Does Monetary Policy Work under Zero-Interest-Rate?[1]

By

Kazusuke Tsujimura* and Masako Tsujimura**

Abstract

In the spring of 1999, the Japanese call money rate reached to the zero-interest-rate level, and has remained under quarter percent since then. "Does monetary policy work under zero -interest-rate at all?" is the question to be answered in this study. We are to examine the effectiveness of so-called Quantitative Easing Policy (QEP) introduced by the Bank of Japan in March 2001 using Asset-Liability-Matrix (ALM) derived from the Flow-of-Funds Accounts. The conclusions of this article is that the performance of the QEP conducted by the BOJ is improving gradually in recent days, partially because of the introduction of new measures including corporate stock and ABS purchasing operations.

1 Introduction

Ten years ago, nobody imagined that the interest rate would ever hit the one percent level. Nowadays, we are commonly talking about zero-interest-rate. The U.S. Federal Open Market Committee lowered its intended federal funds rate to one percent on June 25, 2003. Actually the federal funds rate was hovering somewhere around one percent

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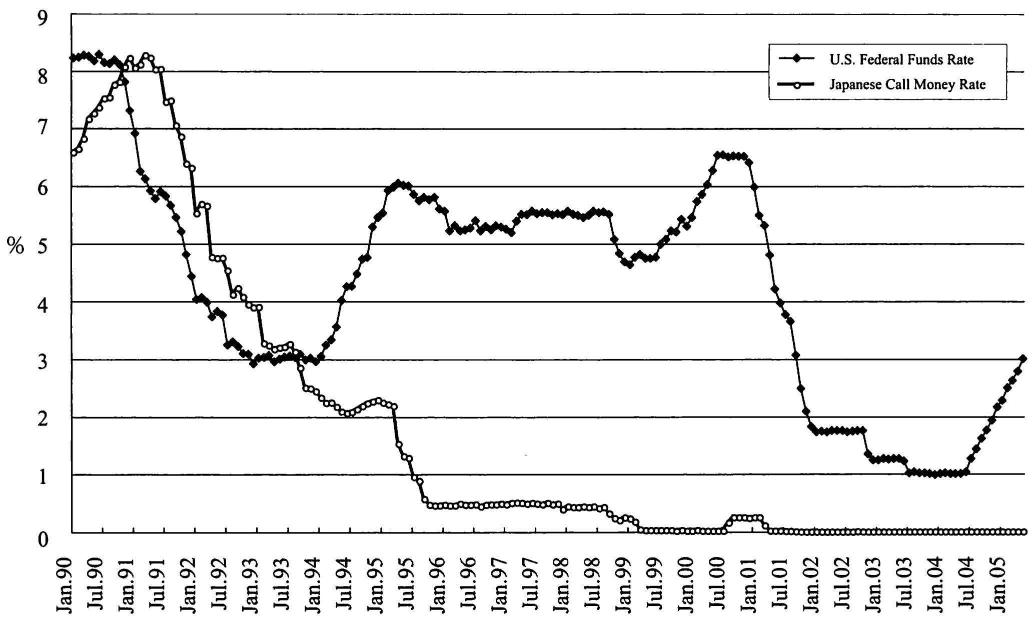
* Faculty of Economics, Keio University, Tokyo, Japan.

** Keio Economic Observatory, Keio University, Tokyo, Japan. E-mail: mizosita@sanken.keio.ac.jp

for more than one year till the Fed raised the interest rate by 25 basis points to 1.25 percent on June 30, 2004. As early as in the spring of 1999, the Japanese call money rate, an equivalent of U.S. federal funds rate, reached to the zero-interest-rate level, and has remained under quarter percent up to now. (See Figure 1.) In June 2003, even the key long-term interest rate, the yield of the Japanese Government Bond (JGB), hit 0.43 percent for a brief time. Keynes (1936) suggests that the interest rate oriented monetary policy become ineffective at near zero interest rate level because of the existence of the liquidity trap. How about some other type of monetary policy, then? "Does monetary policy work under zero-interest-rate at all?" is the question to be answered in this study.

Figure 1 The Overnight Interest Rates



As Bernanke and Reinhart (2004) suggests, there are three alternative monetary strategies for stimulating the economy that do not involve changing the current value of the policy rate. Specifically, these alternatives involve (a) providing assurance to financial investors that short rates will be lower in the future than they currently expect, (b) shifting the composition of the central bank's balance sheet, and (c) increasing the size of the central bank's balance sheet beyond the level needed to set the short-term policy rate at zero. By these definitions, so-called Quantitative Easing Policy (QEP) then newly introduced by the Bank of Japan (BOJ) in March 2001, was a combination of (b) and (c). (See the following section for the details.) If it is the case, the money market operations conducted by the monetary authorities should be fully reflected in their own balance sheets.

In the System of National Accounts (SNA), the financial surplus (i.e. the increment in the difference between the financial assets and the liabilities excluding the changes in the market value) is corresponding to the balance of savings and investments in the non-financial economy. Thus, if there are induced changes in the assets and/or the liabilities of the economic principals (i.e., institutional sectors including corporations, households, governments etc.) as results of the shifting in composition and/or the changes in the size of the central bank's balance sheet, the non-financial economy will be affected as well in terms of capital formation and so on. This might be the channel that the changes in the money market operation would affect the non-financial economic activities without changing the current value of the policy rate. Since the Flow-of-Funds Accounts (FFA) is a collection of the balance sheets of the economic principals, by translating those balance sheets into an Asset-Liability-Matrix (ALM) that is a sector-by-sector matrix, we must be able to calculate the induced effects of the QEP on the financial as well as non-financial economy by application of the Leontief inverse commonly used in the input-output analysis. In our experimental study, we were successful to employ the ALM derived from the FFA to examine the impacts of the introduction of the QEP on the stagnated Japanese Economy. (See Tsujimura and Mizoshita (2003).) It was an attempt to apply the concept of the Leontief inverse to the ALM originally proposed by Stone (1966) and Klein (1983).

Since the observation period of the previous study was only a little more than half a year (December 2000 through September 2001), we used the ALM of March 2001 as a benchmark to calculate the effects of the money market operation of the respective month. After the publication of the paper, we have received many useful comments and suggestions to which we are more than grateful. Among them, we found some remarks including the one from Professor Laurence Klein himself to question the stability of the parameters implied in the ALM in a longer period. If the economic structure represented by the ALM is easily changeable, it must be difficult to educe the efficacy of the monetary policy by means of that. The alterations in the non-financial economy could be derived either from the shifts in the money market operation or from the mutation in the flow-of-funds structure of the economy reflected in the coefficient matrix of the ALM. In this new treatise, we are to demonstrate a new procedure to distinguish the former from the latter based on the method of input-output structural decomposition analysis (IO-SDA)[2], so that we can tell the significance of the monetary policy in more precise manner. The expansion of the observation period up to date, which has been made possible without fearing the confusion of the two causes, put us in position to determine if the QEP adopted by the BOJ last four years is a success. This will be a big step forward to examine the usefulness of the monetary policy in a country where zero interest rate prevails.

Klein (2003) hints that the portfolio parameters of an FFA could be a function of the relevant interest rates and the inflation rate. If it is the case, we might be able to construct a model to trace the serial modulation of the ALM itself, which could be a major breakthrough to expand the horizon of the traditional flow-of-funds analysis.

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[2] IO-SDA was originally proposed by Chenery (1960), Chenery, Shishido & Watanabe (1962) and Carter (1970). The method has been developed by Wolff (1985), Feldman, McClain & Palmer (1987), Blair & Wykoff (1989), Rose & Chen (1991), Martin & Holland (1992), Korres (1996), Cronin & Gold (1998), Liu & Saal (2001) and Andresso-O'Callaghan & Yue (2000, 2002) among others. The detailed comparison of the methods is found in Betts (1989) and Dietzenbacher & Los (1998).

However, when we take only the zero interest rate situations into account, it is a logical contradiction to follow the approach. Actually, in case of today's Japan, the interest rate remains in the vicinity of nil while the changes in the inflation rate is kept minimal somewhere just below zero. Therefore, we had to develop some other line of procedure to single out the very effects of the QEP.

