

# Exchange Rates and Reshoring

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## Abstract

*Under the super yen appreciation since 2011, Japanese manufacturers accelerated overseas production to avoid exchange loss in exports. This tendency stirred concerns about the deindustrialization phenomenon which was referred as 'hollowing-out of industry'. However, yen depreciation in the late 2014 turned the situation around. The weak yen is prompting some Japanese firms to bring overseas production back home, raising expectations the 'reshoring' trend may slow down the ongoing industrial hollowing out of Japan. This 'reshoring' phenomenon has been observed in the United States in recent years, but this is the first taste of reshoring to Japanese economy. This paper investigates the mechanism of 'reshoring', using a system dynamics model. Simulation analysis of yen depreciation scenario reveals the limit of reshoring. Bringing back manufacturing is not as easy as the public believes, because manufacturers enjoy the highly developed global supply chain.*

**Keyword** : reshoring, offshoring, foreign direct investment, deindustrialization, hollowing out

## 1. Introduction

The rapid yen appreciation started in 2011 has brought negative profits to major Japanese manufacturers<sup>1</sup>. Those manufacturers accelerated the foreign direct investment (FDI) to avoid exchange losses in exports. This tendency stirred fears of the negative deindustrialization phenomenon that was referred as “hollowing out” of industry<sup>2</sup>. The relocation of a production process from home country to another cuts home jobs and weakens the home industry. Worsening of domestic employment raises the unemployment rate and negatively affects economy or society. The reason for “hollowing out” phenomenon includes cutting labor costs in overseas production under appreciation of the home currency.

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<sup>1</sup> The rise in the value of the yen started after the Nixon Shock in 1971. Plaza Accord in 1985, U.S.-Japan trade imbalance in the early 1990s, and the bankruptcy of Lehman Brothers in 2008 accelerated the rise. Yen-dollar rate hit a postwar record, 75.32 yen to the dollar on October 31 in 2011.

<sup>2</sup> “Hollowing out” was first used to describe the implications of offshoring by U.S. manufacturers on regional economy in 1970s. Factory closedown of basic industry runs down local economy and community surrounding that plant. These are diminishing the nation’s welfare. Bluestone and Harrison (1982) sounded a warning of it. This phenomenon was introduced to Japan in 1985.

Although deindustrialization is a natural growth process of advanced economies, associated growths of foreign direct investment and offshoring are controversial. Some regard that these are signs of maturity of economies and argue that production in advanced economies inevitably shift from consumer goods to capital goods as predicted in the flying geese paradigm by Akamatsu (1962). According to the principle of comparative advantage, increasing labor costs provokes overseas production of labor-intensive products in low-wage economies. Others regard that any overseas production leads to shrinking of home employment, depreciation of productivity, and fading of economic vitality<sup>3</sup>. Advanced economies require changes in industrial structures such as a shift from labor-intensive production to capital-intensive activities, high-technology industries, or service industries. However, structural changes are often less than successful.

Overseas production or offshoring in the FDI is implemented for several reasons<sup>4</sup>. Reducing the cost of production by use of cheaper wage rates is an important cause. Offshoring of final products under the home currency appreciation regains competitiveness in the world market. Offshoring of intermediate inputs under the home currency depreciation also reduces the cost of production. Offshoring is one of the leading causes of deindustrialization.

However, yen depreciation in the latter half of 2014 turned the situation around<sup>5</sup>. Yen depreciation is bringing returns of investments to Japan. Japanese companies such as Daikin, Panasonic, Sharp, and TDK plan to move production sites back to Japan<sup>6</sup>.

There are several factors that motivate companies to start reshoring. First, rising wage levels in emerging economies take away cost advantages of offshoring manufacturing. Second, it gradually reveals that there is a hidden cost in offshoring<sup>7</sup>. More employees are needed because of low productivity by low-cost labor. More investments are needed to

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<sup>3</sup> American television personality Lou Dobbs (2004) asserted that offshoring hurt American workers and this was a social problem as well as an economic problem. His opinion was somewhat extreme, but it pointed out that there were some problems in offshoring from the viewpoint of the nation's economy.

<sup>4</sup> Offshoring is the practice of basing some of a company's processes or services overseas, so as to take advantage of lower costs. In manufacturing, a company shifts assembly or full manufacturing to a country where labor is cheaper for export and/or import into the manufacturer's home country. The term "offshoring" often refers to "international outsourcing" where business activities are relocated to unaffiliated foreign firms. However, the term "offshoring" usually refers to the relocation of business activities to affiliated firms abroad in Japan, because "international outsourcing" is small. According to McCann (1998), Japanese firms put weight on delivery time whereas Western firms put weight on cost minimization. This difference of philosophy may affect "offshoring." Setting this aside, globalization of the value chain or the supply chain is more likely to expand through FDI (Milberg and Winkler, 2013). We simply define offshoring as transferring production or services to a location abroad.

<sup>5</sup> Yen-dollar rate jumped to the similar level of depreciation of the yen to the dollar since 2007, 120 yen to the dollar on December 4 in 2014. This yen's weakness is due to Prime Minister Shinzo Abe's 'Abenomics' economic policy package, although his monetary policy intended to trigger artificial inflation in the domestic market.

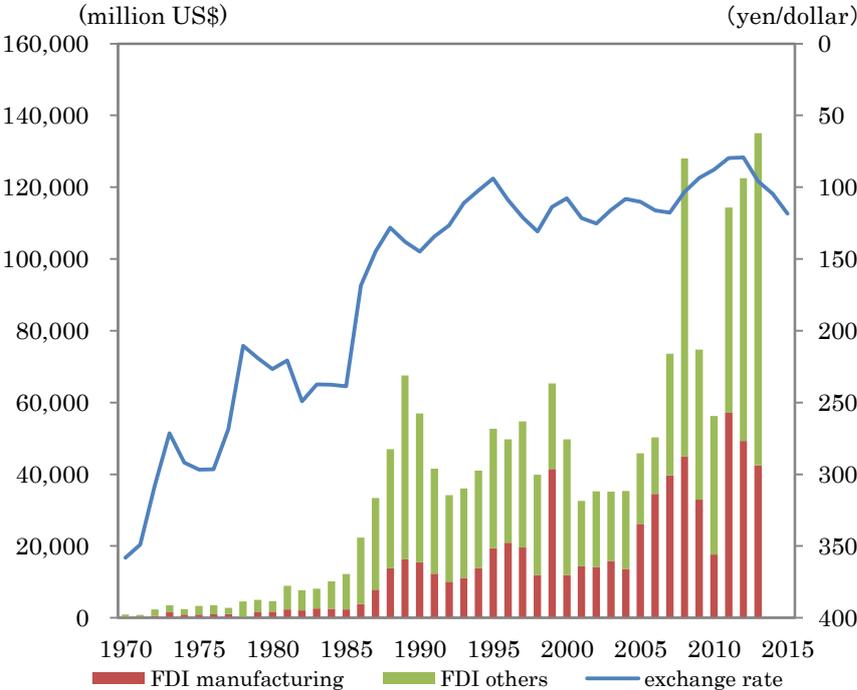
<sup>6</sup> These news were reported in January in 2015: "More firms to bring production back to Japan amid yen weakening," *The MAINICHI Newspaper*, January 8, 2015 (<http://mainichi.jp/english/english/newsselect/news/20150108p2g00m0bu040000c.html>) and "Fading yen forces Japanese firms to bring production home" *Deutsche Welle*, January 20, 2015 (<http://dw.de/p/1ENCQ>).

<sup>7</sup> 'Reshoring US manufacturing,' HSBC Global Connections, December 08, 2014. (<https://globalconnections.hsbc.com/global/en/articles/reshoring-us-manufacturing>)

protect intellectual property rights in emerging economies. Third, global supply chains have shown weakness recently. Furthermore, there is a risk from natural disasters such as floods in Thailand and an earthquake in Japan.

