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Quantitative Evaluation of
Foreign Exchange Intervention
and Sterilization in Japan
—A Flow-of-Funds Approach—

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Abstract

The frequency of foreign exchange intervention by the Ministry of Finance of Japan (MOF) has increased dramatically past two years or three. The Bank of Japan acting as agency of MOF has also intervened in the short term money market by itself, from time to time, to sterilize the yen flooding into it. However, the effectiveness of the operations could be different from one type of operation from the other because the transactions taken place between the monetary authorities and the private sectors are completely different. It is why we have employed Asset-Liability-Matrix (ALM) derived from the flow-of-funds accounts to evaluate the effectiveness of each type of operations. The results can be summarized as follows. 1) Foreign exchange interventions are effective only when the dollar bought in the operation is invested abroad, that is either in the form of U.S. TBs, T-Notes or making deposit in FRB. 2) Only in some cases, sterilization or reverse-sterilization cancels out the effects of foreign exchange interventions. It depends on the type of the operation BOJ chooses. 3) Some type of non-sterilizing money market operation unintentionally cancels out the effects of foreign exchange intervention. The conclusion is that the effectiveness of the foreign exchange interventions as well as the money market operations largely depends on the type of the operations, so that it is worthless to examine the effectiveness of the operations without going into the details.

Key Words

Foreign exchange intervention; sterilization; monetary policy; flow-of-funds;
Asset-liability-matrix

JEL Classification Numbers

F31; E58; C67

1. Introduction

The frequency of foreign exchange intervention by the Ministry of Finance of Japan (MOF) has increased dramatically past two years or three. Especially in 2003, MOF intervened in the market as many as 90 times with a total amount of 20 trillion yen or 190 billion dollars between January and December to cope with the strengthening of Japanese yen (JPY) under the recession worst than ever. The Bank of Japan (BOJ) acting as agency of MOF also intervenes in the short term money market by itself, from time to time, to sterilize the yen flooding into it. Prof. Koichi Hamada of Yale University criticised BOJ of this kind of simultaneous operation, saying that its left hand is cancelling out what its right hand is doing. BOJ fought back at this allegation with conventional weapons like the Mundell-Fleming Model and so forth.

As Lewis (1995) pointed out, the question of how sterilized interventions could affect the exchange rate had been the focus of a great deal of attention in both academic and policy making circles since 1970's. For example, Rogoff (1984), Lewis (1988) and others find no evidence of a portfolio balance channel, through which sterilized intervention changes the currency denomination of relative asset supplies. However, Dominguez and Frankel (1993) showed that there are statistically significant effects of FRB and Bundesbank intervention on exchange rates through the portfolio channel during the mid-1980's. More than decades later, the controversy is still going on. In recent days, the purely empirical studies including event analysis are dominating the argumentation in this field. Fatum and Hutchison (2003) provide evidence supporting the effectiveness of sterilized foreign exchange intervention using the non-parametric sign test and matched sample test.

However, this kind of investigation is overlooking the details of the execution of both foreign exchange interventions and money market operations. For example, on some occasions the dollar bought by the Japanese monetary authorities is spent to purchase U.S. TBs or T-notes. On other occasions, the authorities make a deposit in Japanese domestic banks with the U.S. dollar (USD). The measure to raise the necessary funds in yen is another problem. In usual cases they raise new money in the market by issuing Financial Bills (FBs). However whenever there is a surplus in other departments of the government, MOF tries to borrow the money within the circle of the government privately to avoid the necessary payment of interest.

The definition of the sterilization could be different in these two cases. When the foreign exchange intervention is financed by the issuance of FBs, BOJ purchases them anyway and think if it should sterilize it or not afterwards. If BOJ believe it is appropriate to sterilize the JPY flooded by the foreign exchange intervention, BOJ

would either sell the FBs themselves or else, sell some of the TBs in its possession. In the second case, when MOF raise JPY from other government departments, the foreign exchange intervention is financed by JPY withdrew from the government current account at BOJ. If this is the case, the option left to BOJ is either selling some assets allowing the central bank balance sheet to shrink, or else raising funds by drawing a self-addressed bill. In the sense that BOJ tries to keep the size of its own balance sheet at the level before the foreign exchange intervention, we will call the latter operation *reverse-sterilization*.

Furthermore, the effectiveness of both foreign exchange interventions and money market operations could be different from one type of operation from the other because the transactions taken place between the monetary authorities and the private sectors could be completely different in each case. It is why we are to employ Asset-Liability-Matrix (ALM) derived from the flow-of-funds accounts in this experimental treatise. It is an attempt to apply the concept of Leontief inverse to the ALM originally proposed by Stone (1966) and Klein (1983). Since the Flow-of-Funds Accounts is a collection of balance sheets of economic principals, by translating those balance sheets into ALM that is a sector-by-sector matrix, we are able to calculate the induced effects of the operations on the cross-boarder inflow and/or outflow of capital by application of Leontief inverse commonly used in input-output analysis. In our previous study, we were successful to employ ALM to examine the effectiveness of the money market operations under zero-interest-rate. (See Tsujimura and Mizoshita (2003).) The scheme employed in this tract to evaluate the effects of the foreign exchange intervention and accompanying sterilization is an analogy to this.

2. The Operation Procedures

2.1. Foreign Exchange Interventions

Before going any further, we have to discuss the details of the execution procedures of the foreign exchange interventions practised by the Japanese monetary authorities. In Japan, the foreign exchange interventions are exercised by BOJ by the name of the Finance Minister who is representing the Japanese government. For example, whenever the monetary authorities believe it is appropriate to sell JPY against USD, the first step is to raise JPY either in the market by issuing FBs or to finance it privately in the government circle. In both cases, the transactions are registered on the liabilities side of the balance sheet of the government foreign exchange funds (GFEF). Those two ways of raising money are indifferent up to this point. However, when we look at the balance sheet of BOJ (putting the GFEF aside), the differences are obvious.

Although in case of today's Japan, FBs are issued directly to the market periodically according to prefixed schedule, BOJ accepts the FBs issued in the course of foreign exchange interventions because it is considered as an unpredictable events. This results in the expansion of the size of the balance sheet of the central bank beyond its intended level. In contrast to this, whenever there is a surplus in the government funds, the money will be simply transferred from the government's current accounts at BOJ to GFEF. This would result in an unintended contraction of the size of the BOJ's balance sheet rather than in an expansion.

As the second step, the monetary authorities purchase USD in the market against the JPY obtained in the aforementioned procedures. These transactions are not settled until 'tomorrow next' or $t+2$ when the currencies actually change hands. There are several options to employ the USD purchased in the foreign exchange interventions. The most widely used way of employment is to purchase USD denominated securities such as TBs. The alternatives include deposits with foreign central banks (most probably the FRB) or international financial institutions (BIS etc.). However, most recent days, it is monetary authority's favourite to employ the USD in the form of deposits with the banks located in Japan. Although some of these banks are headquartered outside Japan, a considerable proportion of the deposits are with big name domestic commercial banks straggling to rid of the financial crunch. These USD denominated items are registered on the asset side of the balance sheet of GFEF comprising a principal part of the huge pile of the Japanese international reserves.