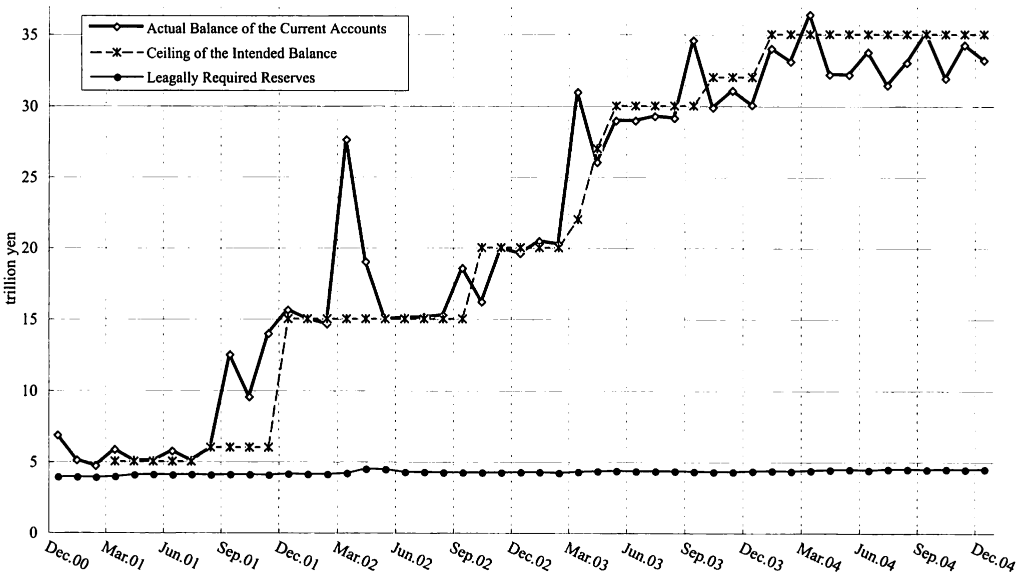
In the first place, we have abandoned the idea to explain why the economic structure symbolized in the ALM has changed at all. Rather, we opted for a simple and easy scheme. We have just decomposed the observed changes in the non-financial economy into two parts: (1) the first component attributed to the shifts in the money market operation, and (2) the second component attributable to the mutation of the ALM itself. The first component is calculated by multiplying the coefficient matrix of the ALM of the previous period and the money market operation vector of the period; and then subtracting the previous period's observed value afterwards. We can calculate the second component likewise, by multiplying the coefficient matrix of the ALM of the period and the money market operation vector of the previous period; and then subtracting the previous period's observed value. The procedure is an analogy to the way we make the NIPA (National Income and Product Accounts) chain index. Moreover, when we take the rate of change into consideration, the geographic mean of the indices of the first component and the second component is consistent with the observed value as Fisher (1927) demonstrated more than seven decades ago.

The second question we are to answer in this study is how effective is each device adopted by the BOJ in its money market operations. In this paper, we are to present the subdivided NII for each market operation instrument. As we discuss in the following sections, the QEP has failed to give favourable results in the early stage of its introduction. Therefore BOJ revised its way of money market operation in the course of trial and error. In the more recent months, the BOJ has introduced drastic measures in face of the prolonged recession and the plunge in the equity prices. One of the most dramatic decisions is to purchase the corporate stocks from the commercial banks, which are obliged to keep the corporate stocks in possession under the value of their equity capital, to cope with the new legislation. Another unprecedented scheme for a central bank is to purchase the Asset-Backed-Securities (ABS) to smooth the financing of the small and medium-sized enterprises to cover up the shortage of the bills in circulation eligible for the BOJ operations. The advantage of the present approach is the capability to single out the effect of a particular policy device upon a particular sector so that we can choose the best combination of the operation instruments.

2 The Quantitative Easing Policy

Before going any further, we have to discuss the details of the QEP adopted by the BOJ. In the spring of 2001, the bank abruptly announced that it would shift the target of the money market operations from the interbank interest rate (overnight call money rate) to the balance of current accounts held by the financial institutions at the central bank. This means that the BOJ expect the commercial banks and other financial institutions to voluntarily build up a balance well over the legally required minimum reserve

Figure 2 The Balance of the Current Accounts with BOJ



in the current account. Simultaneously, the BOJ proclaimed it was to increase the balance of the current accounts (then 4 trillion yen[3]) by one trillion yen to 5 trillion (while keeping the official reserve ratio at the previous level!)[4] , and was to add the same amount of JGB on its asset portfolio. The intended amount of the balance of the current accounts was raised to 6 trillion yen in August, then to "above 6 trillion yen" in September, and even further to 10-15 trillion in December 2001. That was not the end of the story. In February 2002, the BOJ announced that it would "provide more liquid-

[3] The balance of the current accounts temporarily increased to 23 trillion yen in December 1999 by way of precaution against so-called Y2K.

[4] At ordinary times, the financial institutions try to keep the balance of current accounts at the level of legally required minimum reserve. Since the BOJ does not pay interest on the current account balances, the banks do not want to pile up "excess-reserve" while paying interest on the deposit accounts with themselves. Of course zero interbank interest rate does not necessarily mean that all the interest rates on the bank accounts become zero. Actually in case of Japan, the banks are paying small amount of interest on the deposits with them while they receive some interest from their borrowers. In that sense it is magic, even under zero-interest-rate circumstances, if BOJ could persuade its customer banks to accumulate as much funds as it wishes. The results are depicted in Fig.2. After the introduction of the QEP in the spring of 2001, the BOJ successfully persuaded the commercial banks to increase the balance of the current accounts not only well above the legally required minimum reserves, but also comfortably above the intended level that they had then proclaimed. One reason must be that Japan is experiencing worst credit crunch ever in the aftermath of the financial bubble of the 1980's, so that the financial institutions are obliged to have excess reserve as a precaution. Another reason could be that the call loan rate (typical interbank interest rate) was in the sub-zero domain from time to time because some foreign banks were able to get profits by borrowing yen against other currencies of higher interest rate and let it to other banks. However these reasoning may explain only a part of the story, and the remainder is left to be answered.

Figure 3 The Assets of the BOJ

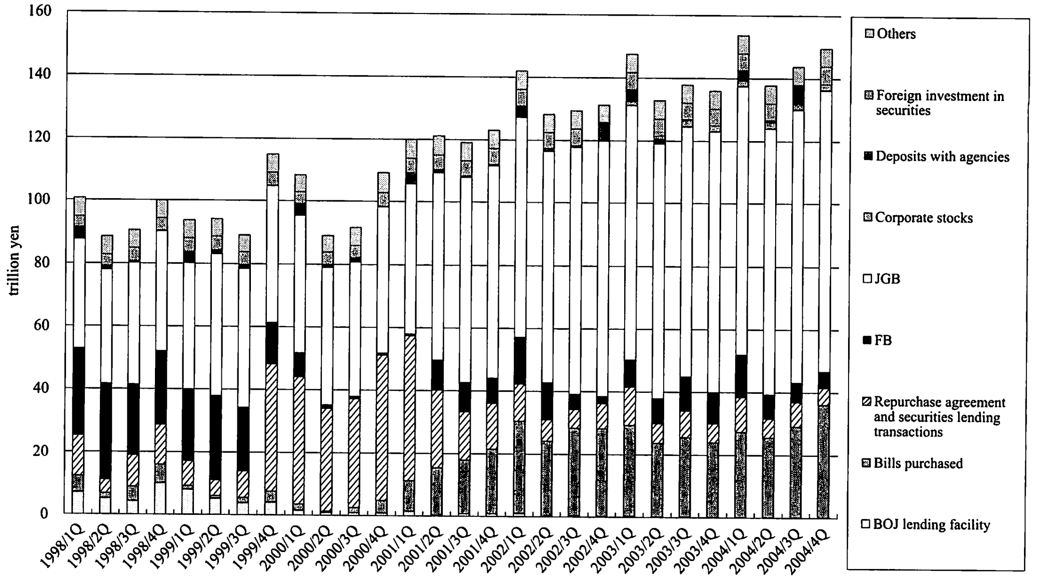
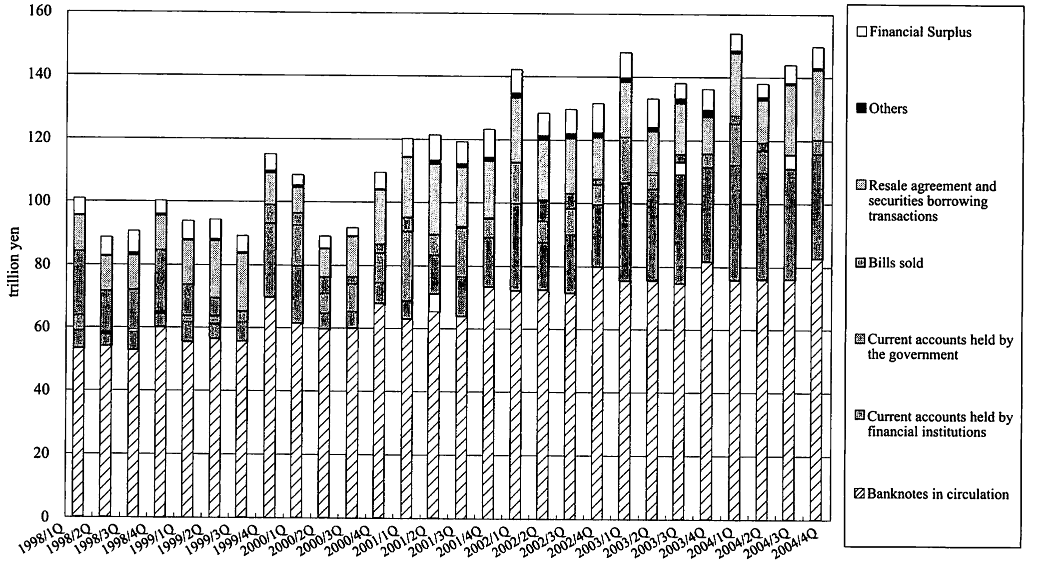