Offshoring in Japan is largely based on the exchange rates. The yen's appreciation deprived competitiveness of Japanese products in the world market, and Japanese manufactures were forced to offshore. On the other hand, the yen's depreciation made the costs of manufacturing products for the Japanese market in other countries higher than production costs in Japan. The weak yen neutralized the cost-reduction effects of production in emerging economies, especially in the People's Republic of China because yen prices of such products go up after they are exported to Japan.

Figure 2 shows the history of yen's exchange rate and the volume of outward FDI. Under the strong yen appreciation phase, the issue of deindustrialization emerged<sup>8</sup>.



**Figure 2. Exchange rate and foreign direct investment**

Source: Own illustration. Data: OECD, *Economic Outlook*. Bank of Japan, every other year.

Statistical background is examined in the next section. After that, system dynamics model is proposed. System dynamics is applied in this study for the following reasons:

- (1) The stock and flow approach explains capital formation well. Economists distinguish between two types of quantity variables: stocks and flow (Mankiw, 2007). The amount of capital in the economy is stock; the amount of investment is a flow. The number of employed people is a stock; the number of people getting their jobs is a flow. Although economic models often neglect this distinction, stocks are the source of delays in

<sup>8</sup> The issue of deindustrialization was first discussed at the end of 1980s and second at the middle of 1990s under the rapid yen appreciation phases in Japan. The third argument started from 2011.

equilibriums.

- (2) System dynamics modeling can implement demographic change that affect labor supply. From the early stage of system dynamics, the stock and flow structure handled the population growth. Among them, Forrester (1969) was a pioneering work of the interaction between economy and population. Although the standard economics usually considers population as an exogenous variable, his idea is of increasing importance in the study of mature economies.
- (3) The structure-based approach of system dynamics works well for elucidating a phenomenon with limited information. It is difficult to obtain a reliable econometric result when data is little. The structure-based approach gives us the ability to explore such a phenomenon.

## **2. Foreign direct investment and supply chain**

Although currency strengthening is a major background for outward FDI, the effects of overseas production on the investing economy are controversial. Overseas production has four effects: reverse import effect, export inducement effect, export substitution effect, and import diverting effect<sup>9</sup>.

The reverse import effect refers to an increase in imports from the invested country to the investing country. The export inducement effect refers to an increase in exports from the investing country to the invested country, because capital and intermediate goods are provided in the early stages of production. The export substitution effect refers to a decrease in exports from the investing country, because finished products are substituted by those produced in the invested country. The import diverting effect refers to a decrease in material imports when production operates outside the home economy.

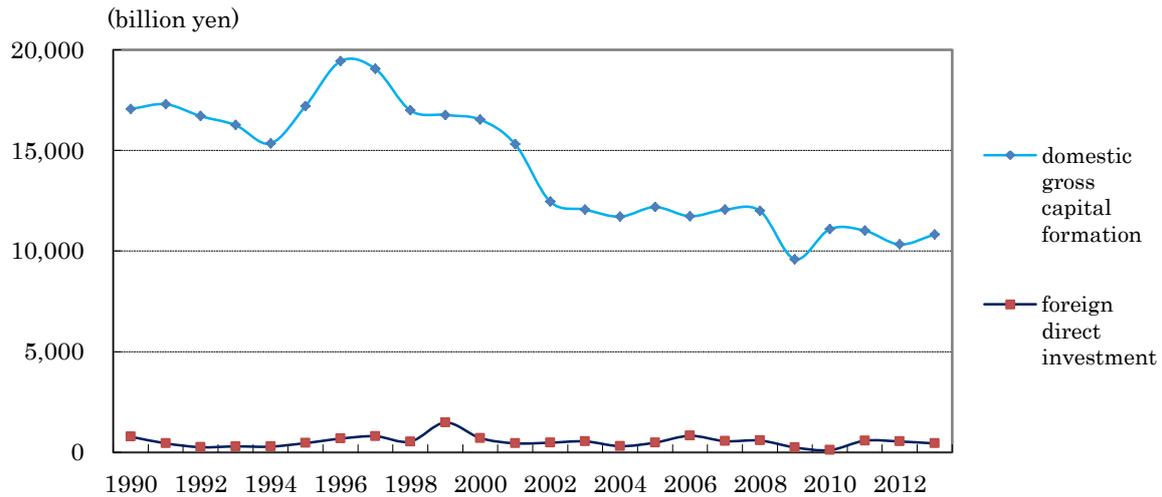
The effects vary according to types of overseas production. Horizontal FDI involves a replication of productive capacity in the foreign country in order to promote sales in that country. Horizontal FDI has the export substitution effect, and this effect reduces domestic output and employment. Vertical FDI involves capital movement mostly in order to seek cost minimization or efficiency. In vertical FDI, when a company transfers its existing process overseas, domestic employment may decrease whereas output increases. The effect varies according to transferring which part of the production process or supply chains to abroad. In reality, most FDI has the characteristics both vertical FDI and horizontal FDI.

Generally speaking, the more time that passes from the start of production, the greater the export substitution effect becomes and the lesser the export inducement effect becomes. However, Basu and Miroshnik (2000) analyzed that Japan's trade structure shows that the export inducement effect of foreign subsidiaries was more prominent than the export substitution effect.

Let us investigate two important sectors of manufacturing industry in Japan: electric machinery and transportation equipment. These industries account for nearly three of ten in manufacturing output and nearly five of ten in manufacturing exports. Figure 3 shows domestic and foreign investments in the electric machinery industry.

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<sup>9</sup> These effects are often discussed in white papers by the Government of Japan as well as academic papers



**Figure 3. Investments in electric machinery industry**

Source: Own illustration. Data: Economic and Social Research Institute, *Annual Report on National Accounts*.  
Bank of Japan, *Balance of Payments*.

Although the electric machinery industry is a large industry, domestic capital formation is declining. Table 1 tells us correlations among exports, FDI, and domestic capital formation.

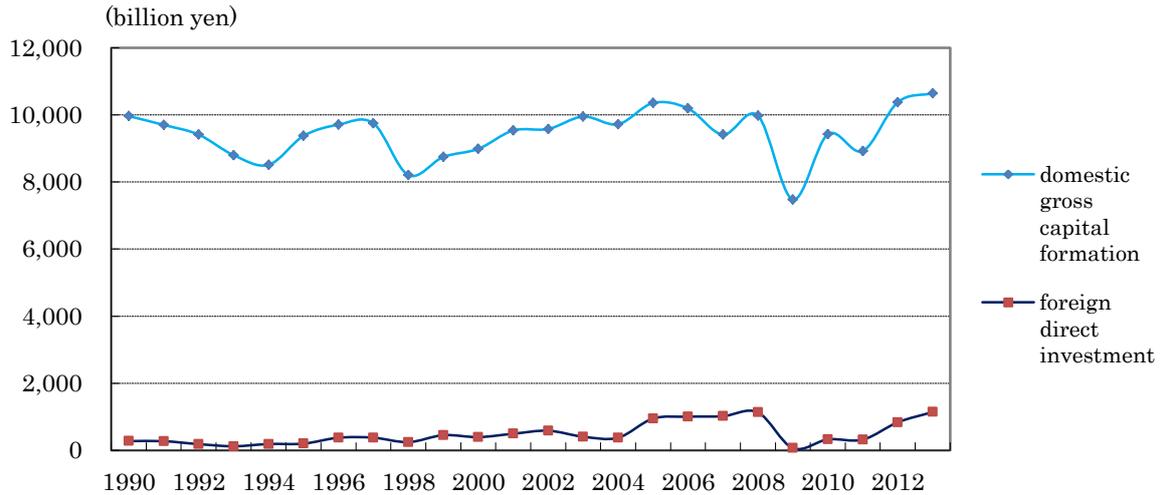
**Table 1. Correlations in electric machinery industry**

|                   | Exports   | FDI      | Capital formation |
|-------------------|-----------|----------|-------------------|
| Exports           |           | 0.303376 | -0.433236         |
| FDI               | 0.303376  |          | 0.221207          |
| Capital formation | -0.433236 | 0.221207 |                   |

Source: Own calculation. Data: Economic and Social Research Institute, *Annual Report on National Accounts*.