2.2. Money Market Operations and Sterilization

As BOJ pointed out in the counterargument against Professor Hamada, it is rather difficult to find material counterparts of sterilization than to define it theoretically. BOJ conducts a variety of money market operations from day to day. Nobody can tell which part of the operations is meant for sterilization because BOJ never make announcements of such kind. The only option left for an observer is to summarize the BOJ operations and tell if it has actually sterilized the foreign exchange interventions or not. Generally speaking, the money market operations of the central banks could be categorized into two main divisions. The first kind is those operations designed to supply liquidities to the private sector. The second sort is the device designed to absorb funds from the private sector. In the usual sense, sterilization mean to absorb the country's own currency flooded by the foreign exchange interventions, so that it is a general idea that sterilization is more closely related to the latter sort of operations. However, when we take reverse-sterilization in mind, the former kind could play

equally important role.

As for BOJ, liquidity-supplying operations include Lombard-type lending facilities, outright purchases of TBs/FBs, purchases of securities under repurchase agreements, outright purchases of commercial bills, purchases of CPs under repurchase agreements, and outright purchases of ABSs. Fund absorbing operations include outright sales of TBs/FBs, sales of securities under repurchasing agreements, and outright sales of bills drawn by BOJ. However it should be noted that the categorization mentioned here has only relative meaning. For example, 'purchases of commercial bills' create shortages of funds rather than surplus in the private sector when they arrive at maturity. All the itemized operations, with few exceptions, could be used for both liquidity supplying and fund absorbing purposes.

In Fig.1, some typical examples of sterilization as well as reverse-sterilization in case of JPY selling foreign exchange interventions are depicted. The upward arrows in the figure mean an increase while the downward ones mean a decrease of the particular items on the balance sheets of GFEF and BOJ.

(a- i) Non-sterilization.

GFEF purchase USD against the JPY obtained by issuance of FBs. The FBs are accepted directly by BOJ, which has obtained funds by selling bills drawn by itself. In this case, the size of the balance sheet of BOJ is expanded.

(a- ii) Sterilization.

GFEF purchase USD against the JPY obtained by issuance of FBs, just like as the former case. The FBs are accepted directly by BOJ as well. The difference is that BOJ raise the necessary funds by selling TBs/FBs of its possession. In this case, the size of the balance sheet of BOJ is unchanged.

(b- i) Reverse-non-sterilization.

GFEF purchase USD against the JPY borrowed from other departments of the government. Since, as a result, the balance of the current accounts held by the government decrease, BOJ is forced to sell some of the TBs/FBs of its possession. In this case, the size of the balance sheet of BOJ contracts accordingly.

(b- ii) Reverse-sterilization.

GFEF purchase USD against the JPY borrowed from other departments of the government, just like as the former case. Since the balance of the current accounts held by the government decrease, BOJ raises funds by selling bills drawn by itself to offset it. In this case, the size of the balance sheet of BOJ is unchanged.

3. Data

3.1. Asset-Liability-Matrix

BOJ publishes *Flow of Funds Accounts of Japan* quarterly. It contains three tables: (1) financial transactions, (2) financial assets and liabilities, (3) reconciliation between flows and stocks. The ALM used in this paper has been compiled from the financial assets and liabilities tables of the flow-of-funds accounts from December 2000 through March 2003 every three month. Only the summary of compilation procedure from flow-of-funds Accounts to ALM is shown here, so refer to Tsujimura and Mizoshita (2003) for details. We start from two tables E and R, which are constructed by picking out the assets and liabilities vectors separately from the balance sheets of the flow-of-funds accounts. Fig.2 presents components of the E and R tables.

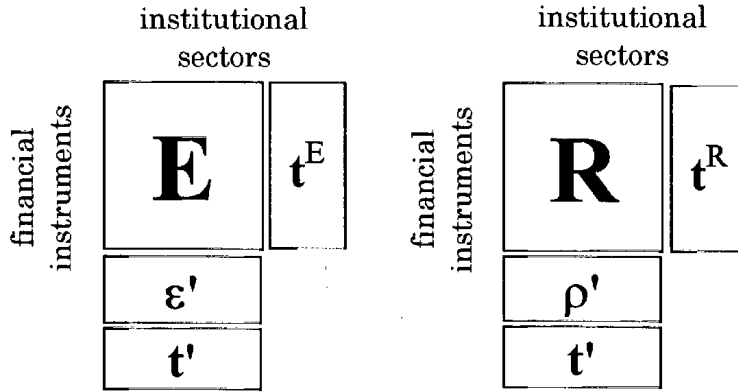


Figure 2 Components of E and R tables

\mathbf{E} is a matrix that shows the portfolio of fund-employment of each institutional sector, $\boldsymbol{\varepsilon}$ and \mathbf{t}^E are vectors that represent excess liabilities and the sum of each row, respectively. \mathbf{t} is the vector that consists of either sum of assets or liabilities, whichever is larger.

$$\mathbf{E} = \begin{bmatrix} e_{11} & e_{12} & \cdots & e_{1m} \\ e_{21} & e_{22} & \cdots & e_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ e_{n1} & e_{n2} & \cdots & e_{nm} \end{bmatrix} \quad \boldsymbol{\varepsilon} = \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \varepsilon_m \end{bmatrix} \quad \mathbf{t}^E = \begin{bmatrix} t_1^E \\ t_2^E \\ \vdots \\ t_n^E \end{bmatrix} \quad \mathbf{t} = \begin{bmatrix} t_1 \\ t_2 \\ \vdots \\ t_m \end{bmatrix}$$

where, n denotes the number of financial instruments and m denotes the number of institutional sectors. \mathbf{R} is a matrix showing the portfolio of fund-raising of each institutional sector, and $\boldsymbol{\rho}$ and \mathbf{t}^R are vectors that represent excess assets and the sum of each row, respectively.

$$\mathbf{R} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{bmatrix} \quad \boldsymbol{\rho} = \begin{bmatrix} \rho_1 \\ \rho_2 \\ \vdots \\ \rho_m \end{bmatrix} \quad \mathbf{t}^R = \begin{bmatrix} t_1^R \\ t_2^R \\ \vdots \\ t_n^R \end{bmatrix} \quad \mathbf{t} = \begin{bmatrix} t_1 \\ t_2 \\ \vdots \\ t_m \end{bmatrix}$$

It is possible to make out two sheets of square matrix, the ALM, using E and R tables in alternative procedures. One is the Y table based on the fund-raising portfolio, the other is Y* table based on fund-employment portfolio. Superscript * denotes the case of fund-employment assumption. To compile the Y-table in accordance with the fund-raising portfolio, first matrix \mathbf{R} is substituted for matrix \mathbf{U} and the transposed matrix \mathbf{E}' is substituted for \mathbf{V} .

$$\mathbf{U} \equiv \mathbf{R} \quad (1)$$

$$\mathbf{V} \equiv \mathbf{E}' \quad (2)$$

In the case of the Y*-table that represents the fund-employment portfolio, we take matrix \mathbf{E} as \mathbf{U}^* and \mathbf{R}' as \mathbf{V}^* .