Figure 4 The Liabilities of the BOJ



ity to meet a surge in demand irrespective of the target of current account balances, (then) around 10 to 15 trillion yen". The target level was lifted to 15–20 trillion yen in October 2002, 17–22 trillion in March 2003, 22–27 trillion[5] in April, 27–30 trillion in May 2003 and finally to 30–35 trillion yen in January 2004. (See Figure 2.)

Under the zero interest rate situations, the means of the money market operation could have decisive significance. As we have mentioned earlier, in the first phase of the QEP, it was the BOJ's intention to increase JGB in their asset portfolio. This line of policy was officially maintained at least till October 2002, when it announced that it

Table 1: Balance sheets of the BOJ (100 million yen)

	Dec–97		Mar–98		Jun–98		Sep–98		Dec–98		Mar–99		Jun–99		Sep–99		Dec–99		Mar–00	
	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
Banknotes in circulation		587154		529946		537599		526885		599865		553298		563469		554547		695920		612165
Current accounts held by financial institutions		34992		58105		40456		57233		43743		61676		46632		60577		233860		183413
Current accounts held by the government		4995		49527		5682		6553		5169		20243		24709		35252		59547		130311
Foreign currency deposits	0		0		0		0		0		0		0		0		0		0	
Loans to private financial institutions	49275		70186		51201		41966		99257		79670		51180		37454		39672		15587	
Bills purchased and sold	49132	51545	53223	202997	16976	130617	46783	128162	60787	195856	11904	99991	8376	58026	17601	0	35993	0	19909	38008
Repurchase agreement and securities lending transactions	128085	112300	129604	113770	42789	112000	100399	110610	126716	110320	79901	141493	51470	183100	84895	185572	407189	101320	405952	81865
Financing Bills	192413		276246		306212		225526		234785		228556		268623		202860		130135		76809	
Central government securities and FILP bonds	327619		346926		362416		387092		379981		401700		451103		441312		435114		435451	
Structured–financing instruments	0		0		0		0		0		0		0		0		0		0	
Corporate stocks	2202	1	2202	1	2202	1	2202	1	2202	1	2002	1	2002	1	2002	1	1202	1	1202	1
Deposits with agencies	2	277	33929	267	9476	276	3552	269	2	274	33543	265	9496	263	11593	254	1	260	36034	247
Accounts receivable/payable	4837	139	2356	215	4419	78	1974	6220	4118	2507	1985	2601	4724	102	2109	143	4866	4362	2579	4373
Other external claims and debts	35568	50	35727	47	36115	176	40608	47	38584	616	43044	73	43401	3950	39113	3403	41875	390	37695	322
Others	50729	7	56303	7	52815	7	54993	7	54070	534	54980	7	50594	7	50921	7	53163	465	52629	7
Financial surplus or deficit		48402		51820		57729		69108		41617		57637		60710		50104		53085		33135
Total	839862	839862	1006702	1006702	884621	884621	905095	905095	1000502	1000502	937285	937285	940969	940969	889860	889860	1149210	1149210	1083847	1083847

	Jun–00		Sep–00		Dec–00		Mar–01		Jun–01		Sep–01		Dec–01		Mar–02		Jun–02		Sep–02	
	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
Banknotes in circulation		594060		598541		676197		628296		652395		639081		732980		720965		724467		714122
Current accounts held by financial institutions		51804		52255		68270		58143		57058		124794		156154		276107		150532		185326
Current accounts held by the government		63769		88542		93827		220725		123691		154797		59651		129284		67229		83418
Foreign currency deposits	194		1525		3244		101		370		729		355		553		306		437	
Loans to private financial institutions	7983		7501		8274		14087		5300		6323		8161		9900		3892		3464	
Bills purchased and sold	5249	50974	18259	22407	40093	28069	98200	43863	148621	65017	173078	4800	207143	3000	295184	0	237496	65804	279974	46188
Repurchase agreement and securities lending transactions	327924	91511	347250	129960	463831	172342	461643	191142	248342	224114	154391	187162	145760	180260	118227	206327	68799	192127	60325	176546
Financing Bills	10918		7492		7131		6335		95415		93289		80300		148743		117277		48096	
Central government securities and FILP bonds	437291		427199		462800		476241		595523		652078		674949		700495		736542		785490	
Structured–financing instruments	0		0		0		0		0		0		0		0		0		0	
Corporate stocks	1202	1	1202	1	1202	1	1202	1	1202	1	1202	1	1202	1	1202	1	1202	1	1202	1
Deposits with agencies	9146	251	11167	241	1446	245	34360	235	9383	238	4430	232	3488	237	35487	229	9471	235	5327	227
Accounts receivable/payable	4254	94	1934	131	4843	807	1638	792	3425	138	3642	127	1835	215	2884	234	3634	134	2961	142
Other external claims and debts	31416	240	32101	200	35776	218	39144	172	38516	9835	38607	10424	42876	9295	42796	12843	41132	11863	43196	12389
Others	48139	7	54320	7	56484	7	59236	7	58381	12	54329	12	55674	15	55444	7	54424	7	55722	7
Financial surplus or deficit		38024		24574		52529		56375		79876		68879		88473		74311		70694		77086
Total	890735	890735	916859	916859	1092512	1092512	1199751	1199751	1212375	1212375	1190309	1190309	1230281	1230281	1420308	1420308	1283093	1283093	1295452	1295452

	Dec–02		Mar–03		Jun–03		Sep–03		Dec–03		Mar–04		Jun–04		Sep–04		Dec–04	
	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
Banknotes in circulation		798383		753579		755347		743875		813323		757665		759094		758817		824484
Current accounts held by financial institutions		195626		309297		289315		345600		300307		363601		337339		350726		331784
Current accounts held by the government		63311		146135		45556		40533		42431		130805		71304		44817		45462
Foreign currency deposits	323		1150		1952		250		258		272		357		348		267	
Loans to private financial institutions	1932		2903		1681		1712		1412		1412		1461		1412		1111	
Bills purchased and sold	280422	17014	291261	0	235185	6003	254203	24179	238429	0	272192	25708	254815	24014	290053	0	360734	0
Repurchase agreement and securities lending transactions	80537	133953	121880	176108	63960	132704	84148	162844	60602	119114	111338	198853	60953	136616	77702	222726	54119	221566
Financing Bills	22177		85938		78208		109426		99615		134922		76243		62129		50761	
Central government securities and FILP bonds	813115		810598		811782		795955		829251		854699		846624		869071		895684	
Structured–financing instruments	0		0		0		310		515		1204		1315		1128		1156	
Corporate stocks	2708	1	12807	1	16069	1	19637	1	20196	1	20689	1	21005	1	21491	1	21064	1
Deposits with agencies	3137	229	38710	0	8813	3	3122	3	139	1	30826	0	5214	2	1526	0	161	0
Accounts receivable/payable	3089	146	2895	135	3410	257	2858	102	3181	235	2780	279	2679	177	2198	59	2365	84
Other external claims and debts	43724	13756	43672	11241	44554	10275	42904	13797	42773	20070	42918	7130	44716	7056	46576	4158	45341	5727
Others	53284	7	54265	7	54430	7	55128	8	53382	8	53068	8	53096	8	53401	8	52097	167
Financial surplus or deficit		91755		78936		90313		48778		64720		52614		42970		56550		66260
Total	1314181	1314181	1475439	1475439	1329781	1329781	1379720	1379720	1360210	1360210	1536664	1536664	1378581	1378581	1437862	1437862	1495535	1495535