The negative value of the correlation between exports and domestic capital formation suggests that overseas production is replacing home production and there emerges the export inducement effect.

Figure 4 shows investments in transportation equipment industry.



**Figure 4. Investments in transportation equipment industry**

Source: Own illustration. Data: Economic and Social Research Institute, *Annual Report on National Accounts*. Bank of Japan, *Balance of Payments*.

Domestic capital formation and FDI increases keeping with FDI.

Theoretically, overseas production can be a substitute or a complement to domestic production. Table 2 reveals that FDI and exports are complements in transportation equipment industry<sup>10</sup>. Manufacturers make the vertical FDI effectively and establish tight supply chains between overseas sites and domestic sites.

**Table 2. Correlations in transportation equipment industry**

|                   | Exports  | FDI      | Capital formation |
|-------------------|----------|----------|-------------------|
| Exports           |          | 0.677183 | 0.230889          |
| FDI               | 0.677183 |          | 0.312645          |
| Capital formation | 0.230889 | 0.312645 |                   |

Source: Own calculation. Data: Economic and Social Research Institute, *Annual Report on National Accounts*

Exchange rate affects the domestic capital formation (Table 3).

**Table 3. Correlations between capital formation and exchange rate**

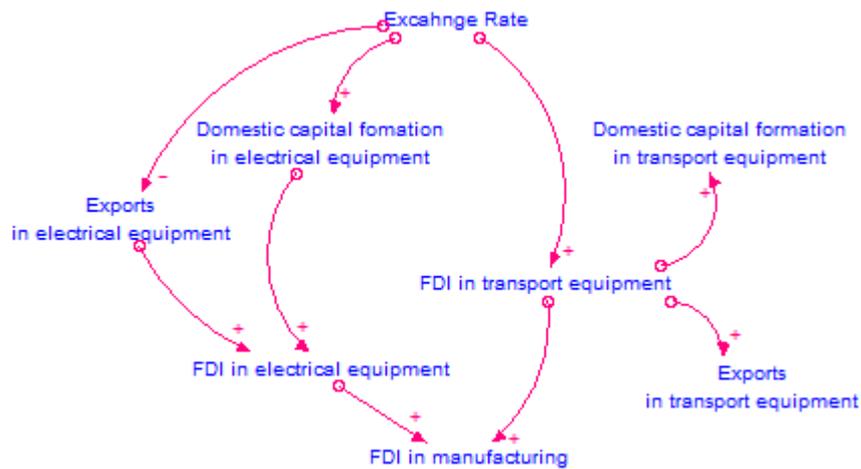
|   | 1990-99  | 2000-2013 |
|---|----------|-----------|
| Capital formation in electrical equipment     | 0.076349 | 0.549925  |
| Capital formation in transportation equipment | 0.304688 | 0.151945  |

Source: Own calculation. Data: Economic and Social Research Institute, *Annual Report on National Accounts*

<sup>10</sup> According to the Japan Automobile Manufacturers Association (JAMA), overseas production exceeds exports in the automobile industry since 1999.

Electrical equipment industry is more sensitive to exchange rate than before. The appreciation of yen, reducing exports and incurring imports, holds back domestic investment.

These investigation are summarized in the following causal loop diagram.



**Figure 5. Determination of FDI**

Source: Own figure.

### 3. Structure of the model

The macroeconomic model was developed with three sectors (traditional, manufacturing, and service sector) those were connected with each other through FDI, exchange rates, and labor immigration. Although independent variables in each equation were assumed from causal relations, the most plausible variables were selected by using econometrics. System dynamics and econometrics are complements as Meadows (1980) explained.

#### 3.1 Capital formation in manufacturing sector

Based on the investigation in Section 2, capital formation in the electrical machinery industry ( $IPE_t$ ) is assumed to depend on previous capital formation, current exchange rate ( $EXR_t$ ), and working-age population ( $WAPOP_t$ ). Exchange rate affects competitiveness against imports, and working-age population determines the size of domestic market.

$$IPE_t = IPE_t(IPE_{t-1}, EXR_t, WAPOP_t) \quad (3.1)$$

Exports in electrical machinery industry ( $EXE_t$ ) depend on exchange rate ( $EXR_t$ ).

$$EXE_t = EXE_t(EXR_t) \quad (3.2)$$

Capital formation in transport equipment industry ( $IPT_t$ ) depends on previous capital formation, FDI ( $FDIM_t$ ), and working-age population ( $WAPOP_t$ ).

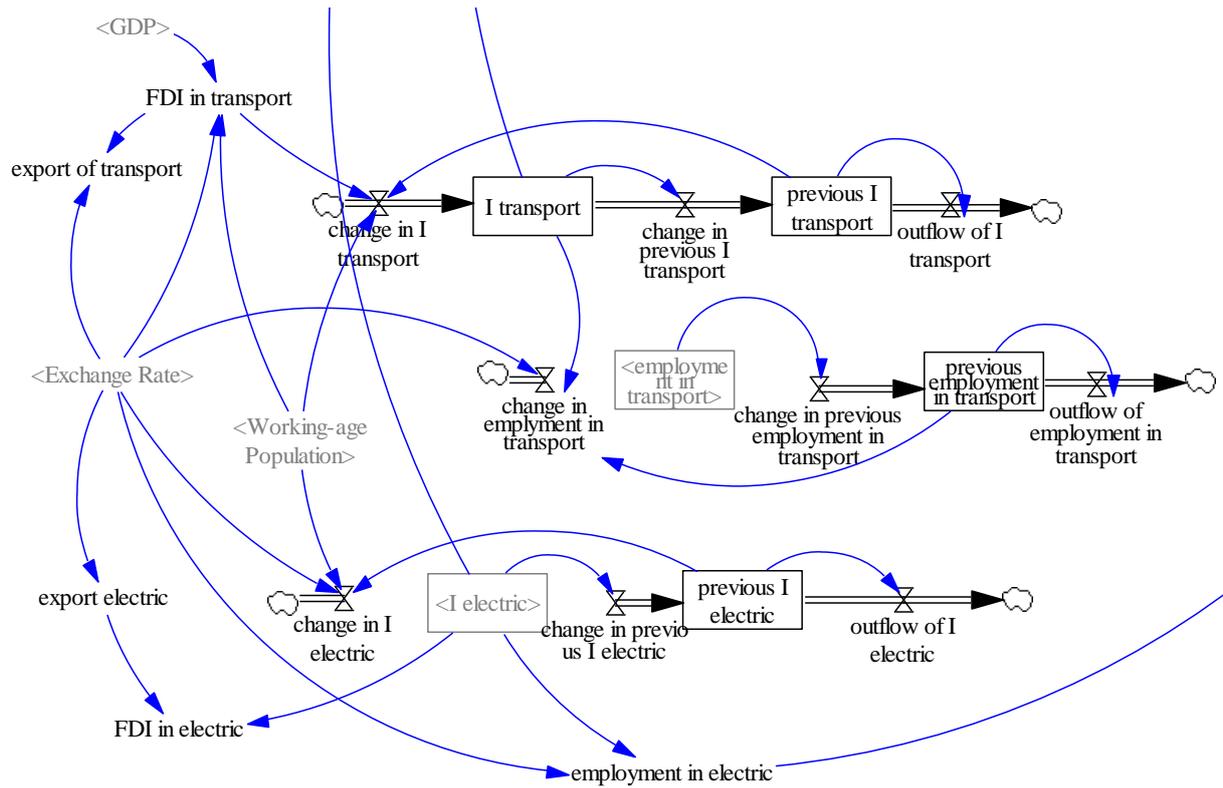
$$IPT_t = IPT_t(IPT_{t-1}, FDIM_t, WAPOP_t) \quad (3.3)$$

Statistical investigation gave us coefficients of the regression equation of (3.3) were largely changing before and after 1990.