$$\mathbf{U}^* \equiv \mathbf{E} \quad (3)$$

$$\mathbf{V}^* \equiv \mathbf{R}' \quad (4)$$

Each element of the coefficient matrices \mathbf{B} and \mathbf{B}^* are defined as follows:

$$b_{ij} = \frac{u_{ij}}{t_j} \quad (5)$$

$$b_{ij}^* = \frac{u_{ij}^*}{t_j} \quad (6)$$

In the same manner, each element of the coefficient matrices \mathbf{D} and \mathbf{D}^* are defined as follows:

$$d_{ij} = \frac{v_{ij}}{t_j^E} \quad (7)$$

$$d_{ij}^* = \frac{v_{ij}^*}{t_j^R} \quad (8)$$

The $m \times m$ coefficient matrices \mathbf{C} and \mathbf{C}^* are estimated using the institutional sector portfolio assumption.

$$\mathbf{C} = \mathbf{DB} \quad (9)$$

$$\mathbf{C}^* = \mathbf{D}^*\mathbf{B}^* \quad (10)$$

Then each element of transaction quantity matrices Y and Y^* are obtained as follows,

$$y_{ij} = c_{ij}t_j \quad (11)$$

$$y_{ij}^* = c_{ij}^*t_j \quad (12)$$

Since GFEF and BOJ change their own portfolio with the intention of working to stabilize the market, it is necessary to treat both of them as exogenous variables as to examine the effect of foreign exchange interventions and sterilization. Moreover the ALM includes overseas as an endogenous sector so that the amount of induced flow of funds to and from the sector indicate the marginal volume of funds traded between Japan and the rest of the world. We regard the induced flow of funds to the overseas sector in the Y -table as Japanese demand of funds from abroad. Likewise, we regard the induced flow of funds to the overseas sector in the Y^* table as Japanese supply of funds to abroad.

The component of Y and Y^* tables are depicted in Fig.3. Y is a matrix that shows the transactions of funds between institutional sectors, ε and ρ are vectors that represent excess liabilities and excess assets, respectively. t is the vector that consist of either sum of assets or liabilities, whichever is larger. Furthermore vector ε_B and vector ε_F denote how much funds BOJ and GFEF raise from other institutional sectors. In opposition to that, funds employment of BOJ and GFEF are marked as ρ_B and ρ_F . Y and Y^* tables are just like two sides of the same coin, that is, matrix Y^* is same as transposed matrix Y and the vectors ε and ρ , ε_B and ρ_B , ε_F and ρ_F are situated symmetrically.

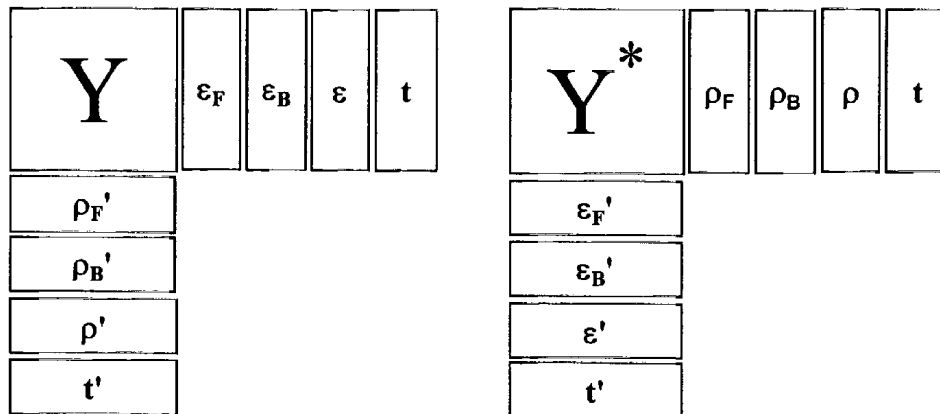


Figure 3 Components of Y and Y^* tables

3.2. Balance Sheet of the Government Foreign Exchange Funds

The figures of the asset portfolio of government foreign exchange funds could be obtained from *International Reserves Statistics* published by MOF monthly. Likewise, the figures of the liability portfolio are found in the *Quarterly Report of the Treasury* also issued by MOF. Table1 shows the balance sheet of GFEE. Six new financial instruments are added to the original flow-of-funds accounts to accommodate these items.

Table1 Balance sheet of GFEE

Assets	Liabilities
Deposits with domestic banks located in Japan	Borrowing from other government departments
Deposits with foreign banks located in Japan	FB
Deposits with foreign central banks and BIS	
Foreign currency denominated securities	
IMF reserve position and SDR	

3.3. The Balance Sheet of the Bank of Japan

Table2 presents the balance sheet of BOJ. No major changes are required in this aspect because BOJ publish its own balance sheet in part of the flow of funds accounts.

Table2 Balance sheet of BOJ

Assets	Liabilities
Deposits with foreign central banks and BIS	Banknotes in circulation
Loans to private financial institutions	Current accounts held by financial institutions
Bills purchased	Current accounts held by the government
Securities under resell agreement	Bills sold
FB*	Securities under repurchase agreement
JGB*	Other corporate stocks

ABS, ABCD	Earnest money
Listed corporate stocks	External debts
Other corporate stocks	
Earnest money	
Foreign investment in securities	
Foreign investment in securities held by foreign exchange special accounts	
External claims	
IMF reserve position and SDR	
Others	

Note: * TB is removed from JGB and added to FB.

4. Methodologies

4.1. Evaluation of Foreign Exchange Interventions

It is necessary to deal with both GFEEF and BOJ as exogenous institutional sectors in order to analyze the effects of the changes in their portfolio by estimating the induced international inflow and outflow of capital by way of Leontief inverse. As mentioned earlier, there are two kinds of ALM, one is Y table and the other is Y* table. The former is based on the fund-raising portfolio assumption expressed as follows:

$$c_{ij} = \frac{y_{ij}}{t_j} \quad (13)$$

and the latter is based on the fund-employment portfolio assumption expressed as follows:

$$c_{ij}^* = \frac{y_{ij}^*}{t_j} \quad (14)$$

The fundamental equations respect to Y and Y* tables depicted in Fig.3 are as follows:

$$\mathbf{C} \cdot \mathbf{t} + \boldsymbol{\varepsilon} + \boldsymbol{\varepsilon}_F + \boldsymbol{\varepsilon}_B = \mathbf{t} \quad (15)$$

$$\mathbf{C}^* \cdot \mathbf{t} + \boldsymbol{\rho} + \boldsymbol{\rho}_F + \boldsymbol{\rho}_B = \mathbf{t} \quad (16)$$

Solving each equation for t yields

$$\mathbf{t} = (\mathbf{I} - \mathbf{C})^{-1} (\boldsymbol{\varepsilon} + \boldsymbol{\varepsilon}_F + \boldsymbol{\varepsilon}_B) \quad (17)$$

$$\mathbf{t} = (\mathbf{I} - \mathbf{C}^*)^{-1} (\boldsymbol{\rho} + \boldsymbol{\rho}_F + \boldsymbol{\rho}_B) \quad (18)$$

where $(\mathbf{I} - \mathbf{C})^{-1}$ is the Leontief inverse matrix, by which we can calculate the amount of ultimately induced demand for funds. $\boldsymbol{\varepsilon}_F$ and $\boldsymbol{\varepsilon}_B$ are vectors of liabilities held by

GFEF and BOJ respectably. From the viewpoint of the non-financial economy, the induced demand for the funds means the gross induced savings (GIS), the amount of new savings required. $(\mathbf{I}-\mathbf{C}^*)^{-1}$ is the Leontief inverse matrix, by which we can calculate the amount of ultimately induced supply of funds. $\boldsymbol{\rho}_F$ and $\boldsymbol{\rho}_B$ are assets vectors where an element denotes the financial instrument held by GFEF and BOJ, respectively. The induced supply of funds refers to the gross induced investment (GII) that enables us to make still more investments. For simplification let us denote $(\mathbf{I}-\mathbf{C})^{-1}$ as $\boldsymbol{\Gamma}$ and $(\mathbf{I}-\mathbf{C}^*)^{-1}$ as $\boldsymbol{\Gamma}^*$.

