$ 3.4 increase billion in the fifth year) and subsidiary sales (US$ 5.0 billion increase in the fifth year) followed by machinery and chemicals.

As discussed earlier, the FDI effects appear in Japanese exports. In addition to the usual price effects, there is also the displacement of Japanese exports and associated exports due to Japanese overseas production. The appreciated yen causes changes of domestic prices relative to foreign prices, thus reducing subsidiary imports from Japan and enhancing subsidiary exports to Japan. All of these effects cause changes in Japanese export and import levels. The trade balance on a dollar basis is gradually being reduced, and its reduction reaches at US$ 16.3 billion in the fifth year. The reduction of the trade surplus in the third year is US$ 11.9 billion, which is the one-third of the actual trade surplus in 1984. As for the impact on trade between the domestic firms and their foreign affiliates, subsidiary exports to Japan (re-imports of Japan) steadily increase. This tendency is particularly notable in chemicals and machinery. The subsidiary imports from Japan (associated exports) decrease considerably especially in machinery, whose overseas production is gradually increasing.

Table 12 : Simulation Results of the 10% Appreciated Exchange Rates for Dollar (1982-86)

% point: (simulation solution - base line solution) / base line solution × 100	1st year	2nd year	3rd year	4th year	5th year
Subsidiary capital stocks (dollar based)					
Agriculture, forestry & fisheries	0.0	-0.3	1.1	-2.0	-3.2
Mining	0.0	0.0	0.0	0.1	0.3
Light manufacturing	1.8	3.8	5.3	6.2	6.6
Chemicals	-0.6	6.4	14.0	18.4	20.1
Metal industry	1.8	2.8	5.7	8.3	9.9
Machinery	0.0	5.8	11.9	16.2	16.4
Wholesale & retail trade	0.6	4.0	4.9	4.8	4.4
FDI capital outflow from Japan (dollar based)	3.8	13.9	12.7	8.9	6.3
Subsidiary sales (dollar based)					
Agriculture, forestry & fisheries	0.0	0.1	0.2	0.1	0.1
Mining	0.0	0.0	0.3	1.5	4.0
Light manufacturing	0.0	0.4	0.7	0.9	1.1
Chemicals	0.0	0.0	0.5	2.3	6.1
Metal industry	0.0	0.0	0.2	1.1	2.1
Machinery	0.0	0.0	0.7	1.4	3.3
Wholesale & retail trade	0.0	0.0	1.3	0.6	1.2
FDI income to Japan (dollar based)	-0.2	0.4	2.6	3.6	4.4

differences from base line solutions (million dollar)	1st year	2nd year	3rd year	4th year	5th year
Subsidiary capital stocks					
Agriculture, forestry & fisheries	0	-1	-3	-6	-9
Mining	0	0	0	5	27
Light manufacturing	157	357	517	615	703
Chemicals	-29	410	1007	1198	1360
Metal industry	136	200	385	522	641
Machinery	0	385	1048	1876	2729
Wholesale & retail trade	189	1082	2589	3104	3432
FDI outflow from Japan	130	760	683	469	727
Subsidiary sales					
Agriculture, forestry & fisheries	0	1	2	7	2
Mining	0	0	15	91	227
Light manufacturing	2	57	111	158	207
Chemicals	0	-1	21	112	544
Metal industry	0	2	14	105	193
Machinery	0	3	228	625	1968
Wholesale & retail trade	-1	138	782	1900	5042
FDI income to Japan	-4	8	59	91	125

4.2.2 The Impact of FDI on the Japanese Trade Balance

The impact of the appreciated yen exchange rates on the Japanese trade balance in this model is caused by the normal effect of relative price changes (denoted as "direct domestic effect), and the effect of displacement of exports, associated exports, and re-imports through Japanese FDI activities (denoted as "FDI effect"). We tried to decompose these two effects in order to extract the impact of FDI on Japanese trade balance. We believe that the following method would enable us to achieve this. First to get the direct domestic effects we carried out the appreciated yen simulation, taking the subsidiary capital stocks, subsidiary sales and trade (FDI block) as exogenous: we assumed that the change of exchange rates did not affect the share of foreign affiliates' activities, and calculated the difference between this simulated solutions and the baseline solutions. Then we carried out a similar simulation, taking the FDI block as endogenous, and calculated the difference between the simulated solutions and the baseline solutions again. Thus, we could extract the impact of FDI on the trade balance by subtracting the former from the latter.