Exports in transport equipment industry ( $EXT_t$ ) depend on exchange rate ( $EXR_t$ ) and its FDI ( $FDIT_t$ ), reflecting the export inducement effect.

$$EXT_t = EXT_t(EXR_t, FDIT_t) \quad (3.4)$$

Figure 6 shows the causal relation of the manufacturing sector.



**Figure 6. Manufacturing sector**

### 3.2 Foreign direct investment

FDI in electrical machinery industry is assumed to happen when there is a surplus of domestic capital formation and foreign demand for exports.

$$FDIE_t = FDIE_t( IPE_t, EXE_t ) \quad (3.5)$$

Manufacturers in transport equipment industry play FDI to replace exports under currency strengthening and to pursue lower-wage. Therefore, FDI ( $FDIT_t$ ) depends on the exchange rate and per capita GDP in home.

$$FDIT_t = FDIT_t( EXR_t, GDP_t / WAPOP_t ) \quad (3.6)$$

Total FDI in the manufacturing industry is assumed to be simply dependent on exchange rate.

$$FDIM_t = FDIM_t( EXR_t ) \quad (3.7)$$

### 3.3 Macroeconomic sector

The standard Keynesian aggregate demand model can be applied to the national economy<sup>11</sup>. Gross domestic expenditure ( $GDE_t$ ) consists of private final consumption expenditure ( $CP_t$ ), private capital formation ( $I_t$ ), government expenditure ( $G_t$ ), exports ( $EX_t$ ), and imports ( $IM_t$ ).

$$GDE_t = CP_t + I_t + G_t + EX_t - IM_t \quad (3.8)$$

A subscript means time  $t$ .

<sup>11</sup> There are many attempts to model system dynamics version of the Keynesian macroeconomic model. Among them, Low (1980) is helpful to know how to improve the traditional model in system dynamics format. The model in this subsection is enhanced with FDI procedure and feedbacks from employment.

### **Private final consumption expenditure**

Private final consumption expenditure is a large and stable component in GDE. Private final consumption expenditure function is assumed as a Keynesian type function in which the level of consumption depends on the gross domestic product ( $GDP_t$ ).

$$CP_t = CP_t(GDP_t) \quad (3.9)$$

### **Gross private fixed capital formation**

The gross private fixed capital formation depends on the previous capital formation, capital formation in electrical machinery, and capital formation in transport equipment.

$$I_t = I_t(I_{t-1}, IME_t, IMT_t) \quad (3.10)$$

Of course, other industries affect the gross capital formation. However, this simple equation gives a statistically good result.

### **Government Expenditure**

The government expenditure grows with population.

$$G_t = G_t(POP_t) \quad (3.11)$$

$POP_t$  is a medium fertility population projection by National Institute of Population and Social Security Research for 2011-2025. Government expenditure is treated as an exogenous variable in many macroeconomic studies. However, it has a positive correlation with population because social security service is a large part of the government expenditure.

### **Exports**

The exports to other countries are assumed to depend on the exchange rate ( $EXR_t$ ), the outflow of FDI in manufacturing ( $FDIM_t$ ) which reflecting that overseas operation induces export of machine tools, and (export-related) employment in the manufacturing sector ( $EMPM_t$ ).

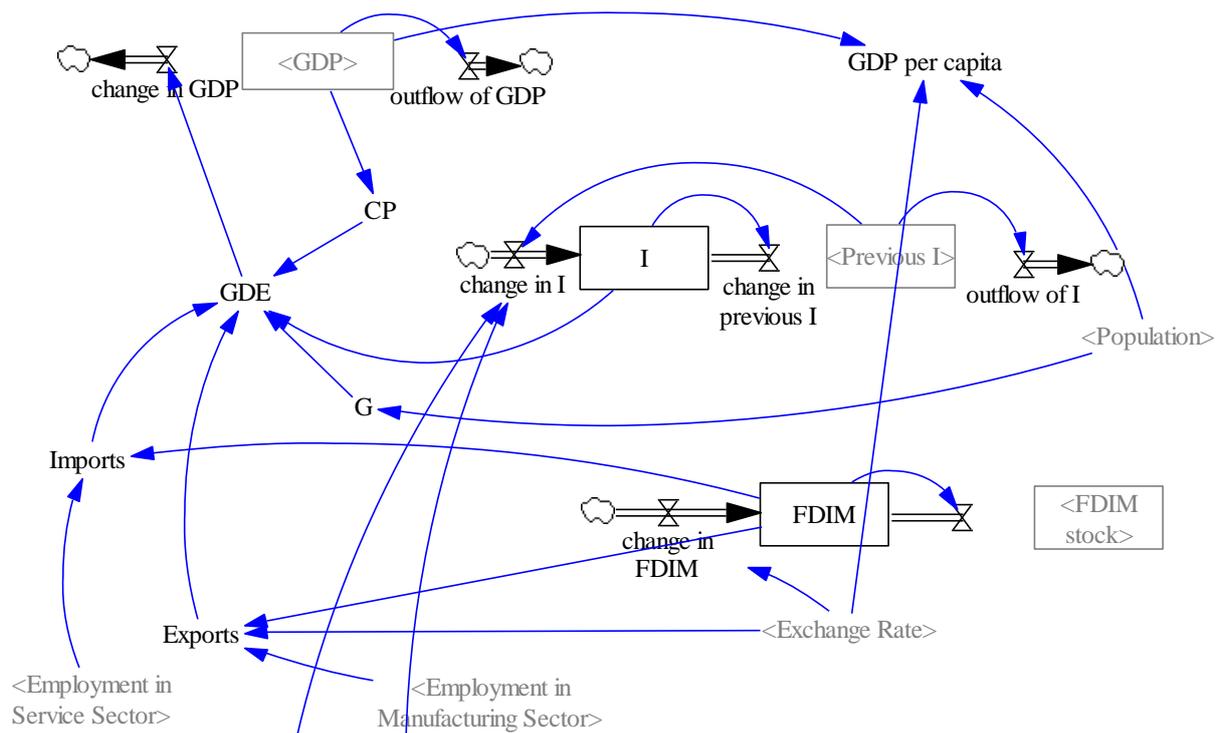
$$EX_t = EX_t(EXR_t, FDIM_t, EMPM_t) \quad (3.12)$$

### **Imports**

Imports are assumed to be dependent on the flow of FDI in manufacturing ( $FDIM_t$ ), reflecting the reverse import effect, and employment in the service sector ( $EMPS_t$ ).

$$IM_t = IM_t(FDIM_t, EMPS_t) \quad (3.13)$$

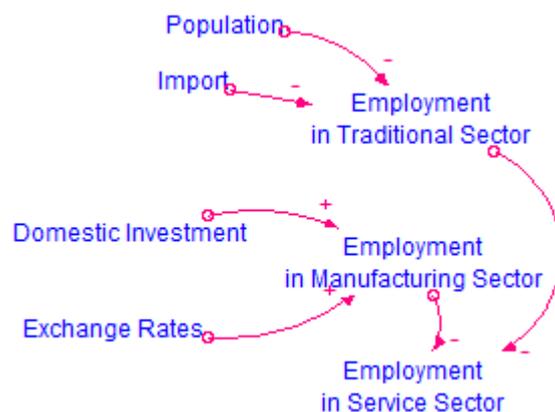
Figure 7 shows the causal relation of the macroeconomic sector.



**Figure 7. Macroeconomic sector**

### 3.4 Employment sector

Before examining employment dynamics, employment is classified into three types of economic subsectors. According to Petty-Clark's Law<sup>12</sup>, the labor moves from depressed industry to growing industry. In reality, the labor movement is not smooth. This paper introduces mobility to model the deindustrialization. The role of labor mobility is discussed in many system dynamics studies. The employment sector is modeled using econometric analysis.



**Figure 8. Determination of employments**

Source: Own figure.

<sup>12</sup> Clark (1940) examined the significance of this tendency and called "Petty's Law" after Sir William Petty who first found this type of tendency in *Political Arithmetic* (1690). This theory is now referred to as 'Petty-Clark's Law'.