4.2. Simulation Procedure of Foreign Exchange Interventions and the Sterilization

The effects of the foreign exchange interventions and the money market operations could be evaluated using the Leontief inverse matrix as mentioned above. Let subscript t be period, for example $\boldsymbol{\varepsilon}_{F,t}$ mean the vector of liabilities held by GFEF at period t .

The quarterly changes in both assets and liabilities are presented as follows:

$$\Delta\boldsymbol{\varepsilon}_F = \boldsymbol{\varepsilon}_{F,t} - \boldsymbol{\varepsilon}_{F,t-1} \quad (19)$$

$$\Delta\boldsymbol{\varepsilon}_B = \boldsymbol{\varepsilon}_{B,t} - \boldsymbol{\varepsilon}_{B,t-1} \quad (20)$$

$$\Delta\boldsymbol{\rho}_F = \boldsymbol{\rho}_{F,t} - \boldsymbol{\rho}_{F,t-1} \quad (21)$$

$$\Delta\boldsymbol{\rho}_B = \boldsymbol{\rho}_{B,t} - \boldsymbol{\rho}_{B,t-1} \quad (22)$$

Given $\Delta\boldsymbol{\varepsilon}_F$, and $\Delta\boldsymbol{\rho}_F$ exogenously, the induced savings and the induced investments brought by foreign exchange interventions are calculated as follows:

$$\mathbf{s}_F = \boldsymbol{\Gamma} \Delta\boldsymbol{\varepsilon}_F \quad (23)$$

$$\mathbf{h}_F = \boldsymbol{\Gamma}^* \Delta\boldsymbol{\rho}_F \quad (24)$$

where each element of vector \mathbf{s}_F means the amount of funds raised from each sector, when the foreign exchange interventions are financed by issuance of FB and so on. On the other hand each element of vector \mathbf{h}_F is the amount of funds supplied to each sector, when official reserve assets increase. What we have to attend on is cross-boarder inflow and outflow of capital, so overseas sector is most important of all. Let subscript w be the overseas sector, then $s_{F,w}$ is the marginal induced inflow of capital (IIC) into

Japan and $h_{F,w}$ is the induced outflow of capital (IOC) from Japan caused by the

foreign exchange interventions.

In the same way, the induced savings and the induced investments created by the money market operations are calculated as follows:

$$\mathbf{s}_B = \Gamma \Delta \boldsymbol{\varepsilon}_B \quad (25)$$

$$\mathbf{h}_B = \Gamma^* \Delta \boldsymbol{\rho}_B \quad (26)$$

where each element of vector $s_{B,w}$ is IIC brought by the changes in the liabilities of the BOJ, each element of vector $h_{B,w}$ is IOC brought by the changes in the assets of the BOJ.

5. The Results

5.1. Capital Inflow and Outflow Induced by Foreign Exchange Interventions

The fluctuations in the cross-boarder inflow and outflow of capital directly or indirectly induced by the foreign exchange interventions (as well as other factors included in the balance sheet of GFEEF) are depicted in Fig.4. The pillars indicate both gross inflow (upwards) and outflow (downwards) of capital while the solid line marks the net inflow of capital. The relations between the net outflow of capital and the foreign exchange interventions are depicted in Fig.5. The first observation is that there is a positive correlation between the amount of foreign exchange interventions and the capital outflow toward abroad. Actually, the correlation coefficient is 0.858 and we can comfortably reject the null-hypothesis that there is no correlation between the two figures. However, a careful observer will notice that capital outflow is positive even in the period where no intervention has taken place. This is because the monetary authorities sometimes reshuffle the portfolio of international reserves for various reasons. Another typical observation is that the net induced capital outflow is no bigger than the amount of the intervention itself. Actually, in some cases, the induced outflow of capital is less than the amount of foreign exchange intervention itself. This is partially because that the fund raising operations by GFEEF inevitably creates gross capital inflow rather than outflow. Most casual observations tell that the purchase of foreign currency denominated securities create most of the net induced capital outflow.

In Table3, the net induced capital outflow created by a unit change in each item included in the balance sheet of GFEEF is listed. The last three columns are mean, standard deviation and coefficient variation, respectively. The coefficient variations for all financial instruments are under 0.15, so it can be said that IIC and IOC are

generally stable during the observation period. According to this table, foreign exchange interventions could create net induced capital outflow because the per-unit gross induced capital outflow produced by the fund employment of GFEF exceed the per-unit inflow produced by the fund raising. Both the issuance of FBs and the borrowing from the other departments of the government produce relatively small amount of inflow of capital from abroad. In contrast to this, purchases of foreign currency denominated securities and deposits with foreign central banks yield considerable amount of outflow of capital toward abroad, both directly and indirectly. However, an alternative way of fund employment, the deposits with both foreign and domestic banks located in Japan produce only a small amount of capital outflow that is merely sufficient to offset the capital inflow produced by the fund raising activities.

5.2. The Effects of Sterilization

In Fig.6, the net capital outflow induced by foreign exchange interventions as well as money market operations of BOJ is depicted. The dark portion of the pillar indicate the net inflow produced by the foreign exchange interventions while the light portion indicate the net inflow produced by the BOJ money market operations. The solid line marks the net inflow of capital combined. The Xs in the figure indicate that foreign exchange interventions have exercised during the period. In case of the third quarter of 2001, the foreign exchange interventions brought net capital outflow while the effects of the BOJ money market operations were neutral. In that sense, we can call it non-sterilization. Rather, it is reverse-non-sterilization because, in this quarter, GFEF borrowed money from other departments of the government. On the other hand, in case of the second quarter of 2002, the foreign exchange interventions created net capital outflow while BOJ money market operations produced net inflow. We can call this sterilization because, in this quarter, government foreign exchange funds raised funds by means of issuance of FB. Another typical example is the second quarter of 2003 when the capital inflow created by the money market operations completely offset the capital outflow created by the interventions. We call it sterilization because the government foreign exchange funds raised funds through issuance of FB on this occasion. No typical case of reverse-sterilization was found throughout the observation period.

In Fig.7, the decomposition of the net capital inflow or outflow produced by the BOJ operations is depicted. Each segment of the pillar indicates either inflow (upward) or outflow (downward) of capital induced by the changes in particular items of the BOJ balance sheet. In case of the second quarter of 2002, the decrease in the bills purchased as well as in the securities purchased under resale agreement is the dominant factor of

the sterilization. As for the second quarter of 2003, the increase in the current accounts held by the financial institutions is playing equally important role in the process of sterilization. In the first quarter of 2003, the decrease in the bills sold and the increase in the bills purchased as well as the securities under resale agreement contributed to boost the capital outflow even further in assistant to the foreign exchange interventions. These observations tell us that BOJ is not acting positively in the course of sterilization, rather it produce sterilization more or less in passive manners. Since BOJ is conducting various money market operations day to day, it can sterilize the foreign exchange interventions, for example, simply by not purchasing additional bills when some of them in possession reach maturity.