Source: Bank of Japan

would increase the monthly outright purchase of the JGB from 1 trillion yen to 1.2 trillion yen. Some other measures included the easing of the restrictions on the use of the Lombard-type lending facility (August 2001 and February 2002), more active purchase of Commercial Papers (December 2001) and the extension of maturities for the bills purchased eligible for the operations (October 2002). More dramatic measures were on their way. In October 2002, the BOJ asked permission to purchase corporate stocks in the form of "money in trust" and the Ministry of Finance (MOF) authorized it immediately. In June 2003, the BOJ announced the scheme for the outright purchases of the ABS, and it was put in practice by the end of the following month.

Figure 3 and Figure 4 as well as Table 1 show the changes in the asset and liability portfolios of the BOJ under the QEP. As indicated in the height of the pillars, the total of the assets and the liabilities have increased gradually since the introduction of the policy in the spring of 2001. It is obvious that the balance of the current accounts has risen dramatically. However, that is not the only cause to make the monetary base grow. The balance of the banknotes has swelled as well, most probably because of the policy shift in April 2002 to allow the liquidation of insolvent financial institutions. On the asset side, there is no doubt that the JGB enlarged its magnitude significantly not only in size, but also in the proportion to the total assets. Another instrument that has expanded its position is bills-purchased in open market operations, especially in more recent days. In contrast to that, the balance of repurchase-agreement and securities-borrowing-transactions has been slashed after the introduction of the QEP.

3 Data

The BOJ publishes *Flow of Funds Accounts of Japan* quarterly. It contains three tables: (1) financial transactions, (2) financial assets and liabilities, and (3) reconciliation between flows and stocks. The ALM used in this paper has been compiled from the financial assets and liabilities tables of the FFA from December 1997 through December 2004 every three months[6]. Only the summary of the compilation procedure from the FFA to the 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 FFA. Figure 5 presents the components of the E and R tables.

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

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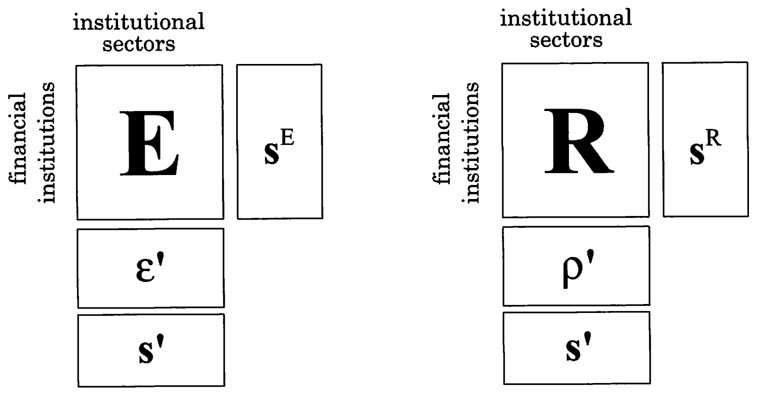
[5] The intended amount of the balance of the current accounts was increased to 27–32 trillion yen in October 2003.

[6] In our scheme, assets are evaluated in current value while the liabilities are evaluated in book value. For further details, see Tsujimura and Mizoshita (2004).

Figure 5 Components of E– and R– tables



$$\mathbf{E} = \begin{bmatrix} e_{11} & e_{12} & \cdots & e_{1m} \\ e_{21} & e_{22} & \cdots & e_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ e_{n1} & e_{n2} & \cdots & e_{nm} \end{bmatrix} \quad \boldsymbol{\varepsilon} = \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \varepsilon_m \end{bmatrix} \quad \mathbf{s}^{\mathrm{E}} = \begin{bmatrix} \mathrm{s}_1^{\mathrm{E}} \\ \mathrm{s}_2^{\mathrm{E}} \\ \vdots \\ \mathrm{s}_n^{\mathrm{E}} \end{bmatrix} \quad \mathbf{s} = \begin{bmatrix} \mathrm{s}_1 \\ \mathrm{s}_2 \\ \vdots \\ \mathrm{s}_m \end{bmatrix}$$

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

$$\mathbf{R} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{bmatrix} \quad \boldsymbol{\rho} = \begin{bmatrix} \rho_1 \\ \rho_2 \\ \vdots \\ \rho_m \end{bmatrix} \quad \mathbf{s}^{\mathrm{R}} = \begin{bmatrix} \mathrm{s}_1^{\mathrm{R}} \\ \mathrm{s}_2^{\mathrm{R}} \\ \vdots \\ \mathrm{s}_n^{\mathrm{R}} \end{bmatrix} \quad \mathbf{s} = \begin{bmatrix} \mathrm{s}_1 \\ \mathrm{s}_2 \\ \vdots \\ \mathrm{s}_m \end{bmatrix}$$

It is possible to make out two different sheets of square matrices, the ALM, using E and R tables in alternative procedures. One is Y table based on the fund-raising portfolio, the other is Y^* table based on the fund-employment portfolio. Superscript $*$ denotes the case of fund-employment. To compile Y-table in accordance with the fund-raising portfolio, first, matrix **R** is substituted for matrix **U** (use table or use matrix) and the transposed matrix **E'** is substituted for **V** (supply table or make matrix).

$$\mathbf{U} \equiv \mathbf{R} \tag{1}$$

$$\mathbf{V} \equiv \mathbf{E}' \tag{2}$$

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

$$\mathbf{U}^* \equiv \mathbf{E} \tag{3}$$

$$\mathbf{V}^* \equiv \mathbf{R}' \tag{4}$$

Each element of the coefficient matrices **B** and **B*** are defined as follows:

$$b_{ij} = \frac{u_{ij}}{s_j} \tag{5}$$

$$b^*_{ij} = \frac{u^*_{ij}}{s_j} \tag{6}$$

In the same manner, each element of the coefficient matrices **D** and **D*** are defined as follows:

$$d_{ij} = \frac{v_{ij}}{s^E_j} \tag{7}$$

$$d^*_{ij} = \frac{v^*_{ij}}{s^R_j} \tag{8}$$

The m × m coefficient matrices **C** and **C*** are estimated using the institutional sector portfolio assumption.

$$\mathbf{C} = \mathbf{DB} \tag{9}$$

$$\mathbf{C}^* = \mathbf{D}^*\mathbf{B}^* \tag{10}$$

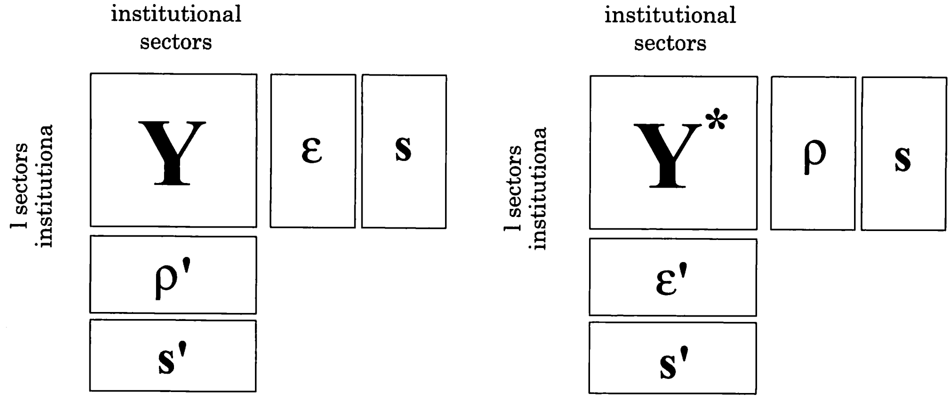
Then each element of the transaction quantity matrices **Y** and **Y***are obtained as follows,

$$y_{ij} = c_{ij}s_j \tag{11}$$

$$y^*_{ij} = c^*_{ij}s_j \tag{12}$$

The above procedure leads us to Y and Y* tables depicted in Fig.6.