Table 13 shows direct domestic effect and FDI effect. Nearly 65% of the reduction of the trade balance in the first year (US$ 11.9 billion) comes from the direct domestic effect. This difference increases and reaches US$ 11 billion in the fifth year (direct domestic effect: US$ -13.6 billion vs. FDI effect: -US$ 2.6 billion).

When we look at the direct domestic effect of the export and import level in the first year, the exports' increase marks US$ 8.3 billion increase due to the appreciated yen, while the yen based real export values decrease. Over 90% of the export increase comes from machinery. As the import increase is larger than the export increase, total direct domestic effects are negative (US$ -2.2 in the first year). The first year's FDI effect comes mainly from machinery exports (US$ -1.0 billion) and the re-import increase is only US$ 0.2 billion. The direct domestic effect becomes more dominant and reaches US$ -13.6 billion in the fifth year, which is five times as that of the first year, while the fifth year's FDI effect (US$ -2.6 billion) grow only two times as that of the first year. As for the direct domestic effect, higher production costs cause large export changes from US$ 8.3 billion surplus in the first year to US$ 5 billion reduction in the fifth year. On the other hand, the effects on imports, which differ by industry, are not so large as those on exports. The effects on total imports change from US$ 10.5 billion in the first year to US$ 8.7 billion in the fifth year. As for the FDI effects, the effects on exports steadily decrease and reach at US$ -2.4 billion in the fifth year, more than two times as those of the first year, while the effects on re-imports fluctuate.

4.3 A Simulation of an Autonomous Increase of FDI

The history of the Japanese economy after 1971, following the Japanese government's abandonment of the fixed exchange rate regime since 1949, tells us that Japanese FDI was triggered by the sharp appreciated of the yen against the dollar all time. As the simulation in 4.2 shows, the yen's appreciation causes fairly large impacts on FDI, subsidiary production and the trade balance in Japan. Apart from the exchange rate fluctuation, does also Japanese FDI itself have a great impact on the trade balance? This will be discussed next.

As we showed in 3.1, the FDI of each industry is explained by the relative profit differential, market growth factors, production cost factors, and institutional factors. Of course these are not all the factors which induce FDI. Some changes of political and economic environment in host counties may also influence the Japanese FDI

Table 13 : The 10% Appreciated Yen's Exchange Rate for Dollar (1982-86) and Its Effects on the Trade Balance (billion dollar)

	1st year domestic effect	1st year FDI effect	2nd year domestic effect	2nd year FDI effect	3rd year domestic effect	3rd year FDI effect	4th year domestic effect	4th year FDI effect	5th year domestic effect	5th year FDI effect
Exports										
Light manufacturing	0.7	0.0	0.3	-0.2	0.3	-0.2	0.2	-0.2	0.1	-0.3
Chemicals	0.1	0.0	-0.3	0.4	-0.6	0.6	0.8	0.6	-1.0	0.5
Metal industry	-0.3	-0.1	-0.2	-0.1	-0.2	-0.1	-0.2	-0.2	-0.1	-0.2
Machinery	7.7	-0.1	2.4	-1.4	-1.2	-1.7	-2.8	-1.6	-3.9	-2.3
Sub total	8.3	-1.1	2.2	-1.2	-1.6	-1.4	-3.7	-1.3	-5.0	-2.4
Imports										
Agriculture, forestry and fisheries	1.3	0.0	1.2	-0.1	1.1	-0.1	1.0	0.0	1.0	0.0
Mining	5.7	-0.1	4.9	-0.1	4.2	-0.1	4.3	0.0	3.3	0.0
Light manufacturing	1.7	-0.1	1.6	-0.1	1.6	-0.2	1.7	-0.2	2.7	-0.2
Chemicals	1.7	0.4	1.0	1.0	0.9	1.0	0.8	1.0	1.1	0.7
Metal industry	-0.7	-0.1	-0.7	-0.1	-0.3	-0.3	-0.6	-0.4	-0.2	-0.3
Machinery	1.2	0.0	1.1	0.1	0.1	0.1	0.8	0.2	0.7	0.2
Sub total	10.5	0.2	9.2	0.8	8.3	0.6	8.0	0.5	8.7	0.3
Trade balance	-2.2	-1.3	-6.9	-2.0	-9.9	-2.0	-11.6	-1.8	-13.6	-2.6
Total	-3.4		-8.9		-11.9		-13.4		-16.3	

behavior. The FDI functions do not include these changes, which can be captured by dummy variables. Suppose a change of political and/or economic environment in host countries induce the Japanese FDI. We treat this change as an autonomous change in the FDI functions.