In Table4, the outcome of sterilization as well as non-sterilization is listed for each money market operation devices. Those items in the parentheses are not readily changeable intentionally by BOJ, so just for reference. In case of non-sterilization, the net capital inflow is positive for most operation devices, contrary to common sense. Only when bills are sold to finance the acceptance of FBs issued by GFEF, the net inflow of capital from abroad is negative, that is net capital outflow takes place. In case of sterilization, net capital inflow is positive for any operation devices, so to offset the outflow induced by the foreign exchange interventions. In case of reverse-non-sterilization, net capital inflow is negative for the sale of TB/FB leaving the capital outflow created by the foreign exchange intervention as it is. In case of reverse-sterilization, all the operation devices but sale of bills give positive net capital inflow as expected.

6. The Conclusions

As we have already discussed, foreign exchange interventions and sterilization could be divided into many cases. The operation devices employed could be different from one occasion to another. On some occasions the dollar bought by the Japanese monetary authorities is spent to purchase U.S. TB's or T-notes. On other occasions, the authorities make a deposit in Japanese domestic banks with the dollar. The measure to raise the necessary funds in yen is another problem. In usual cases they raise new money in the market by issuing FBs. However whenever there is a surplus in other departments of the government, MOF tries to borrow the money within the circle of the government privately to avoid the necessary payment of interest.

The definition of the sterilization could be different in these two cases. When the foreign exchange intervention is financed by the issuance of FBs, BOJ purchase them anyway and think if it should sterilize it or not afterwards. If BOJ believe it is

appropriate to sterilize the yen flooded by the foreign exchange intervention, BOJ might draw a bill by itself to absorb the yen. In the second case, when government foreign exchange funds raise yen from other government departments, the foreign exchange intervention is financed by the yen withdrawn from the government current account at BOJ. If this is the case, the option left to BOJ is either selling some assets allowing the central bank balance sheet to shrink, or else raising funds by drawing a self-addressed bill. In the sense that BOJ try to keep the balance sheet at the level before foreign exchange intervention, we call the latter operation *reverse-sterilization*.

The effectiveness of the aforementioned operations is different from one type of operation from the other because the transactions taken place between the monetary authorities and the private sectors are completely different. The results can be summarized as follows. 1) Foreign exchange interventions are effective only when the dollar bought in the operation is invested abroad, that is either in the form of U.S. TBs, T-Notes or making deposits in FRB. 2) Only in some cases, sterilization or reverse-sterilization cancels out the effects of foreign exchange intervention. It depends on the type of the operation BOJ chooses. 3) Some type of non-sterilizing money market operation unintentionally cancels out the effects of foreign exchange intervention. The conclusion is that the effectiveness of the foreign exchange interventions as well as the money market operations largely depends on the type of the operations, so that it is worthless to examine the effectiveness of the operations without going into the details.

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Figure 1 Classification of non-sterilization and sterilization

(a) Raising funds by the issuance of FBs

(i) Non-sterilization

GFEF	Foreign reserves ↑	FB ↑
		BOJ
		FB ↑
		Bills sold ↑

(ii) Sterilization

GFEF	Foreign reserves ↑	FB ↑
		BOJ
		FB ↑
		TB ↓

(b) Raising funds privately in the government circle

(i) Reverse-non-sterilization

GFEF	Foreign reserves ↑	Borrowing from other government departments ↑
		BOJ
		TB ↓
		Current account held by the government ↓

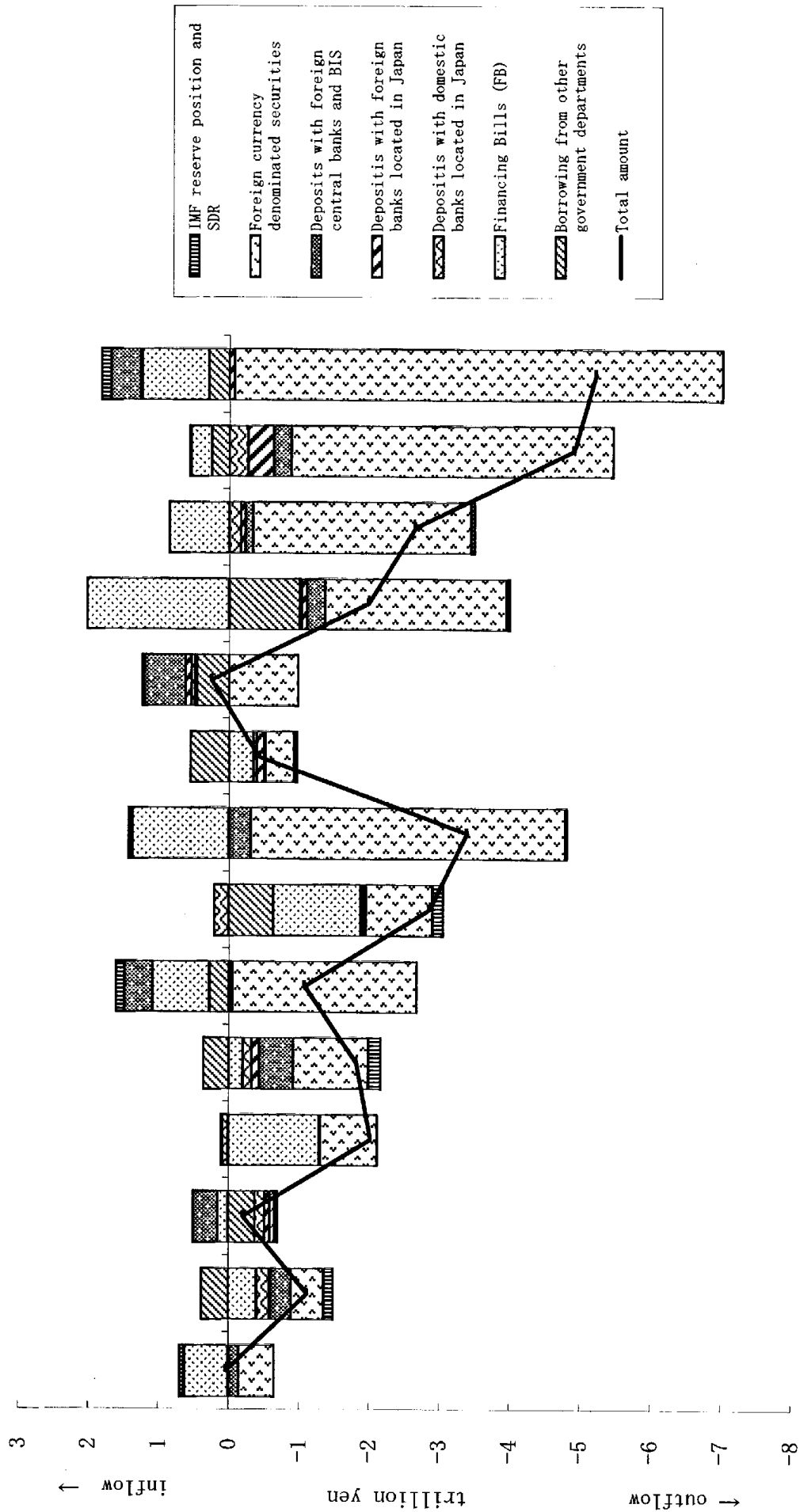
(ii) Reverse-sterilization

GFEF	Foreign reserves ↑	Borrowing from other government departments ↑
		BOJ
		Current account held by the government ↓
		Bills sold ↑

Note 1: The sign ↑ means increase and ↓ means decrease.