Figure 6 Components of Y- and Y*- tables



4 Methodologies

4.1. Evaluation of the Quantitative Easing Policy

It is necessary to treat BOJ, the central bank, as an exogenous institutional sector in order to analyse the effect of the monetary policy by estimating the induced amount of demand and supply of funds through the intersectoral financial transactions represented in the Leontief inverse. The fundamental equations respect to Y and Y^* tables are expressed as follows:

$$\mathbf{C}_{BOJ}\,\mathbf{s} + \boldsymbol{\varepsilon}_J = \mathbf{s} \tag{13}$$

$$\mathbf{C}^*_{BOJ}\,\mathbf{s} + \boldsymbol{\rho}_J = \mathbf{s} \tag{14}$$

where $\mathbf{C}_{BOJ}$ and $\mathbf{C}^*_{BOJ}$ are the matrices obtained from the matrices **C** and $\mathbf{C}^*$ respectably, by removing the row and the column containing the elements concerning the BOJ. $\boldsymbol{\varepsilon}_J$ is a $(m-1) \times 1$ vector of which each element is the sum of excess liabilities and the liabilities of the BOJ. $\boldsymbol{\rho}_J$ is a $(m-1) \times 1$ vector which contains the sum of excess assets and the BOJ's financial assets. Solving each equation for **s** yields

$$\mathbf{s} = (\mathrm{I} - \mathbf{C}_{BOJ})^{-1}\,\boldsymbol{\varepsilon}_J \tag{15}$$

$$\mathbf{s} = (\mathrm{I} - \mathbf{C}^*_{BOJ})^{-1}\,\boldsymbol{\rho}_J \tag{16}$$

where I denotes $(m-1) \times (m-1)$ unit matrix, $(\mathrm{I} - \mathbf{C}_{BOJ})^{-1}$ is the $(m-1) \times (m-1)$ Leontief inverse matrix, which gives the demand for funds as induced by each institutional sector, and $(\mathrm{I} - \mathbf{C}^*_{BOJ})^{-1}$ is the $(m-1) \times (m-1)$ Leontief inverse matrix, by which we can calculate the amount of ultimately induced supply of funds. For simplification, let us denote $(\mathrm{I} - \mathbf{C}_{BOJ})^{-1}$ as $\boldsymbol{\Gamma}$ and $(\mathrm{I} - \mathbf{C}^*_{BOJ})^{-1}$ as $\boldsymbol{\Gamma}^*$. From the viewpoint of the non-financial economy, the induced demand for funds means gross induced savings (GIS), the amount of new savings required, while the induced supply of funds refers to gross induced investment (GII) that enables us to make still more investments.

It is possible to calculate the effect of the QEP carried by the BOJ using Leontief inverse in the same framework described above. $\boldsymbol{\varepsilon}_{BOJ}$ is a $n \times 1$ vector of which element $\varepsilon_{BOJ,i}$ is the liability held by the BOJ in the form of financial instrument i. The $n \times 1$ vector $\boldsymbol{\rho}_{BOJ}$ is the assets vector where element $\rho_{BOJ,i}$ denotes the financial instrument i held by the BOJ. Vectors $\boldsymbol{\varepsilon}_{BOJ}$ and $\boldsymbol{\rho}_{BOJ}$ then should be transformed into $(m-1) \times 1$ vectors $\mathbf{f}_\varepsilon$ and $\mathbf{f}_\rho$, each of which is classified by institutional sector in order to make it possible to use Leontief inverse. The method of transformation adopted here is as follows:

$$\mathbf{f}_\varepsilon = \mathbf{D}_{BOJ}\,\boldsymbol{\varepsilon}_{BOJ} \tag{17}$$

$$\mathbf{f}_\rho = \mathbf{D}^*_{BOJ}\,\boldsymbol{\rho}_{BOJ} \tag{18}$$

where $\mathbf{D}_{BOJ}$ and $\mathbf{D}^*_{BOJ}$ are $(m-1) \times n$ matrices obtained by omitting the row of BOJ from **D** and $\mathbf{D}^*$ respectively. Given $\boldsymbol{\varepsilon}_{BOJ}$ and $\boldsymbol{\rho}_{BOJ}$ exogenously, the induced savings and the induced investments are calculated as follows:

$$\boldsymbol{\eta}_S = (\mathbf{I} - \mathbf{C}_{BOJ})^{-1}\,\mathbf{f}_\varepsilon \tag{19}$$

$$\boldsymbol{\eta}_I = (\mathbf{I} - \mathbf{C}^*_{BOJ})^{-1}\,\mathbf{f}_\rho \tag{20}$$

where $\boldsymbol{\eta}_S$ is the (m – 1) × 1 vector of induced savings and element η_{Si} denotes the induced savings generated in institutional sector i, $\boldsymbol{\eta}_I$ is the (m – 1) × 1 vector of induced investments, where element η_{Ii} indicates induced investment generated in institutional sector i. Note that GIS $[H_S = \sum_i \eta_{Si}]$ is the sum of the elements $\boldsymbol{\eta}_S$, and GII $[H_I = \sum_i \eta_{Ii}]$ is the sum of the elements of $\boldsymbol{\eta}_I$. Subtracting GIS from GII, we obtain NII as follows:

$$H_N = H_I - H_S \tag{21}$$

NII calculated by (21) have significant economic meanings, that is whether current policy stimulate the capital formation in the non-financial economy or not.

4.2. Decomposition of the changes in NII

We have calculated the GIS, GII and NII for December 1997 through December 2004 quarterly. It is possible to decompose the cause of increasing or decreasing of these indices into two elements. These are 1) the portion attributed to BOJ's monetary policy, that is $\mathbf{f}_\varepsilon$ and $\mathbf{f}_\rho$, and 2) the segment attributable to the structural change of the financial market, i.e., $\boldsymbol{\Gamma}$ and $\boldsymbol{\Gamma}^*$. Let $\mathbf{f}_{\varepsilon,t}$ ($\mathbf{f}_{\rho,t}$) be the (m – 1) × 1 vector of liabilities (Assets) held by BOJ at period t, and $\boldsymbol{\Gamma}_t$ ($\boldsymbol{\Gamma}^*_t$) be the (m – 1) × (m – 1) Leontief inverse matrix at period t. The decomposition of the output change over a period can be calculated as the first difference of H_{Nt}, which is:

$$\Delta H_{Nt} = H_{Nt} - H_{Nt-1} \tag{22}$$

$$\Delta H_{Nt} = (H_{It} - H_{St}) - (H_{It-1} - H_{St-1}) \tag{23}$$

In the matrix notation, by using equations (19) and (20), (23) could be transformed to:

$$\Delta H_{Nt} = (\mathbf{i}'\boldsymbol{\Gamma}^*_t\mathbf{f}_{\rho,t} - \mathbf{i}'\boldsymbol{\Gamma}_t\mathbf{f}_{\varepsilon,t}) - (\mathbf{i}'\boldsymbol{\Gamma}^*_{t-1}\mathbf{f}_{\rho,t-1} - \mathbf{i}'\boldsymbol{\Gamma}_{t-1}\mathbf{f}_{\varepsilon,t-1}) \tag{24}$$

The IO-SDA method we have adopted is the arithmetic average of the Laspeyres and Paasche decomposition that is proved to be exact and non-arbitrary[7].