$$\text{Japanese FDI} = f(\text{explanatory variables in 3.1}) + \text{an autonomous change of FDI}$$

The characteristics of these changes seem to differ by industry and host area. We performed sustained change simulations of a 10% autonomous FDI increase in each manufacturing industry during 1982-86. In each simulation, we assumed when FDI autonomously increased in some industry, there were no autonomous changes in other manufacturing industries.

4.3.1 The Effects of an Autonomous FDI Increase

An autonomous increase of FDI in some industry in the first year causes not only the FDI changes of other industries, but also the FDI change of its own industry in the subsequent years. Table 14 and 15 show the effects of autonomous FDI changes on FDI and subsidiary sales respectively. As expected, the effects on the industry, in which an autonomous FDI increase occurred, are dominant in both, FDI and subsidiary sales(denoted as "own effect"). The own effect on FDI differs by industry in spite of the first year's effects being almost the same in each industry. The first year's FDI effect marks about 10% increase in each industry. In the fifth year, machinery reaches

60% point increase, whereas light manufacturing remains still at 24% increase. Although there is small subsidiary increase in light manufacturing in the first year, other industries need more than a year to see their increase because of the gestation period of production, which is peculiar to each industry. Chemicals and machinery needs 3 years and 4 years to see substantial increase of subsidiary sales. The increase of subsidiary sales of the wholesale and retail industry is the largest since it includes the subsidiary sales of primary commodities and manufactured goods as its subsidiary inputs.

In general the increase of subsidiary sales affects the trade balance through associated exports, export substitution, and re-imports. This simulation do not cause any change of import price because it is treated as exogenous in this model. Although the change of the domestic economy induces the increase of import and re-import, their effects are very small compared to the effects on exports except for metal industry. Thus, we focus on the effects on exports through associated exports and export substitution. We have the following relation:

Subsidiary sales = local sales and exports to the third countries
+ exports to Japan (re-imports)

So, little change of exports to Japan means that change of local sales and exports to the third countries is nearly equal to change of subsidiary sales. The increase of export substitution through local sales and exports to third countries reduces exports of Japan. On the other hand, increase of subsidiary production promotes Japanese exports through associates exports. Table 16 shows the effects on the trade balance, the export substitution, the associated exports in each industry.

As for the export substitution, substantial increase in light manufacturing and machinery appear in the third year. Chemicals and metal industry need more than three years to show the substantial increases which correspond to the gestation period as discussed before. The effects on associated exports have almost the same pattern as that of export substitution. The table shows the effects on export substitution are larger than that of associated exports on the whole. So, except for the metal industry the effects on the trade balance, which is the effects on the associated exports minus the effects on the export substitution, are negative. As for the metal industry, its exports decrease, and then the imports decrease through the declined domestic product and domestic producers price. The effects on the trade balance marks some positive figure because the positive effects due to decreased imports is slightly larger than the negative effect due to decreased exports. Thus, the effects of an autonomous FDI increase on the trade balance differ by industry, but these effects are very small compared to the huge trade surplus in Japan. While a large increase of subsidiary sales in machinery produces US$ 30 billion of export substitution and US$ 28 billion of associated exports in the sixth year, their difference is not so large, neither is the change of the trade balance.