Note 2: Borrowing from other government departments in GFEF results in the decrease of current account held by the government

Figure 4 The fluctuations in the cross-boarder inflow and outflow of capital induced by the foreign exchange interventions



Sep-00 Dec-00 Mar-01 Jun-01 Sep-01 Dec-01 Mar-02 Jun-02 Sep-02 Dec-02 Mar-03 Jun-03 Sep-03 Dec-03

Figure5 Foreign exchange interventions and net induced outflow of capital

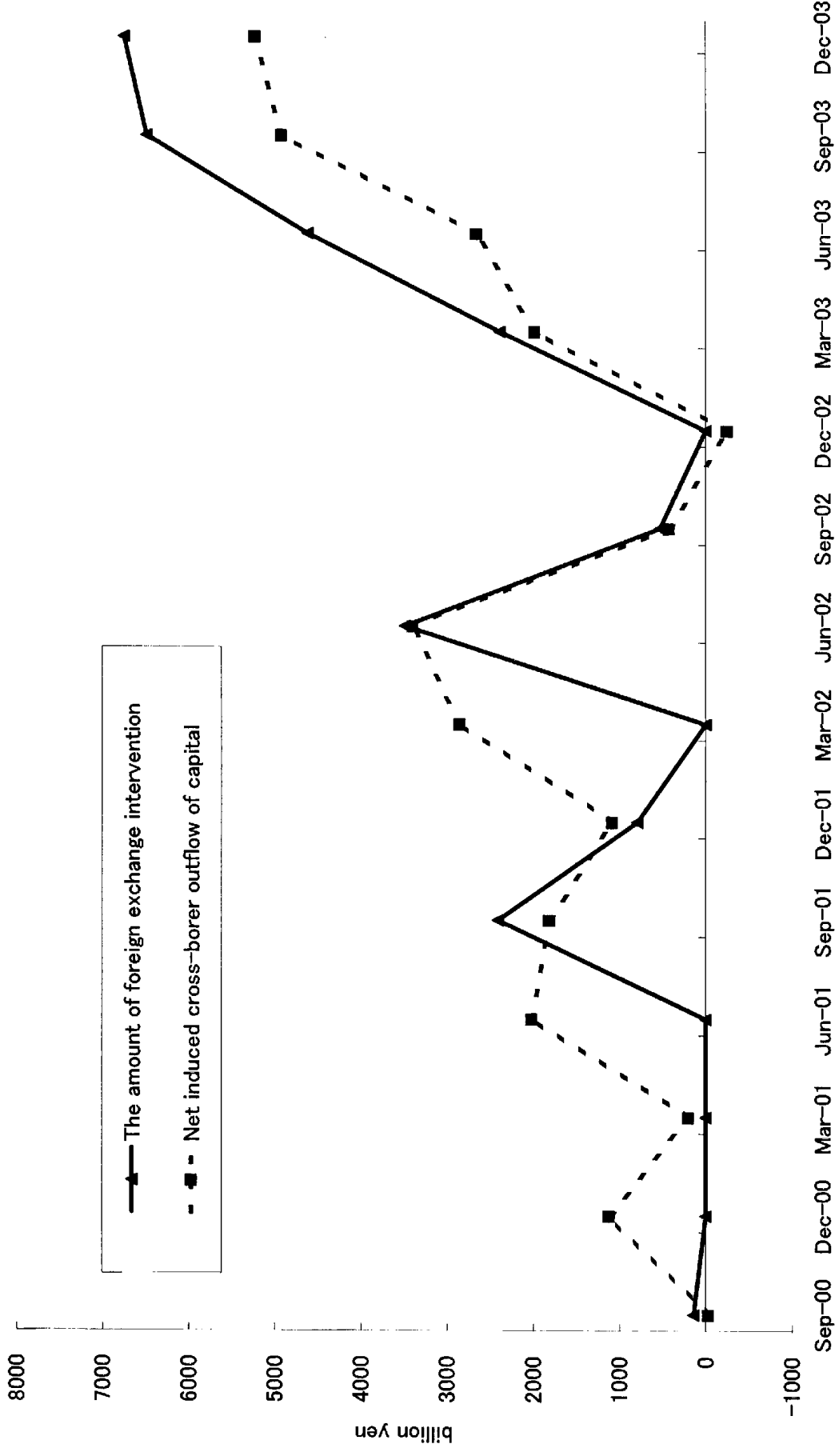


Figure6 Induced cross-border inflow and outflow of capital

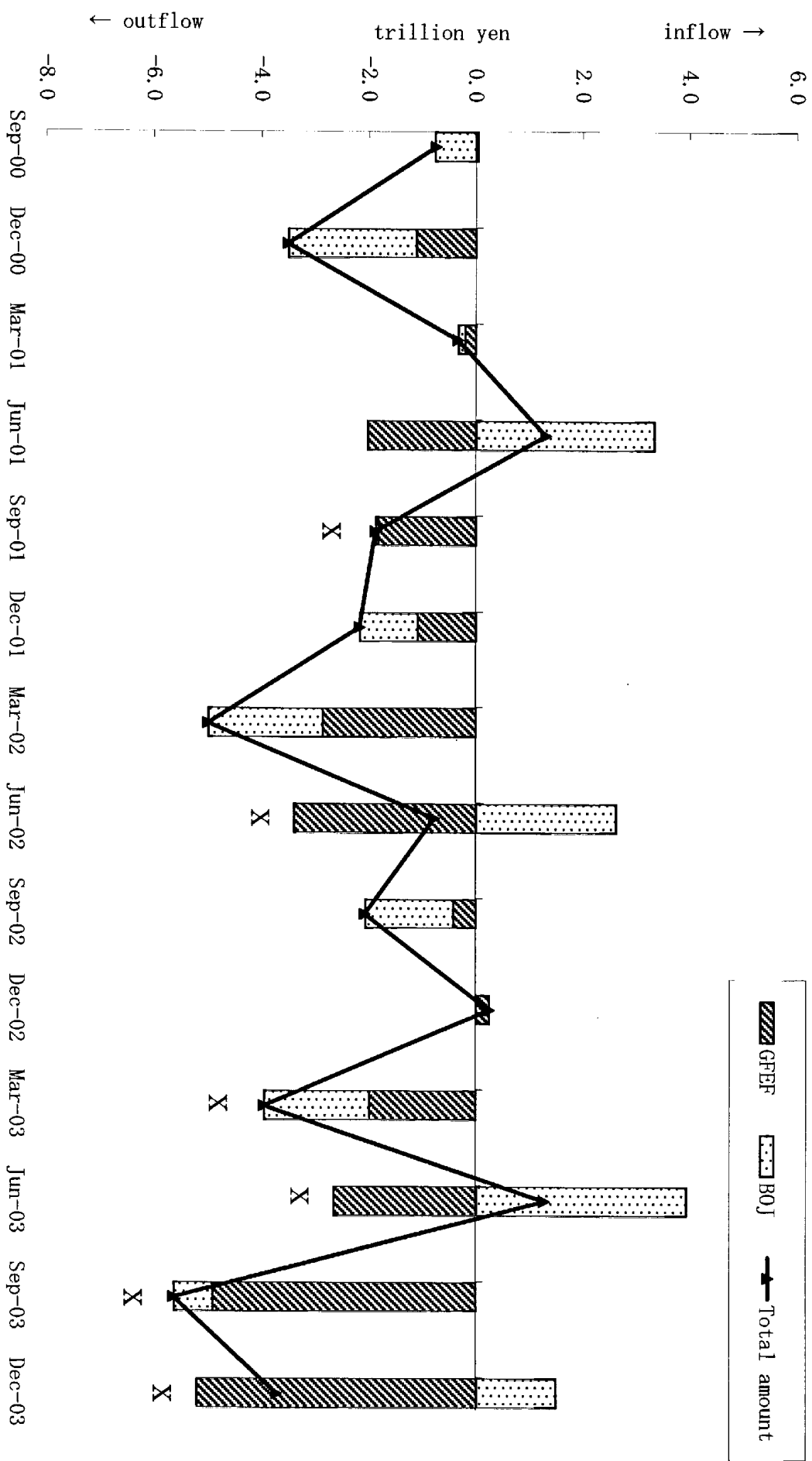
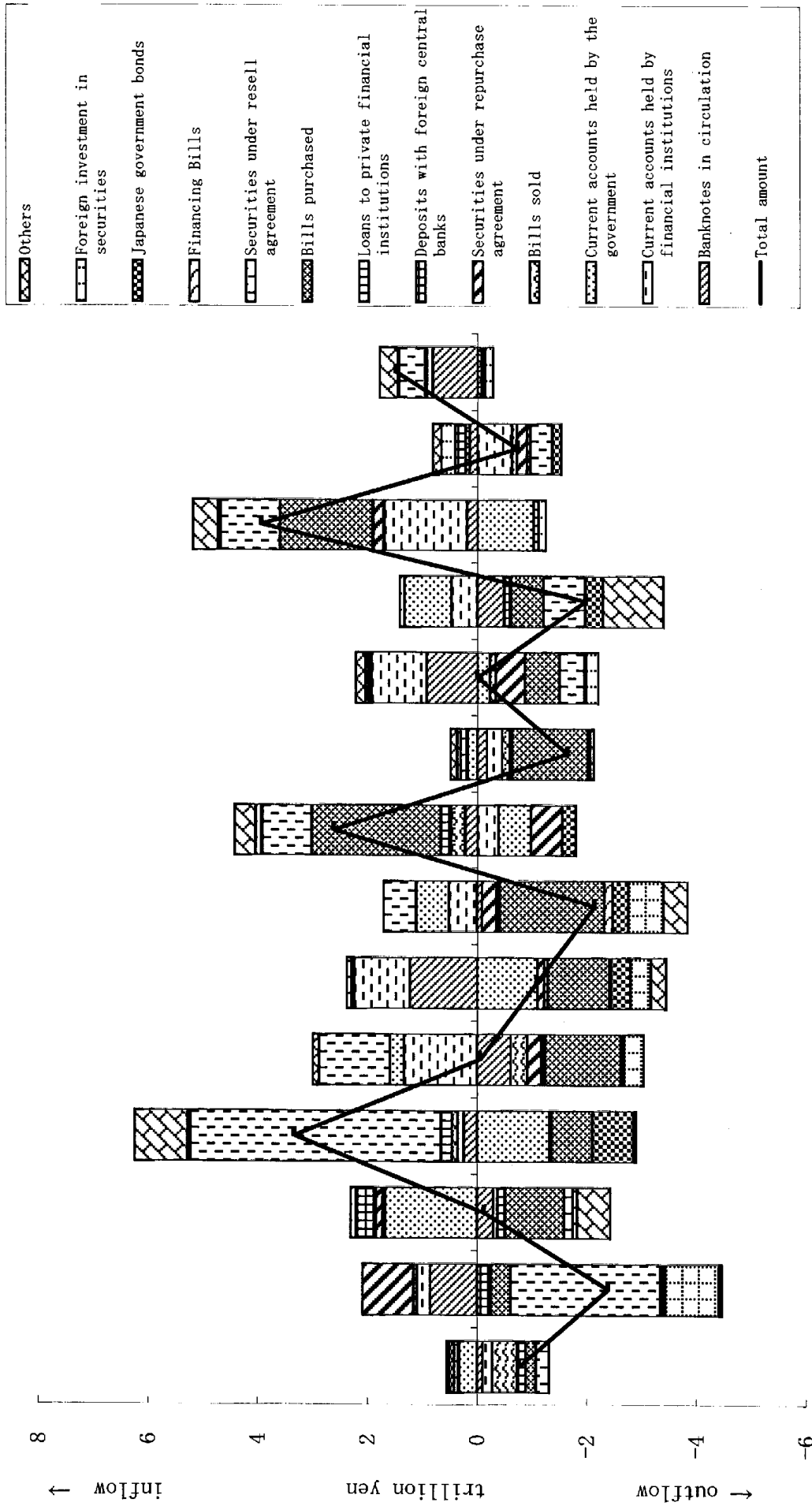


Figure 7 The decomposition of the net capital inflow or outflow produced by the BOJ operations



Sep-00 Dec-00 Mar-01 Jun-01 Sep-01 Dec-01 Mar-02 Jun-02 Sep-02 Dec-02 Mar-03 Jun-03 Sep-03 Dec-03