First, the traditional sector consists of Agriculture, Hunting, Forestry and Fishing, Mining, Electricity, Gas and Water, and Construction. Employment of the traditional sector ( $EMPT_t$ ) depends on the job loss by imports and the job creation by capital formation in electrical machinery. It is also affected by population.

$$EMPT_t = EMPT_t(IM_t, IPE_t, POP_t) \quad (3.14)$$

Second, the manufacturing sector consists of several sub-industries. Among them, total employment ( $EMPM_t$ ) in Manufacturing depends on employment in electrical machinery ( $EMPME_t$ ) and employment in transport equipment ( $EMPMT_t$ ), according to statistical investigation.

$$EMPM_t = EMPM_t(EMPME_t, EMPMT_t) \quad (3.15)$$

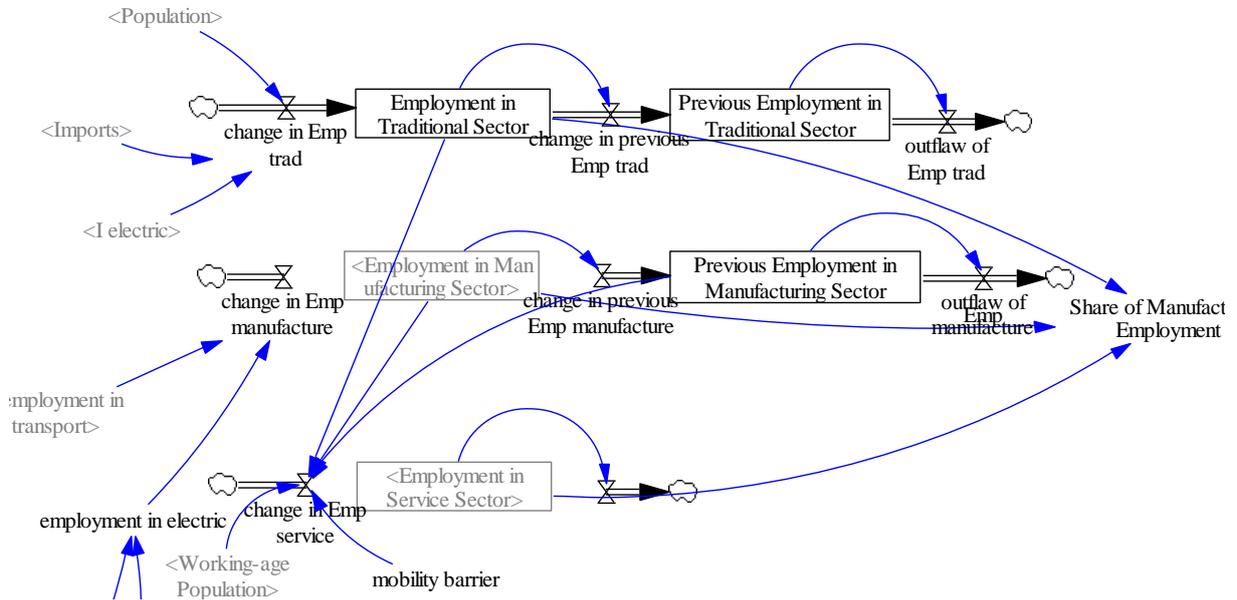
$$EMPME_t = EMPME_t(IPE_t, EXR_t) \quad (3.16)$$

$$EMPMT_t = EMPME_t(EMPME_{t-1}, IPT_t, EXR_t) \quad (3.17)$$

Third, the service sector consists of Transport and Communication, Finance, Insurance, Real Estate, Business Services, Wholesale and Retail Trade, Restaurants and Hotels, Community, and Social and Personal Services. Employment ( $EMPS_t$ ) is explained by the exchange rate and the employment shift from the manufacturing sector.

$$EMPS_t = EMPS_t(EXR_t, EMPM_t, MB_t) \quad (3.18)$$

$MB_t$  is a barrier to labor mobility which prevents the employment shift.



**Figure 9. Employment sector**

#### 4. Offshoring and deindustrialization

Before proceeding to simulations, it is informative to clear up the issues caused by offshoring. Globalization of production is increasing the pace of deindustrialization while increasing trade and FDI. Many empirical studies investigated the effects of FDI and offshoring. A variety of studies on FDI and associated offshoring considers the positive effects in the home country: domestic employment and labor productivity. However, there is also evidence that FDI or

offshoring is a source of negative effects<sup>13</sup>.

In the postwar North-South trade, South was specializing in labor-intensive manufacturing goods. Facing these cheap imports, North needed to change the industrial structure. Outsourcing of labor-intensive activities previously carried out within the manufacturing sector to countries with cheaper labor. In the 1970s, under the pressure of dollar depreciation, off-shoring was adopted by US manufacturers. This tendency hollowed out the manufacturing sector by closing home factories and removing many employees from the job. Offshoring production was put into practice with large outward FDI.

Although the manufacturing sector in a number of advanced economies experienced the decline in output and employment, it does not mean the decline of the economy as a whole. For example, scaling down of the manufacturing sector in the United States was compensated by the expansion of the service sectors. A shift from the manufacturing sector to the service sector is a typical economic development process, predicted by the Petty-Clark's Law.

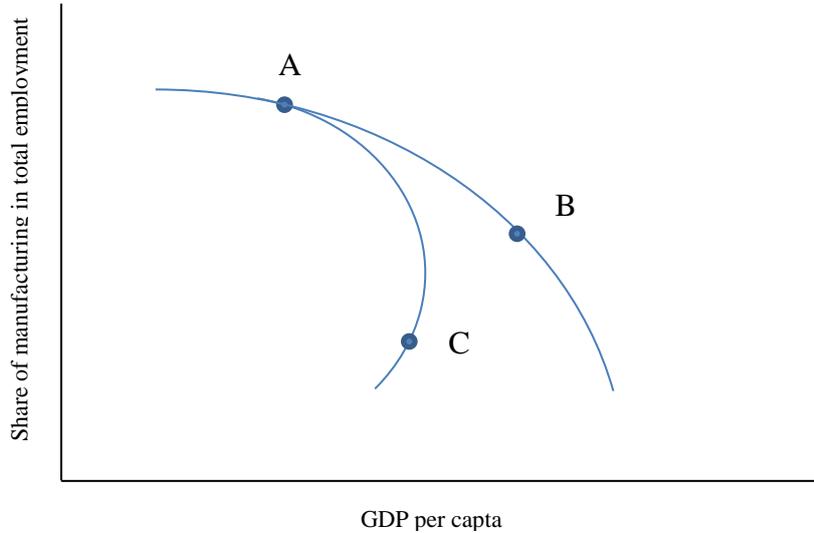
Rowthorn and Wells (1987) examined the merits and demerits of deindustrialization of the economy; they distinguished between deindustrialization explanations that saw it as a positive process of maturity of the economy and those that associated deindustrialization with negative factors like poor economic performance. Positive deindustrialization accompanies full employment and rising real incomes, while negative deindustrialization accompanies rising unemployment and stagnant real incomes. They suggested deindustrialization might be both an effect and a cause of poor economic performance.

Basen and Thirlwall (1992) further explain that the employment in manufacturing declines when rate of growth of output is lower than the rate of labor productivity. If employment is falling because a high rate of growth of productivity is being outstripped by a higher rate of productivity, it is desirable. This is positive deindustrialization. However, if employment is falling because a rate of growth of productivity is being surrendered by a low growth of output, it is not desirable. This is negative deindustrialization.

Figure 10 helps to define deindustrialization. The share of manufacturing is set to the vertical axis and GDP per capita is set to the horizontal axis in Figure 10. Positive deindustrialization occurs when the share of manufacturing in total employment falls because of rapid productivity growth. Economy sustains its growth while displaced labor in the manufacturing sector is absorbed into the non-manufacturing sector. This can be seen by the movement from A to B. On the other hand, negative deindustrialization results from a slow growth or decline in demand for manufacturing output. The labor in manufacturing is displaced in unemployment rather than being absorbed into the non-industrial sector. This is represented by the movement from A to C.