Table 14 : The Effects of the 10% Autonomous FDI Increase on FDI (1982-87)

Million dollar, % point in the parenthesis: (simulation solution - base line solution) / base line solution × 100

	1st year	2nd year	3rd year	4th year	5th year	6th year
FDI increase in light manufacturing						
The Effects on						
Light manufacturing	861 (10.0)	1608 (17.3)	2117 (21.9)	2357 (23.9)	2603 (24.4)	2939 (24.4)
Chemicals	0	0	5	12	20	26
Metal industry	0	3	7	12	18	25
Machinery	0	0	0	0	1	0
Wholesale & retail trade	0	-1	-9	-22	-38	-53
Total	861	1610	2120	2359	2606	2933
FDI increase in chemicals						
The Effects on						
Light manufacturing	0	0	0	0	0	0
Chemicals	427 (10.0)	1247 (19.5)	1774 (24.7)	1773 (27.2)	1902 (28.1)	2073 (31.0)
Metal industry	0	0	2	4	9	18
Machinery	0	0	0	0	0	0
Wholesale & retail trade	0	0	-2	-10	-6	-57
Total	427	1267	1774	1767	1885	2028
FDI increase in metal industry						
The Effects on						
Light manufacturing	0	0	0	0	0	0
Chemicals	0	0	0	0	3	9
Metal industry	702 (9.2)	1149 (16.2)	1519 (22.5)	1624 (25.7)	1719 (26.5)	2009 (26.6)
Machinery	0	0	0	0	0	0
Wholesale & retail trade	0	0	0	1	3	-15
Total	702	1149	1519	1625	1722	2003
FDI increase in machinery						
The Effects on						
Light manufacturing	0	0	0	0	0	0
Chemicals	0	0	5	15	33	66
Metal industry	0	3	8	16	32	65
Machinery	589 (10.2)	1364 (20.4)	2679 (30.5)	4691 (40.6)	8390 (50.3)	14970 (59.5)
Wholesale & retail trade	0	-2	-16	-49	-94	-166
Total	589	1365	2676	4673	8361	14935

Table15 : The Effects of the 10% Autonomous FDI Increase on Subsidiary Sales (1982-87)

Million dollar, % point in the parenthesis: (simulation solution - base line solution) / base line solution × 100

	1st year	2nd year	3rd year	4th year	5th year	6th year
FDI increase in light manufacturing						
The Effects on						
Light manufacturing	-1 (-0.0)	303 (1.9)	479 (2.9)	625 (3.7)	773 (3.9)	867 (3.9)
Chemicals	0	6	6	16	33	47
Metal industry	0	11	20	25	27	30
Machinery	1	17	27	39	48	58
Wholesale & retail trade	-3	1108	1108	1298	1481	1514
Total	-3	1445	1650	2003	2362	2516
FDI increase in chemicals						
The Effects on						
Light manufacturing	0	0	0	0	0	0
Chemicals	0 (0.0)	28 (0.7)	125 (3.0)	265 (5.5)	864 (9.7)	1350 (11.8)
Metal industry	0	1	8	18	36	43
Machinery	0	2	11	28	68	95
Wholesale & retail trade	0	93	464	914	2141	2481
Total	0	124	608	1225	3109	3969
FDI increase in metal industry						
The Effects on						
Light manufacturing	0	0	0	0	0	0
Chemicals	0	0	0	6	19	32
Metal industry	0 (0.0)	0 (0.0)	0 (0.0)	356 (3.9)	616 (6.6)	916 (9.0)
Machinery	0	0	0	20	35	56
Wholesale & retail trade	0	0	0	672	1095	1465
Total	0	0	0	1048	1765	2469
FDI increase in machinery						
The Effects on						
Light manufacturing	0	0	0	0	0	0
Chemicals	0	7	16	31	127	243
Metal industry	0	11	30	56	130	191
Machinery	0 (0.0)	337 (1.2)	783 (2.4)	1540 (3.5)	4478 (7.5)	7284 (9.2)
Wholesale & retail trade	0	808	1679	2856	7651	11097
Total	0	1163	2508	4483	12386	18815

Table 16 :The Effects of the 10% Autonomous FDI Increase on Trade Balance (1982-87)