$$\Delta H_{Nt} = \frac{\{(\mathbf{i}'\boldsymbol{\Gamma}^*_t\mathbf{f}_{\rho,t}-\mathbf{i}'\boldsymbol{\Gamma}_t\mathbf{f}_{\varepsilon,t})-(\mathbf{i}'\boldsymbol{\Gamma}^*_t\mathbf{f}_{\rho,t-1}-\mathbf{i}'\boldsymbol{\Gamma}_t\mathbf{f}_{\varepsilon,t-1})\}+\{(\mathbf{i}'\boldsymbol{\Gamma}^*_{t-1}\mathbf{f}_{\rho,t}-\mathbf{i}'\boldsymbol{\Gamma}_{t-1}\mathbf{f}_{\varepsilon,t})-(\mathbf{i}'\boldsymbol{\Gamma}^*_{t-1}\mathbf{f}_{\rho,t-1}-\mathbf{i}'\boldsymbol{\Gamma}_{t-1}\mathbf{f}_{\varepsilon,t-1})\}}{2}$$
$$+\frac{\{(\mathbf{i}'\boldsymbol{\Gamma}^*_t\mathbf{f}_{\rho,t}-\mathbf{i}'\boldsymbol{\Gamma}_t\mathbf{f}_{\varepsilon,t})-(\mathbf{i}'\boldsymbol{\Gamma}^*_{t-1}\mathbf{f}_{\rho,t}-\mathbf{i}'\boldsymbol{\Gamma}_{t-1}\mathbf{f}_{\varepsilon,t})\}+\{(\mathbf{i}'\boldsymbol{\Gamma}^*_t\mathbf{f}_{\rho,t-1}-\mathbf{i}'\boldsymbol{\Gamma}_t\mathbf{f}_{\varepsilon,t-1})-(\mathbf{i}'\boldsymbol{\Gamma}^*_{t-1}\mathbf{f}_{\rho,t-1}-\mathbf{i}'\boldsymbol{\Gamma}_{t-1}\mathbf{f}_{\varepsilon,t-1})\}}{2} \tag{25}$$

where **i** is the (m – 1) × 1 vector, which contains a column of 1s. As proved in the Ap-

[7] For further details, see Betts (1989). The deference between the traditional IO–SDA and ours is that all the components in (25) are scalars instead of vectors because they are multiplied by **i'**.

pendix 1, equation (24) could be transformed to (25), so that we can trace the change in the NII to two sources. While the first term of the right hand of equation (25) represents the effects of the changes in the BOJ's fund-raising or fund-employment portfolio, the second term represents the effects of the mutation in the Leontief inverse. Denoting Δf_t as the first term, and $\Delta\Gamma_t$ as the second term, (25) can be simplified as:

$$\Delta H_{Nt} = \Delta f_t + \Delta\Gamma_t \tag{26}$$

Furthermore, we have another method of decomposition to compare the ratio of the NII at t to the NII at t − 1, which is based on the well-known Fisher's ideal formula of index numbers[8]. The decomposition of the NII's change over a period can then be calculated as the ratio of H_{Nt} to H_{Nt-1},

$$\delta H_{Nt} = \frac{H_{Nt}}{H_{t-1}} \tag{27}$$

which is:

$$\delta H_{Nt} = \frac{(H_{It} - H_{St})}{(H_{It-1} - H_{St-1})} \tag{28}$$

In matrix notation, using equations (19) and (20), (28) can be transformed to:

$$\delta H_{Nt} = \frac{\mathbf{i}'\boldsymbol{\Gamma}_t^*\mathbf{f}_{\rho,t} - \mathbf{i}'\boldsymbol{\Gamma}_t\mathbf{f}_{\varepsilon,t}}{\mathbf{i}'\boldsymbol{\Gamma}_{t-1}^*\mathbf{f}_{\rho,t-1} - \mathbf{i}'\boldsymbol{\Gamma}_{t-1}\mathbf{f}_{\varepsilon,t-1}} \tag{29}$$

Expanding (29) yields (see Appendix 2):

$$\delta H_{Nt} = \sqrt{\frac{\mathbf{i}'\boldsymbol{\Gamma}_{t-1}^*\mathbf{f}_{\rho,t} - \mathbf{i}'\boldsymbol{\Gamma}_{t-1}\mathbf{f}_{\varepsilon,t}}{\mathbf{i}'\boldsymbol{\Gamma}_{t-1}^*\mathbf{f}_{\rho,t-1} - \mathbf{i}'\boldsymbol{\Gamma}_{t-1}\mathbf{f}_{\varepsilon,t-1}} \times \frac{\mathbf{i}'\boldsymbol{\Gamma}_t^*\mathbf{f}_{\rho,t} - \mathbf{i}'\boldsymbol{\Gamma}_t\mathbf{f}_{\varepsilon,t}}{\mathbf{i}'\boldsymbol{\Gamma}_t^*\mathbf{f}_{\rho,t-1} - \mathbf{i}'\boldsymbol{\Gamma}_t\mathbf{f}_{\varepsilon,t-1}}} \tag{30}$$

$$\times \sqrt{\frac{\mathbf{i}'\boldsymbol{\Gamma}_t^*\mathbf{f}_{\rho,t-1} - \mathbf{i}'\boldsymbol{\Gamma}_t\mathbf{f}_{\varepsilon,t-1}}{\mathbf{i}'\boldsymbol{\Gamma}_{t-1}^*\mathbf{f}_{\rho,t-1} - \mathbf{i}'\boldsymbol{\Gamma}_{t-1}\mathbf{f}_{\varepsilon,t-1}} \times \frac{\mathbf{i}'\boldsymbol{\Gamma}_t^*\mathbf{f}_{\rho,t} - \mathbf{i}'\boldsymbol{\Gamma}_t\mathbf{f}_{\varepsilon,t}}{\mathbf{i}'\boldsymbol{\Gamma}_{t-1}^*\mathbf{f}_{\rho,t} - \mathbf{i}'\boldsymbol{\Gamma}_{t-1}\mathbf{f}_{\varepsilon,t}}}$$

where **i** is the unit vector. The first square root on the right hand side of (30) means the effect of the changes in the BOJ's fund-employment or fund-raising portfolio, and the second square root does that of the changes in the Leontief inverse. Denoting δf_t as the first square root, and $\delta\Gamma_t$ as the second square root, (30) can be further simplified as:

$$\delta H_{Nt} = \delta f_t \times \delta\Gamma_t \tag{31}$$

This relation is originated in the property of the Fisher index (Fisher (1927))[9] . Although δH_{Nt} is the changing rate from t − 1 to t, it can be used as chain index as well. When we calculate the changing rate from term 0 to term τ, that is given by:

$$\prod_{t=1}^{\tau} \delta H_{Nt} = \prod_{t=1}^{\tau} \delta f_t \times \prod_{t=1}^{\tau} \delta\Gamma_t \tag{32}$$

8 Fisher (1927), pp.243–248.

9 It should be noted that all the components become scalar by multiplying **i'**, so that (30) reduces to the original Fisher's formula.

5 The Results

There is an asymmetry in the propagation of the supply and the demand of the funds in the financial system. The demand for funds should be eventually financed by the gross induced savings (GIS), while the supply of funds brings gross induced investments (GII) in due course. The QEP requires the central bank to choose two items simultaneously, one in assets and another in liabilities. This action changes GII on the one hand and the GIS on the other. The asymmetry in the propagation process gives net induced investments (NII) as a difference between the GII and the GIS. The sign and the amount of the NII is nothing but the indicator of the effectiveness of the monetary policy made on the non-financial economy. A policy that induces a positive number of NII gives an expansion in the economy, so that it will be welcomed, especially in the course of a recession. In contrast, a money market operation that yields a negative NII, i.e., net induced savings (NIS), weakens the economy so that it should be avoided while the depression prevails[10].

The fluctuations in the three indices, GII(H_I), GIS(H_S) and NII(H_N), between March 1998 and December 2004 are depicted in Figure 7 quarterly. Just for information, same three indicators between March 1980 and March 2004[11] are presented in Figure 8 annually. The first impression might be that the GIS is a mirror image of the GII. Since the asset and the liabilities are matched up on the balance sheet of the BOJ, these two indices fluctuate hand in hand. However, the NII that is the difference between the GII and the GIS is not stable at all. In Figure 8, the NII remains negative between 1980 and 1986 and then stays in the positive domain from 1987 through 1993. The indicator turned into negative in 1994 and remained so since then. As it is obvious in Figure 7, despite the introduction of the QEP in March 2001, the NII stayed in the negative region throughout the period. In that sense, the policy did not help to bail out Japan from its worst recession in more than five decades. But the magnitude of the NII is not stable by any means. After the inauguration of the policy, the NII experienced a set back for more than one year, and the indicator started to show gradual improvement suggesting that the performance of the money market operation was getting better. Especially in 2004, the improvement seems rather obvious.