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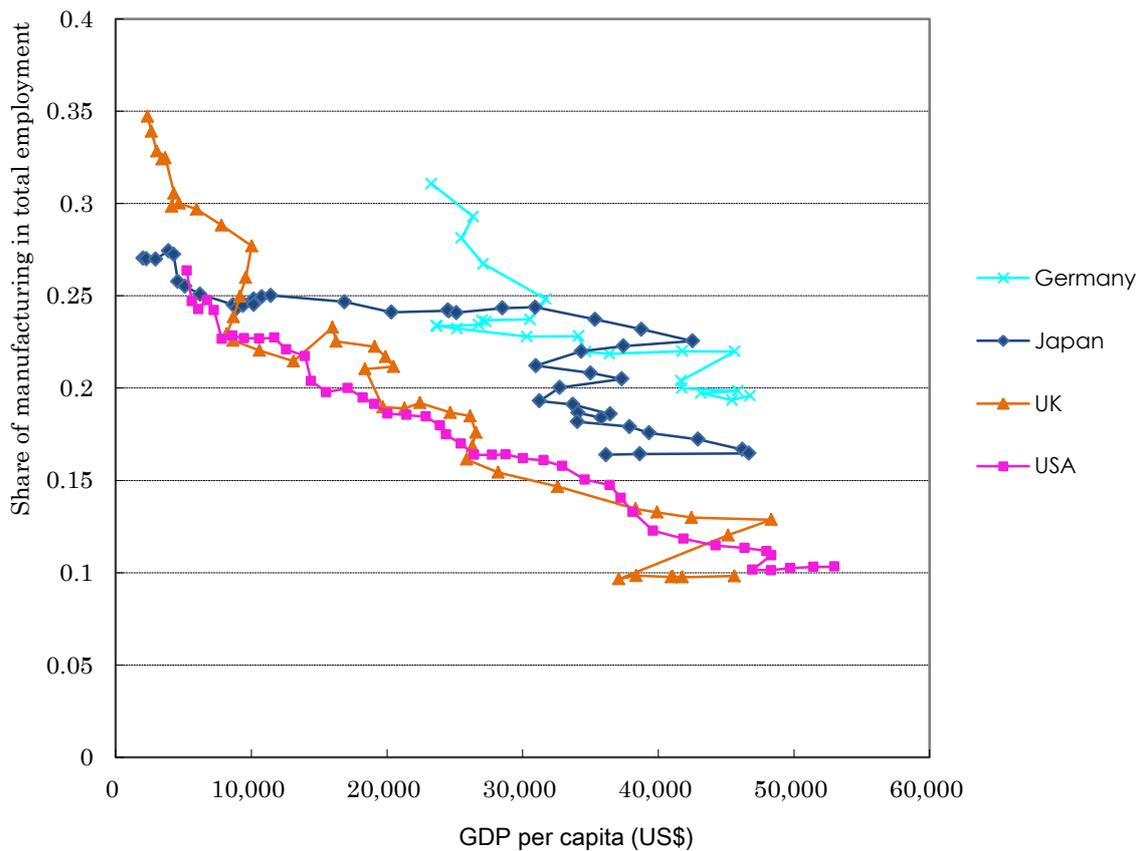
<sup>13</sup> Recent studies such as Tanaka (2012) have found either positive or nonnegative employment effects.



**Figure 10. Positive and negative deindustrialization**

Source: Basen and Thirlwall (1992).

Figure 11 indicates the share of manufacturing in total employment and the GDP per capita in several advanced economies.



**Figure 11. Comparison of deindustrialization (1970-2014)**

Source: Own calculation. Data: ILO, *Labour Statistics*. OECD, *Economic Outlook*.

We can confirm that deindustrialization in the United States is a positive one. The

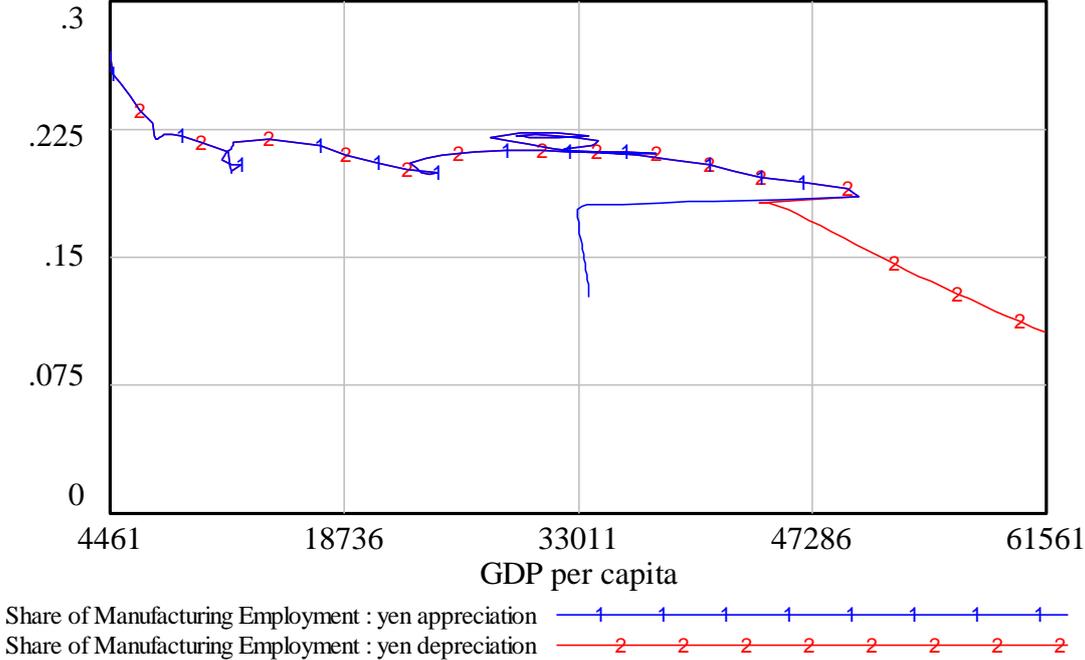
United Kingdom experienced negative deindustrialization phases several times. Recently, Japan experiences negative deindustrialization. Japan experienced negative turns from 1995 to 1998, from 2000 to 2002, from 2004 to 2007, and from 2012. The United Kingdom and the United States experienced negative turn in 2009 presumably due to the bankruptcy of Lehman Brothers.

This criterion serves to evaluate the outcome of offshoring in FDI. In order to overcome this negative deindustrialization or “hollowing out” in Japan, economic policies that shift the exchange rate from weak yen to strong yen, creates new business that absorb the unemployed, and so on are under debate.

**5. Simulation of reshoring**

Let us examine simulations. Based on the data from 1970 to 2013, two scenarios were simulated from 2015 to 2025: yen appreciation<sup>14</sup> and yen depreciation<sup>15</sup>.

Figure 12 indicates the transition of the share of manufacturing in total employment and the GDP per capita (thousand yen). This result explains an important implication for exchange rate policy.