Million dollar	1st year	2nd year	3rd year	4th year	5th year	6th year
FDI increase in light manufacturing						
The Effects on						
Export substitution						
own industry	0	-64	-102	-129	-161	-156
other industries	0	-14	-36	-46	-53	-51
Associated exports						
own industry	0	5	20	29	53	61
other industries	0	9	13	20	25	30
Trade balance	0	-53	-72	-87	-104	-89
FDI increase in chemicals						
The Effects on						
Export substitution						
own industry	0	-11	-55	-121	-228	-311
other industries	0	-1	-9	-20	-44	-58
Associated exports						
own industry	0	1	3	7	21	33
other industries	0	0	1	3	6	8
Trade balance	0	-4	-21	-45	-83	-91
FDI increase in metal industry						
The Effects on						
Export substitution						
own industry	0	0	0	-4	-111	-201
other industries	0	0	0	-12	-22	-36
Associated exports						
own industry	0	0	0	24	60	79
other industries	0	0	0	9	15	25
Trade balance	0	0	0	-9	2	44
FDI increase in machinery						
The Effects on						
Export substitution						
own industry	0	-239	-601	-917	-2298	-3001
other industries	0	-3	-14	-30	-55	-101
Associated exports						
own industry	0	132	304	593	1727	2782
other industries	0	2	5	9	24	45
Trade balance	0	-98	-263	-283	-527	-182

4.3.2 The effects of an Autonomous FDI Change with Associated Change of the Local Contents.

How large associated exports due to subsidiary production are, depend upon the delivery ratio from Japan to total subsidiary inputs, as the following relation shows:

Subsidiary imports from Japan (associated exports)
= subsidiary sales × ratio of subsidiary inputs to subsidiary sales
× delivery ratio from Japan to subsidiary total inputs.

The delivery ratio from Japan in manufacturing was roughly over 25% in the early 1980's, and it declined to around 20% in the late 1980's (see Table 17). This downward tendency is especially remarkable in metal industry and machinery. The decline of the delivery ratio weakens the effects on associated exports, and strengthens the effect on export substitution through the rise of the local contents and the delivery ratio from third countries. We guess that the high overseas production ratio to domestic production in the 1990's has lead to the high local contents. As we can see in Table 18, machinery has had a huge trade surplus, and even metal industry had a big trade surplus in the early 1980's. Had the decline of delivery ratio been combined with an autonomous FDI increase in the early and mid 1980's, would it

Table 17 : Delivery Ratio from Japan to Total Subsidiary Inputs (% point)

	manufacturing as a whole	light manufacturing	chemicals	metal industry	machinery
1982	24.6	21.7	26.6	27.8	64.3
83	26.3	24.6	23.6	32.5	68.0
84	30.3	26.8	27.2	35.7	66.8
85	28.5	24.7	23.7	36.4	62.9
86	34.2	39.9	20.2	38.2	61.5
87	21.0	20.2	25.0	18.0	56.3
88	22.5	21.7	27.3	19.6	59.8
89	23.8	25.5	16.2	26.5	55.4
90	31.5	33.4	32.7	25.4	49.6
91	19.2	19.0	23.2	13.5	48.1
92	19.0	19.5	22.1	13.3	46.2

Source: The Ministry of International Trade and Industry, The Survey of Overseas Of Japanese Companies, various issues

Table 18:Trade Balance of Manufacturing (billion dollar)

	light manufacturing	chemicals	metal industry	machinery
1982	-2.3	-5.6	12.1	83.1
82	-2.7	-6.0	9.4	88.3
84	-4.0	-6.4	9.0	100.7
85	-9.1	-4.6	10.5	107.9
86	-8.3	-2.1	6.4	135.1
87	-15.5	-2.7	4.8	160.7
88	-35.6	-4.8	1.0	179.7
89	-40.5	-6.1	-0.3	155.6
90	-37.8	-5.6	0.1	175.6
91	-38.4	-4.6	-2.8	221.2
92	-45.1	-3.5	1.0	216.7

Source: The Economic Planning Agency, Annual report on National Accounts
Note; The original year base data are converted into dollar base ones by using the average yen's exchange rate which the International Financial Statistics of IMF provides.

have considerably affected the trade balance in Japan? To answer this question, we attempted the joint simulations of 10% sustained autonomous increase of FDI and 10% sustained decrease of the delivery ratio from Japan to total subsidiary inputs during the period 1982-87 in metal industry and machinery, respectively.