Table3 IIC and IOC created by a unit change in each item

[GFEF]	Jun-00	Sep-00	Dec-00	Mar-01	Jun-01	Sep-01	Dec-01	Mar-02	Jun-02	Sep-02	Dec-02	Mar-03	Jun-03	Sep-03	Dec-03	mean	standard deviation	coefficient variation
IIC																		
Borrowing from other government departments	0.1230	0.1253	0.1251	0.1287	0.1221	0.1143	0.1120	0.0981	0.1006	0.1024	0.0991	0.1015	0.1020	0.0956	0.0967	0.1098	0.0122	0.1109
FB	0.1461	0.1586	0.1586	0.1490	0.1182	0.1147	0.1371	0.0943	0.1140	0.1172	0.1295	0.1355	0.1389	0.1345	0.1410	0.1325	0.0180	0.1359
IOC																		
Deposits with domestic banks located in Japan	0.1534	0.1923	0.2259	0.2348	0.2307	0.2374	0.2604	0.2468	0.2575	0.2555	0.2498	0.2502	0.2444	0.2350	0.2342	0.2365	0.0205	0.0866
Deposits with foreign banks located in Japan	0.2003	0.2067	0.2081	0.2095	0.2053	0.2058	0.2185	0.2510	0.2322	0.2546	0.2288	0.2362	0.1991	0.2140	0.1917	0.2171	0.0188	0.0868
Deposits with foreign central banks and BIS	1.1528	1.1486	1.1665	1.1671	1.1658	1.1581	1.1647	1.1688	1.1665	1.1627	1.1598	1.1560	1.1527	1.1582	1.1596	1.1596	0.0058	0.0050
Foreign currency denominated securities	1.1528	1.1486	1.1665	1.1671	1.1658	1.1581	1.1647	1.1688	1.1665	1.1627	1.1598	1.1560	1.1527	1.1582	1.1596	1.1596	0.0058	0.0050
IMF reserve position and SDR	1.1528	1.1486	1.1665	1.1671	1.1658	1.1581	1.1647	1.1688	1.1665	1.1627	1.1598	1.1560	1.1527	1.1582	1.1596	1.1596	0.0058	0.0050
[BOJ]																		
IIC																		
Banknotes in circulation	0.1019	0.0995	0.1006	0.1096	0.1035	0.0962	0.1006	0.1012	0.1037	0.1030	0.1036	0.1034	0.1056	0.1091	0.1098	0.1030	0.0035	0.0336
Current accounts held by financial institutions	0.1670	0.1303	0.1353	0.1439	0.1656	0.1823	0.2108	0.1380	0.2275	0.1690	0.2117	0.1490	0.2115	0.1585	0.1861	0.1724	0.0314	0.1824
Current accounts held by the government	0.1230	0.1253	0.1251	0.1287	0.1221	0.1143	0.1120	0.0981	0.1006	0.1024	0.0991	0.1015	0.1020	0.0956	0.0967	0.1098	0.0122	0.1109
Bills sold	0.1241	0.0799	0.0594	0.0489	0.0487	0.0049	0.0031	0.0007	0.0396	0.0275	0.0105	0.0056	0.0096	0.0316	0.0052	0.0333	0.0349	1.0493
Securities under repurchase agreement	0.1060	0.0890	0.0881	0.0957	0.1084	0.1221	0.1270	0.1324	0.1532	0.1530	0.1545	0.1659	0.2284	0.2326	0.2612	0.1478	0.0543	0.3676
Other corporate stocks	0.1109	0.1086	0.1101	0.1123	0.1123	0.1046	0.1080	0.1062	0.1086	0.1118	0.1083	0.1130	0.1142	0.1171	0.1186	0.1110	0.0038	0.0345
Earnest money	0.1232	0.1189	0.1218	0.1152	0.1245	0.1171	0.1230	0.1155	0.1269	0.1284	0.1292	0.1171	0.1289	0.1394	0.1404	0.1246	0.0078	0.0628
External debts	0.5309	0.5476	0.4672	0.4672	0.5019	0.5074	0.4795	0.5096	0.4488	0.4912	0.5460	0.5315	0.5409	0.5125	0.5255	0.5072	0.0310	0.0611
IOC																		
Deposits with foreign central banks and BIS	1.1528	1.1486	1.1665	1.1671	1.1658	1.1581	1.1647	1.1688	1.1665	1.1627	1.1598	1.1560	1.1527	1.1582	1.1596	1.1596	0.0058	0.0050
Loans to private financial institutions	0.2009	0.2018	0.2320	0.2329	0.2367	0.2479	0.2680	0.2576	0.2643	0.2405	0.2498	0.2273	0.2447	0.2341	0.2342	0.2382	0.0192	0.0806
Bills purchased	0.0633	0.1079	0.1358	0.1652	0.1593	0.2166	0.2354	0.2301	0.1870	0.2081	0.2304	0.2424	0.2285	0.2140	0.2294	0.1915	0.0502	0.2632
Securities under resell agreement	0.1696	0.1653	0.1818	0.1842	0.1605	0.1759	0.1885	0.1866	0.1957	0.2057	0.2277	0.2025	0.2153	0.2105	0.2141	0.1922	0.0200	0.1043
FB	0.0135	0.0115	0.0134	0.0146	0.0175	0.0149	0.0123	0.0129	0.0132	0.0125	0.0120	0.0111	0.0111	0.0102	0.0097	0.0127	0.0020	0.1558
JGB	0.0278	0.0264	0.0296	0.0318	0.0338	0.0339	0.0404	0.0455	0.0480	0.0478	0.0459	0.0493	0.0477	0.0490	0.0480	0.0403	0.0087	0.2164
ABS, ABCD																		
Listed corporate stocks																		
Other corporate stocks	0.1201	0.1263	0.1460	0.1506	0.1485	0.1538	0.1672	0.1615	0.1703	0.1751	0.1562	0.1584	0.1571	0.1624	0.1627	0.1544	0.0150	0.0970
Earnest money	0.1427	0.1487	0.1730	0.1825	0.1728	0.1909	0.2096	0.2048	0.2155	0.2371	0.1964	0.2113	0.1989	0.2015	0.1996	0.1917	0.0239	0.1245
Foreign investment in securities	1.1528	1.1486	1.1665	1.1671	1.1658	1.1581	1.1647	1.1688	1.1665	1.1627	1.1598	1.1560	1.1527	1.1582	1.1560	1.1596	0.0058	0.0050
External claims	0.7710	0.7471	0.8706	0.8757	0.8537	0.8183	0.8697	0.8259	0.8992	0.8529	0.7893	0.8005	0.7886	0.8233	0.8044	0.8247	0.0428	0.0519
IMF reserve position and SDR	1.1528	1.1486	1.1665	1.1671	1.1658	1.1581	1.1647	1.1688	1.1665	1.1627	1.1598	1.1560	1.1527	1.1582	1.1560	1.1596	0.0058	0.0050
Others	0.1448	0.1378	0.1685	0.1650	0.1522	0.1441	0.1799	0.1605	0.1734	0.1727	0.1550	0.1623	0.1742	0.1683	0.1693	0.1619	0.0126	0.0776

Table4 The simulation results of non-sterilization and sterilization (per unit, end of December 2003)

Non-sterilization				
Increase in assets	Inflow or outflow	Increase in liabilities	Inflow or outflow	
			Net inflow (upward pressure on yen)	
Purchase of FB	-0.0097	Sale of Bills	0.0052	-0.0045
Purchase of FB	-0.0097	Sale of securities under repurchase agreement	0.2612	0.2515
Purchase of FB	-0.0097	[Increase in banknotes in circulation]	0.1098	0.1001
Purchase of FB	-0.0097	[Increase in current accounts held by financial institutions]	0.1861	0.1764
Purchase of FB	-0.0097	[Increase in current account held by the government]	0.0967	0.0870
Sterilization				
Increase in assets		Decrease in assets		
Purchase of FB	-0.0097	Sale of TB/FB	0.0097	0.0000
Purchase of FB	-0.0097	Bills in possession reached maturity	0.2294	0.2197
Purchase of FB	-0.0097	Return of borrowed securities	0.2141	0.2044
Reverse non-sterilization				
Decrease in assets		Decrease in liabilities		
Sale of TB/FB	0.0097	Decrease in current accounts held by the government	-0.0967	-0.0870
Bills in possession reached maturity	0.2294	Decrease in current accounts held by the government	-0.0967	0.1327
Return of borrowed securities	0.2141	Decrease in current accounts held by the government	-0.0967	0.1174
Reverse sterilization				
Increase in liabilities		Decrease in liabilities		
Sale of Bills	0.0052	Decrease in current accounts held by the government	-0.0967	-0.0915
Sale of securities under repurchase agreement	0.2612	Decrease in current accounts held by the government	-0.0967	0.1645
[Increase in banknotes in circulation]	0.1098	Decrease in current accounts held by the government	-0.0967	0.0131
[Increase in current accounts held by financial institutions]	0.1861	Decrease in current accounts held by the government	-0.0967	0.0894
[Increase in current account held by the government]	0.0967	Decrease in current accounts held by the government	-0.0967	0.0000

* Capital inflow is presented in positive numbers (no sign), while outflow is in negative numbers (-).