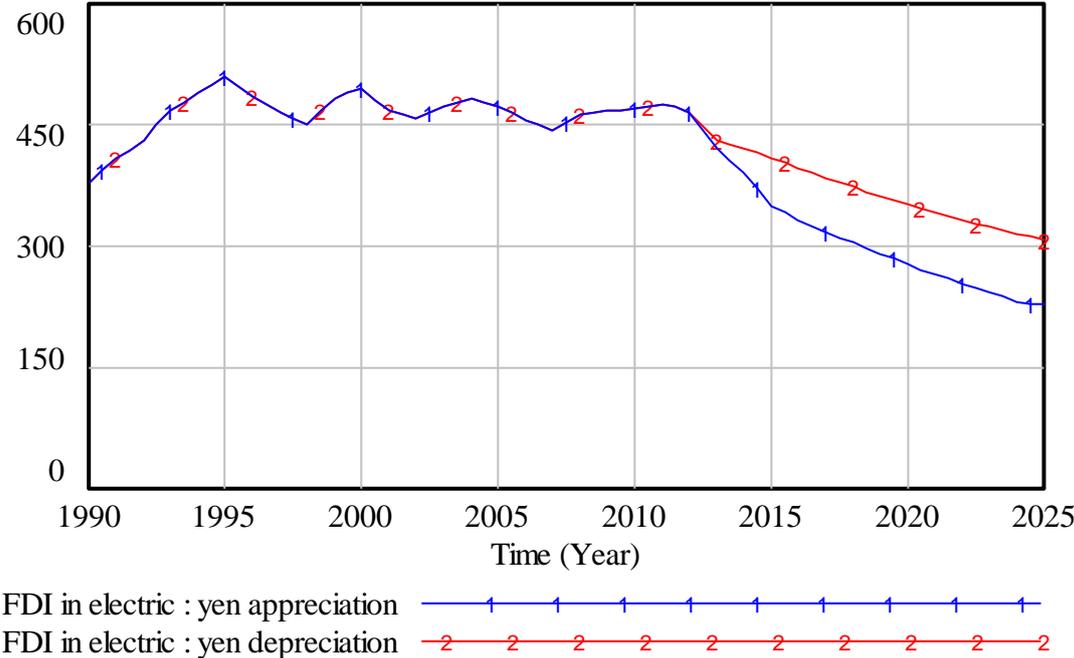
**Figure 12. Exchange rate and deindustrialization**

The share of manufacturing employment falls under the yen depreciation scenario than under

<sup>14</sup> OECD Economic Outlook estimated 77.0 yen to the dollar for 2012 and 2013 in November 2011. Yen appreciation scenario extends this trend using a logarithmic function from 2012 to 2025.  
<sup>15</sup> Several economists, including Minister of Finance Tarō Asō, considered the exchange rate (around 108 yen to the dollar in 2008) before the bankruptcy of Lehman Brothers was a fair rate for Japanese economy. Yen depreciation scenario uses 122 yen to the dollar from 2015 to 2025 adopting several predictions by bankers for 2015.

the yen appreciation scenario. Contrary to the public belief, the policy of letting yen depreciation does not have a beneficial effect on maintaining manufacturing employment. However, yen depreciation brings a successful macroeconomic outcome. GDP per capita is increasing. Yen appreciation scenario brings us a negative deindustrialization, which we examined in the previous section.

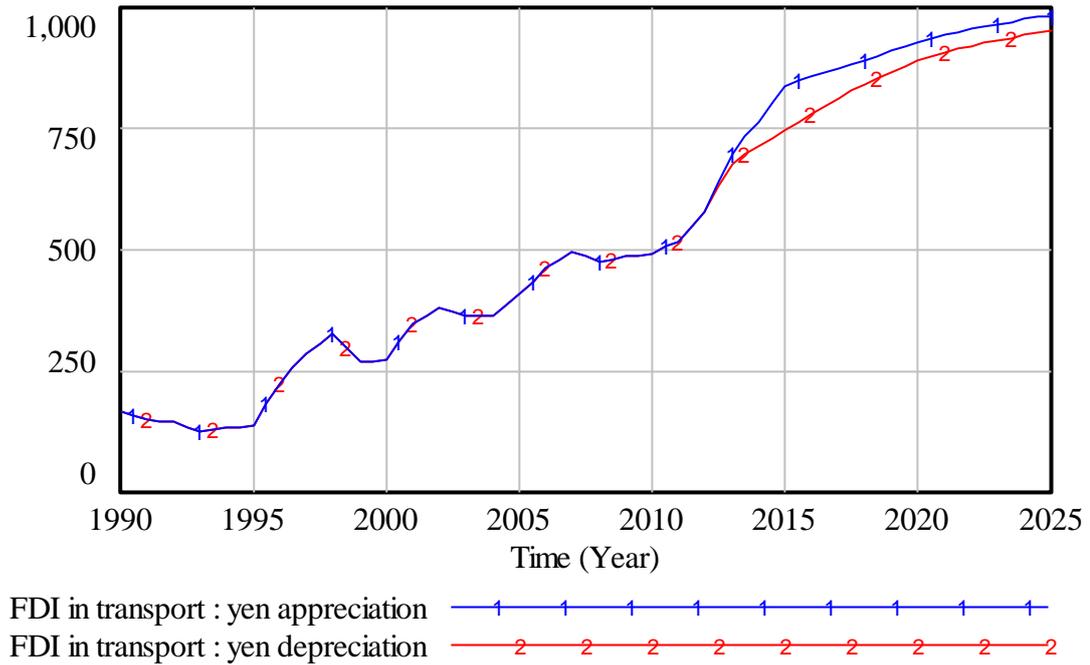
Capital goods or intermediate goods to overseas production bases are essential components of exports under the global supply chains or value chains network. Yen depreciation tones down FDI and decreases these FDI-related exports. Figure 13 and Figure 14 show the different types of offshoring.



**Figure 13. Forecast of FDI in electric machinery industry**

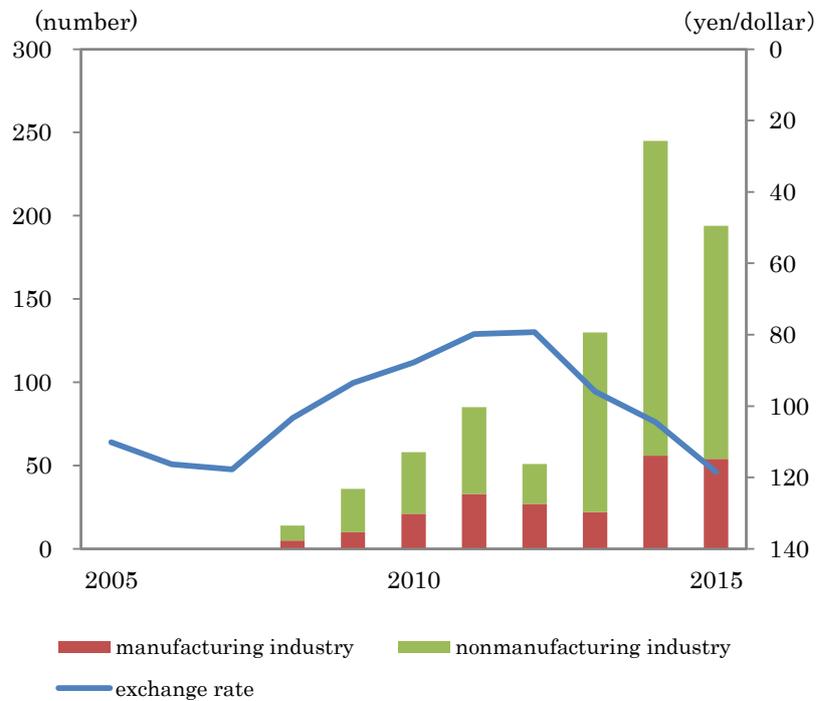
FDI in electric machinery industry was suppressed under yen appreciation. In this industry, both output and employment in 2013 shrink to nearly 60% of those in 1994 while exports increase and imports quadruple. It is clear that exports compensate the loss of domestic sale due to population declines and import competition. Expansion of business depends on exports and offshoring is also depends on exports.

Yen appreciation promoted FDI of the transport equipment industry. In this industry, a basic part of offshoring is the assembly of final products. The appreciation of yen transfers the assembly line to offshore while important intermediate goods are produced at home. This division of labor is the source of the export inducing effect.



**Figure 14. Forecast of FDI in transport equipment industry**

Recently, Teikoku Databank, the Japan’s largest company of corporate credit research, reports the numbers of “strong yen-related bankruptcies” and “weak yen-related bankruptcies.”