Table 19 shows the simulation results in the metal industry. As expected from Table 14, FDI increase is dominant in metal industry and it reaches at US$ 21 billion in the sixth year, US$ about 1 billion higher than the case of Table 14. As we see in Table 15, it takes 3 years for the real effects on the subsidiary production to occur, so the substantial increase appears in the fourth year. The increase of subsidiary sales is US$ 25.6 billion in the sixth year, US$ about 0.9 billion higher than that in the case of Table 16. The decline of the delivery ratio from Japan makes the effect of associated exports negative, US$ -0.4 billion in the first year, while it was positive in Table 16. The export substitution becomes substantial in the fifth year. Thus, the negative effect of associated exports and the positive effect of export substitution has a negative impact on the trade balance, and the latter effect is always dominant. As was shown in 4.3.1, the positive direct domestic effect due to the decreased imports (US$ -0.95 billion) is much stronger than the negative FDI effect, so the total effect on the trade balance is positive.

If we had managed to use some economic policies such as stimulation policies of domestic consumption or import promoting policies to offset the decline of imports, the effect on the trade balance would become US$ -0.67 billion in the sixth year.[13] Now, the actual trade balance of metal industry was US$ 10.5 billion in 1985, which corresponds to the fourth year of the simulation period. The effect on trade balance in the fourth year is US$ -0.4 billion, less than 4% of the actual trade balance of metal industry, and only 1% of the actual total trade surplus US$ 44.3 billion at that time.

What would the effect on the trade balance have been, if the decline of the delivery ratio from Japan had been combined with the autonomous FDI increase in machinery ? Table 20 shows that there is a fairly large FDI increase in machinery. Substantial increase of subsidiary sales appears in machinery and wholesale and retail trade industry. As for the effect on the trade balance, while only the negative effect of associated exports appears in the first year, the positive effect on export substitution becomes larger than that of associated exports in the third year. The effect on trade balance reaches the level of US$ -7.9 billion in the sixth year, and the effect of export substitution shares three-fourth of the total effect on trade balance. Now, the fourth year's effect on trade balance is US$ -4.4 billion, which amounts to nearly 10% of the total trade surplus, and seems to contribute to the reduction of the trade friction due to the huge trade surplus to a certain degree.[14] This simulation suggests that the structural change of overseas production such as the decline of delivery ratio in the late 1980's has had a more evident effect on the trade between parent companies and subsidiaries with a much higher overseas production ratio to domestic production.

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[13] These simulation results can be derived from all variables of the domestic sector being exogenous and attempting the joint simulation of 10% increase of FDI and of 10% decline of delivery ratio from Japan in metal industry.

[14] Table 20 shows that shrinking of the domestic economy causes US$ 1.25 billion of import reduction in the sixth year. To see the FDI effect only, all variables of the domestic sector were taken as exogenous, and then the same simulation above was performed. The simulation results show that the effect on trade balance is US$ -9.3 billion, about US$ 1.25 billion lower than that in Table 20. If we could have prevented the reduction of Japanese imports successfully by introducing some expansive domestic policies, the huge trade surplus could have been more effectively reduced.

Table 19 : The Simulation Results of 10% Autonomous Increase of FDI 10% Decrease of the Delivery Ratio from Japan in Metal Industry

million dollar, % point in the parenthesis : (simulation solution − base line solution)/ base line solution × 100

	1st year	2nd year	3rd year	4th year	5th year	6th year
The effects in FDI						
Light manufacturing	0	0	0	0	0	0
Chemicals	-1	1	1	1	3	9
Metal industry	709	1154	1542	1667	1779	2094
	(9.3)	(16.3)	(22.9)	(26.4)	(27.9)	(27.8)
Machinery	0	1	5	11	20	31
Wholesale and retail trade	-8	-75	-140	-230	-320	-460
Total	700	1081	1480	1449	1482	1674
The effects on subsidiary sales						
Light manufacturing	0	0	0	0	0	0
Chemicals	0	0	0	6	20	34
Metal industry	0	0	0	360	619	930
	(0.0)	(0.0)	(0.0)	(4.2)	(6.6)	(9.2)
Machinery	0	0	0	23	47	76
Wholesale and retail trade	0	0	0	685	1121	1516
Total	0	0	0	1074	1807	2556
The effects on trade balance						
Export substitution						
own industry	-15	6	2	2	-109	-199
other industry	1	-15	-17	-29	-36	-37
Associated exports						
own industry	-397	-332	-479	-400	-418	-510
other industry	0	0	0	11	21	34
Import including re-imports						
own industry	-257	-253	-387	-345	-416	-708
other industry	-133	-83	-132	-125	-148	-245
Trade balance	-20	-5	26	53	22	241