The quarterly changes in the NII alongside its decomposition are shown in Figure 9. Although the NII stayed in the negative region throughout the period, the indicator moved favourably in and after December 2001. The pillars are divided into two parts: the dotted portion indicates the alteration attributed to the changes in the portfolio of the central bank, and the segment with oblique lines attributable to the mutation of the coefficients of the ALM. As far as the absolute value is concerned, in 23 out of 28 cases (82 per cent), the contributions of the shift in money market operation reflected in the asset and liability portfolio of the central bank are greater than those of the mutation of the ALM. Same thing is demonstrated in Figure 10 in a different manner. The solid line presents the changes in the NII as a proportion to the previous period. Likewise, the broken and dotted lines display those attributable to the BOJ portfolio and

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[10] For further discussion in this respect, see Appendix 3.

[11] End of Japanese fiscal year 1979–2003.

Figure 7 Quarterly Fluctuations in GII, GIS and NII

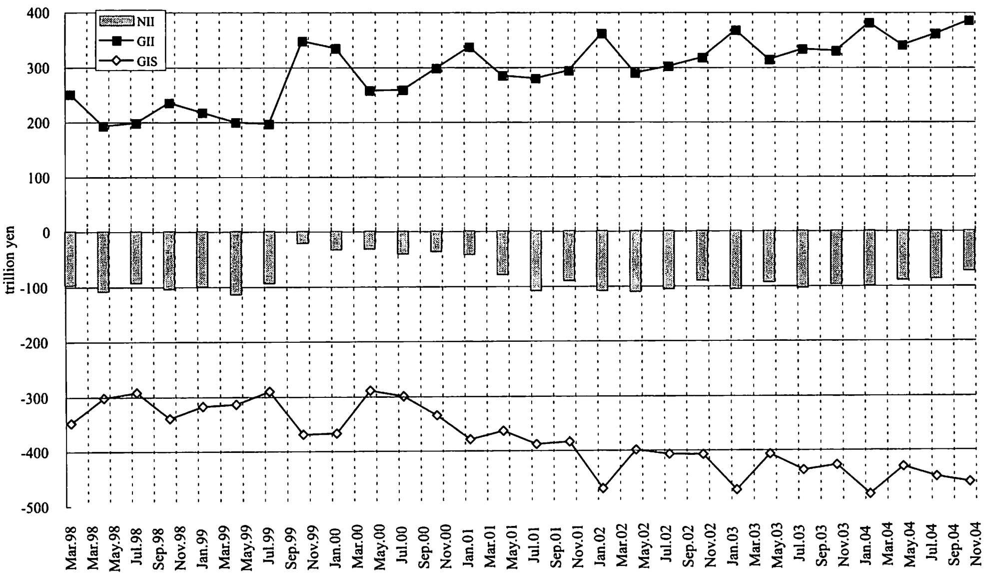
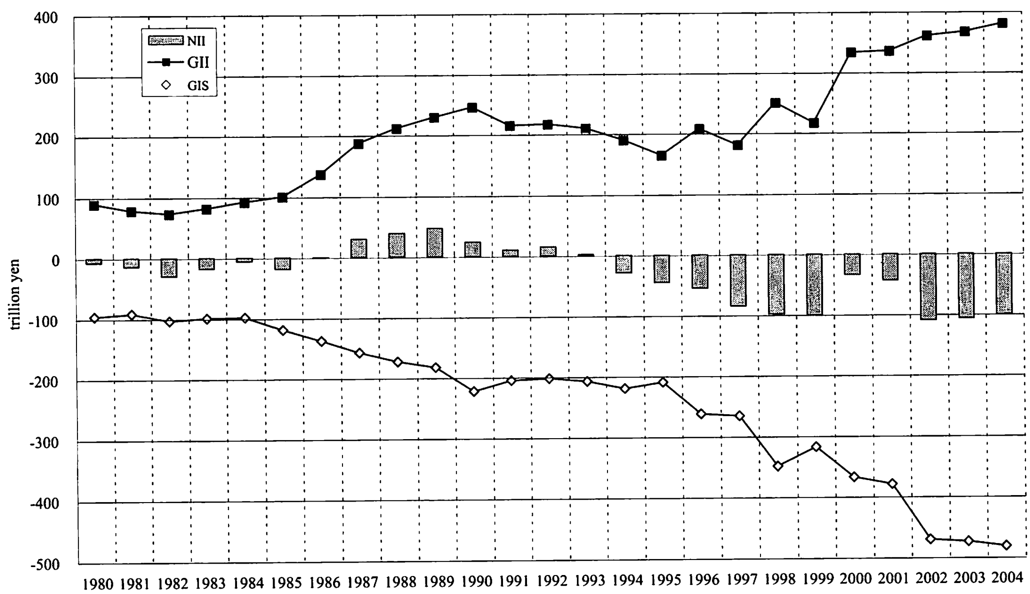


Figure 8 The Fluctuations in GII, GIS and NII (March of the year)



the mutation in ALM respectively. Do mind that the larger the proportion, the absolute magnitude of the NII increases in the negative domain. This picture more or less clearly tells us that the shifts in the portfolio of the central bank have absolute significance to the performance of the non-financial economy in most periods. Actually, in 24 out of 27 cases (90 per cent), the direction of the effects of the money market operation coincides with that of the NII in total. Comparing to this, in only 11 out of 27 cases (41 per cent), the direction of the effects of the mutation of ALM coincides with

Figure 9 The Decomposition of the Changes in NII (differences)

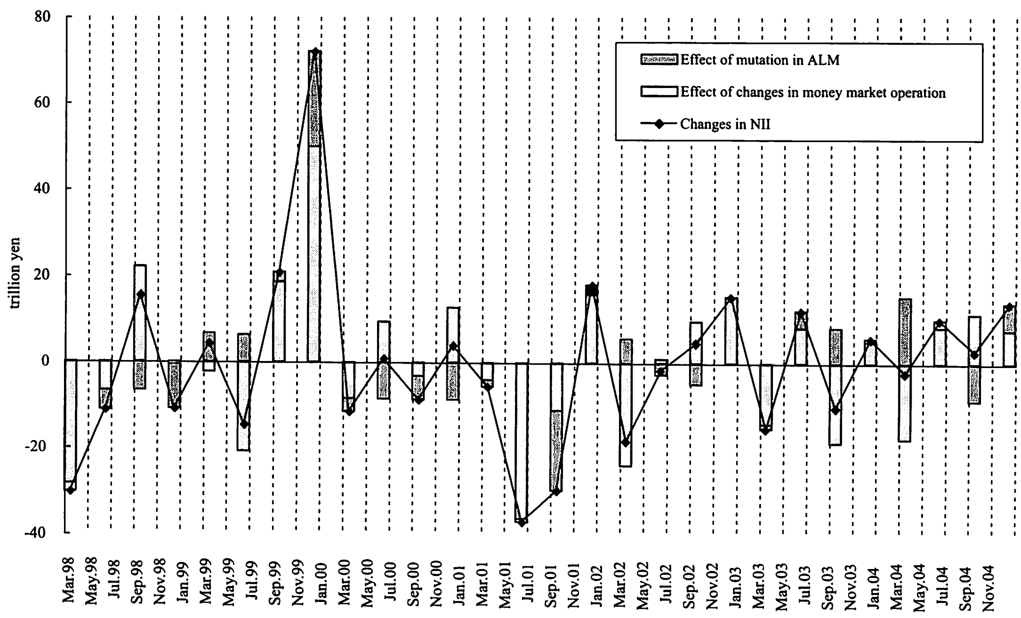
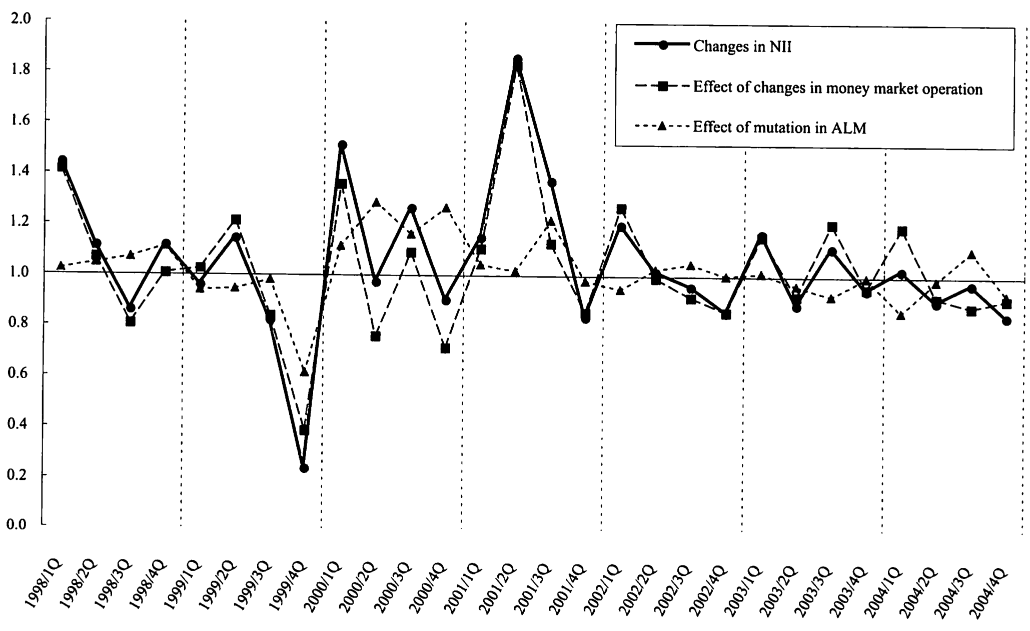


Figure 10 The Decomposition of the Changes in NII (proportion)



that of combined NII. Therefore, it can be said that the money market operation plays a dominant role in the determination of the NII, which in its turn influence the rise and the fall of the non-financial economy.