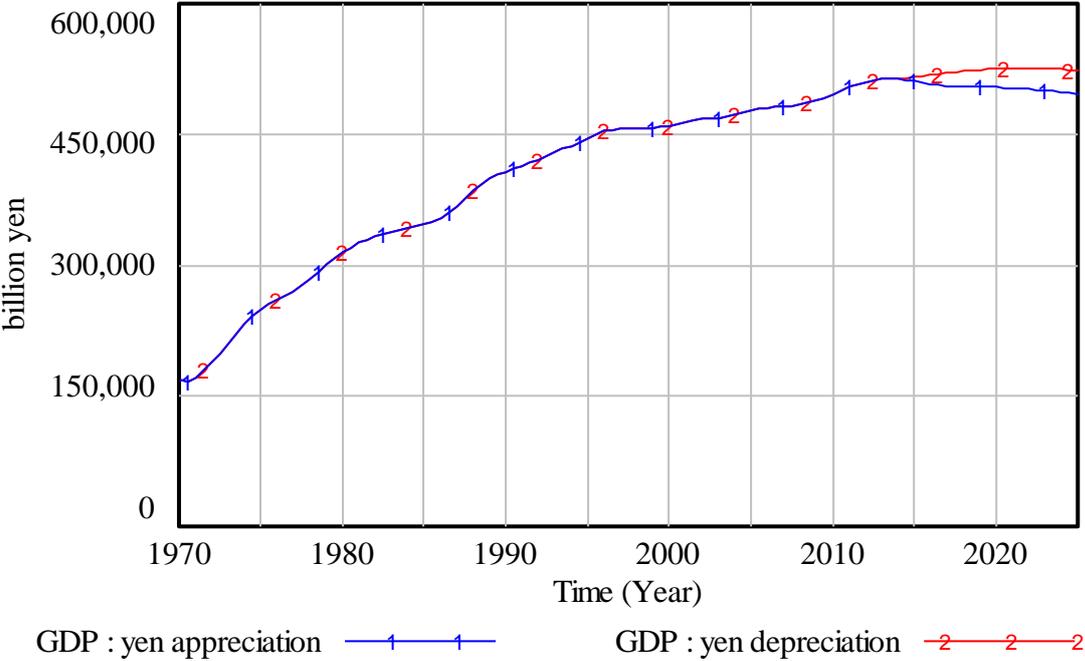
**Figure 15. Exchange related bankruptcies**

Source: Own illustration. Data: Teikoku Databank, every each month

The number of bankruptcies was counted from January to May in 2015.

Bankruptcies are increasing rather than decreasing under the yen depreciation phase. This report is evidence in favor of the simulation in this section.

Obviously, the exchange rate and associated offshoring have significant effects on the home country. Figure 16 shows the forecast of gross domestic product. Yen appreciation is not good for the whole economy unless productivity growth or new promising industry will emerge.



**Figure 16. Forecast of GDP**

**6. Conclusion**

Offshoring in the FDI is not just an extension of international trade, but a more important economic issue. Offshoring has possibilities of a large-scale reallocation of labor in the home country and disruptive effect on nation’s welfare as Blinder (2006) suggested. It is not surprising that results of empirical investigations are modest and ambiguous because those studies are subject to the observation period and types of employment. One way to approach economic problems in a complex environment is thinking in systems. Deindustrialization process led by offshoring is reproduced and examined with system dynamics.

The findings of this paper are summarized as follows:

- 1) Offshoring in FDI has a significant effect on the home country. Offshoring enhanced the pace of deindustrialization.
- 2) Currency appreciation brings negative deindustrialization or hollowing-out.
- 3) Reshoring, associated with home currency depreciation, is effective to escape from the negative deindustrialization.
- 4) Currency intervention designed to weaken the currency is not effective to recover the manufacturing employment under deindustrialization.

Under the highly developed global supply chains or divisions of labor, reshoring cannot

bring back the whole benefit that the home country enjoyed before. Bringing back manufacturing is not as easy as public debates believe. System dynamics approach requires deep thinking about causal sequence behind the economic problems.

At the moment of writing, depreciation of the yen is still proceeding to 125 yen to a dollar. Further studies are needed.

## Appendix: Estimation of equations

A data set was assembled for the years from 1970 to 2013. A value in parentheses under the coefficient is t-distribution,  $R^2$  is a coefficient of determination,  $\bar{R}^2$  a coefficient of determination adjusted for the degrees of freedom.

$$IPE_t = -35887.4996 - 0.6113IPE_{t-1} + 5.8208EXR_t + 0.4788WAPOP_t \quad \bar{R}^2 = 0.9623$$

(-3.050)                      (5.182)                      (1.315)                      (3.154)

$$EXE_t = 21906.0238 - 64.4482EXR_t \quad \bar{R}^2 = 0.7798$$

(22.012)                      (-12.195)

$$IPT_{1970-89} = -7798.4618 - 0.6689IPT_{t-1} + 1.9623FDIM_t + 0.1235WAPOP_t \quad \bar{R}^2 = 0.9491$$

(-1.282)                      (3.292)                      (0.554)                      (1.398)

$$IPT_{1990-2013} = -1653.8654 - 0.0390IPT_{t-1} + 1.6741FDIM_t + 0.1245WAPOP_t \quad \bar{R}^2 = 0.3212$$

(-0.243)                      (-0.202)                      (3.434)                      (1.616)

$$EXT_t = 15223.50 - 34.1255EXR_t + 6.4854FDIT_t \quad \bar{R}^2 = 0.7452$$

(11.077)                      (-5.535)                      (4.536)

$$FDIE_t = -179.9489 + 0.0150IPE_t + 0.0289EXE_t \quad \bar{R}^2 = 0.5322$$

(-2.245)                      (1.524)                      (3.494)

$$FDIT_t = -2212.85189 - 3.5464EXR_t + 394.6506GDP_t/WAPOP_t \quad \bar{R}^2 = 0.5894$$

(-3.922)                      (2.911)                      (5.108)

$$\log(FDIM_t) = 19.1872 - 2.4413\log(EXR_t) \quad R^2 = 0.7909$$

(19.875)                      (-12.792)

$$CP_t = 17595.3987 + 0.5469GDP_t \quad R^2 = 0.9915$$

(5.558)                      (70.858)

$$I_t = 9770.9144 + 0.4986I_{t-1} + 0.6981IME_t + 2.5782IMT_t \quad \bar{R}^2 = 0.9231$$

(2.745)                      (5.582)                      (2.235)                      (3.666)

$$G_t = -468328.864 + 4.5763POP_t \quad R^2 = 0.9470$$

(-22.552)                      (26.755)

$$EX_t = 147593.264 - 122.1479EXR_t + 4.2650FDIM_t - 6.6790EMPM_t \quad \bar{R}^2 = 0.9250$$

(12.209)                      (-17.362)                      (3.805)                      (-8.895)

$$IM_t = -24434.2415 + 3.3736FDIM_t + 1.7818EMPS_t \quad \bar{R}^2 = 0.8873$$

(-3.601)                      (3.252)                      (7.983)

$$EMPT_t = 35863.8897 - 0.0259IM_t + 0.1592IPE_t - 0.2134POP_t \quad \bar{R}^2 = 0.9215$$

(14.602)                      (-3.540)                      (7.259)                      (-8.987)

$$EMPM_t = 5136.4431 + 50.2189EMPME_t - 13.6306EMPMT_t \quad \bar{R}^2 = 0.9730$$

(9.470)                      (29.966)                      (-2.819)

$$EMPME_t = 3.1223 + 0.0103IPE_t + 0.3901EXR_t \quad \bar{R}^2 = 0.7668$$

(14.602)                      (11.422)                      (7.010)

$$EMPMT_t = -27.8290_{(-1.570)} + 0.8511_{(11.800)} EMPMT_{t-1} + 0.0034_{(3.025)} IPT_t + 0.1216_{(3.672)} EXR_t \quad \bar{R}^2 = 0.8321$$

$$EMPS_t = 17612.5149_{(2.989)} - 3.1821_{(-15.520)} EMPMT_{t-1} + 1.2115_{(1.851)} (EMPMT_{t-1} - EMPMT_t) + 0.6280_{(11.673)} WAPOP_t$$

$$\bar{R}^2 = 0.9598$$

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