Table 20. The Simulation Results of 10% Autonomous Increase of FDI 10% Decrease of the Delivery Ratio from Japan in Machinery

million dollar, % point in the parenthesis : (simulation solution − base line solution)/ base line solution × 100

	1st year	2nd year	3rd year	4th year	5th year	6th year
The effects in FDI						
Light manufacturing	0	1	2	4	4	3
Chemicals	0	4	3	16	29	55
Metal industry	0	3	7	14	28	55
Machinery	589	1367	2164	4507	7656	12794
	(10.2)	(20.4)	(30.3)	(39.0)	(45.9)	(50.8)
Wholesale and retail trade	-21	-219	-557	-1027	-1631	-2635
Total	568	1148	2119	3504	6096	10272
The effects on subsidiary sales						
Light manufacturing	0	0	0	1	1	1
Chemicals	0	7	16	30	122	228
Metal industry	0	11	30	56	126	176
Machinery	0	337	785	1532	4320	6718
	(0.0)	(1.2)	(2.4)	(3.5)	(7.2)	(8.5)
Wholesale and retail trade	0	808	1683	2839	7386	10246
Total	0	1163	2514	4458	11955	17369
The effects on trade balance						
Export substitution						
own industry	42	-1544	-2583	-3195	-5441	-6453
other industry	0	-3	-33	-57	-85	-110
Associated exports						
own industry	-1812	-1663	-1920	-1854	-2153	-2683
other industry	0	2	4	11	30	51
Import including re-imports						
own industry	0	-78	-149	-222	-358	-609
other industry	-207	-311	-410	-429	-424	-647
Trade balance	-1562	-2813	-3973	-4443	-6869	-7940

5. Conclusions

We formulated a macro-econometric model which includes Japanese FDI behavior and its subsidiary production for the purpose of analyzing their main determinants and their effects on Japanese trade balance and the domestic economy. The major concern of our analysis was how much the yen's appreciation promoted Japanese FDI and its overseas production and whether the increased overseas production contributed to reducing the huge trade surplus. The simulation results can be summarized as follows:

(1) The sharp appreciation of yen accelerated Japanese FDI in manufacturing through both, rising relative export price (production cost factors) and shrinking the domestic economy (market growth factors). The increased subsidiary production contributed to somewhat reducing the trade surplus (FDI effect), but its effects are much smaller than the effect through direct price effect on exports (direct domestic effect).

(2) Even if the yen's exchange rate remain unchanged, an autonomous FDI increase stimulates Japanese FDI and subsidiary production, but the effects on export substitution and associated exports are still not really large except for machinery. While the simulation of an autonomous FDI increase in machinery marks fairly large export substitution and associated exports, their difference is small, so is the effect on trade balance. If an autonomous FDI increase in machinery had been combined with the decline of delivery ratio from Japan, it could have contributed to a fairly large reduction of the trade surplus.

Thus, the sharp appreciation of yen promoted Japanese FDI, but the subsequent increase of subsidiary production itself did not necessarily contribute to easing the trade friction. We found that whether subsidiary production has effects on the huge trade surplus depends on the production structure of subsidiaries. At the first stage of production, Japanese affiliates tend to increase the imports of intermediate goods or capital goods from Japan. The subsidiary imports from Japan increase with the expansion of subsidiary production unless the delivery ratio from Japan decreases.

These analyses focused on the Japanese FDI behavior in the 1980's. The figures for the 1990's show a fairly large decline of the delivery ratio from Japan and a high path of re-import increase. If the same kind of simulation analyses which we performed in this paper were applied in the 1990's by adding the new data, the effects on export substitution and re-imports would become stronger and the effect on associated exports would become weaker. So, the simulation results could be different from those we attempted in this paper.

The determinants of FDI and their economic effects depend both on the industry concerned and the host area. Although our model analyzed Japanese FDI behavior by industry, it did not distinguish countries accepting Japanese FDI from third countries. The model only covered Japanese FDI to the rest of the world, and not by area. We may have to construct models for each host country or area for Japanese FDI, considering the effects of third countries explicitly.

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