The next question to be answered is what kind of money market operation brings favourable effects on the NII. Table 2 presents per-unit GII (in the descending order) and GIS (in the ascending order) generated by each available device of money market operations. Since NII is the difference between GII and GIS, the greater is preferred to the smaller in GII while the smaller is preferred to the greater in GIS. It is obvious at the first glance that the newly introduced device, the purchase of the ABS, is more efficient than any other instruments to push up the NII. Among the traditional money market operation tools, the bill purchasing operation and the loans to the commercial banks are the most powerful of all, followed by repurchase agreement and securities lending transactions by narrow margin. The purchasing of corporate stocks, also a new comer, follows close behind the bill purchasing operation. Unfortunately, JGB, the leading item in the BOJ asset portfolio, gives only small GII. On the liabilities side, bill-selling operation is the best device to raise funds because it gives least burden in terms of GIS[12]. The issuance of the bank notes as well as the repurchase agreement and the securities lending transactions give relatively smaller GIS. In contrast to that, the current accounts at BOJ held by the financial institutions and the government are a little more burdensome to the economy.

Table 2: Per unit GII and GIS produced by each money market operation device (Dec 2004)

(2004Q4)

Assets of BOJ	GII	Liabilities of BOJ	GIS
Asset–Backed–Securities	4.4386	Bills sold	0.0266
Loans to private financial institutions	4.1272	Banknotes in circulation	3.0409
Bills purchased	3.9787	Resale agreement and securities borrowing transactions	3.1190
Corporate stocks	3.9291	Current accounts held by financial institutions	3.6301
Repurchase agreement and securities lending transactions	3.1636	Current accounts held by the government	3.7380
JGB	1.9217		
Financing Bills	1.4608		

Note: The amount of GII and GIS produced by increases of 1 unit in asset or liability items.

One advantage of the ALM analysis is that it gives more detailed figures on the sector-by-sector GII and GIS generated by the money market operations. The summarized results are listed in Table 3. The non-financial private enterprises are the largest beneficiary of all in terms of the relative proportion of GII to GIS in general. Both of the newly introduced BOJ's devices of money market operation, i.e., corporate stock and ABS purchasing operations, give large per unit GII to this sector. In sharp contrast to this, money market operations do not benefit households well; rather they give more burdens in the form of GIS. Unless the central bank sells bills to finance it, any type of money market operation fails to produce positive NII on the households. The financial institutions are affected a lot by the money market operations in either way. The ABS and bill purchasing operations as well as the central bank loan directed to them give

[12] The problem is that bill–selling operation causes least GIS because most of the available bills are eventually purchased by the BOJ itself.

Table 3: Monetary operation options and GII GIS for each institutional sector (2004Q4)

Nonfinancial private enterprises

Assets	GII	Liabilities	GIS
Corporate stocks	1.6966	Bills sold	0.0017
Asset–Backed–Securities	0.9277	Current accounts held by the government	0.1991
Loans to private financial institutions	0.8342	Repurchase agreement and securities borrowing transactions	0.2297
Bills purchased	0.7234	Current accounts held by private financial institutions	0.3673
Repurchase agreement and securities lending transactions	0.5542	Banknotes in circulation	0.6825
JGB	0.1683		
Financing Bills	0.0992		

Households and Private nonprofit institutions seving households

Assets	GII	Liabilities	GIS
Asset–Backed–Securities	0.4219	Bills sold	0.0043
Loans to private financial institutions	0.4182	Resale agreement and securities borrowing transactions	0.5561
Bills purchased	0.3359	Current accounts held by the government	0.7401
Corporate stocks	0.3148	Current accounts held by private financial institutions	0.8657
Repurchase agreement and securities lending transactions	0.2359	Banknotes in circulation	1.0529
JGB	0.0775		
Financing Bills	0.0365		

Financial institutions

Assets	GII	Liabilities	GIS
Asset–Backed–Securities	2.5494	Bills sold	0.0193
Bills purchased	2.3988	Banknotes in circulation	1.1917
Loans to private financial institutions	2.3276	Current accounts held by the government	1.5841
Repurchase agreement and securities lending transactions	1.9701	Resale agreement and securities borrowing transactions	2.0725
Corporate stocks	1.5219	Current accounts held by private financial institutions	2.2129
JGB	0.6103		
Financing Bills	0.2285		

Nonfinancial public institutions

Assets	GII	Liabilities	GIS
Financing Bills	1.0967	Bills sold	0.0013
JGB	1.0657	Banknotes in circulation	0.1138
Loans to private financial institutions	0.5472	Current accounts held by private financial institutions	0.1841
Asset–Backed–Securities	0.5396	Resale agreement and securities borrowing transactions	0.2608
Bills purchased	0.5206	Current accounts held by the government	1.2148
Repurchase agreement and securities lending transactions	0.4034		
Corporate stocks	0.3960		

relatively large GII to the financial institutions. However, the commercial banks' own current accounts with BOJ give GIS of 2.2; which will offset most of the GII created by any devices of the central bank operation. Although both per unit GII and GIS are generally small in the non-financial public institutions including central and local governments, they tend to be benefited by FB and JGB operations. JGB purchasing operation, BOJ's prominent operation device, gives significant GII to non-financial public institutions while giving minimal GII to the private sectors.

6 Conclusions

The above-mentioned observation put us in position to determine if the QEP adopted by the BOJ last four years is a success without fearing the confusion of the two causes, i.e., the effects attributed to the BOJ's monetary policy itself and those attributable to the structural changes in the financial market. The analysis suggests that the effect of the former is obviously greater than that of the latter. This reconfirms the usefulness of the ALM derived from the FFA in the assessment of the effects of the money market operations[13]. It is proved that the selection of the operation instrument is vital because there are vast differences between their effects on the non-financial economy. Moreover we can tell that each operation method give conflicting net results on different institutional sectors.

To overcome the persistent recession, it is preferable to adopt money market operation devices that create more NII in the non-financial sectors rather than in public sectors. In this regards, the open market operation of JGB, the device the BOJ has selected at the first stage of the QEP, is the least likely candidate. JGB creates relatively large amount of NII in the public sector, but gives only small amount in the private sectors. Comparing to this, those traditional money market operation devices like bill purchasing or lending facilities induces more favourable effects on the private sectors in terms of NII. Although it is criticized as unusual measures for a central bank, the introduction of new instruments including corporate stocks and ABS to BOJ's asset portfolio widens the opportunity to create more NII in the private sectors.

Four years has passed since the introduction of the QEP by the BOJ that is fighting against the worst recession in the post-war Japan where zero-interest-rate is a matter of fact. The overall performance of the QEP is improving gradually in recent days, partially because of the introduction of the new measures including corporate stock and ABS purchasing operations. As a conclusion it can be said that some type of monetary policy could work even under zero-interest-rate. BOJ, the pioneer in this field, is getting some experiences through trial and error, but still it is a long way to be truly successful.

Appendix 1

[13] For further investigation in the stability of the parameters involved in the ALM in a longer perspective, see Tsujimura and Mizoshita (2004).

Equation (25) in the main text is obtained through the following manipulation of (24):

$$\Delta H_{Nt} = (\mathbf{i}'\boldsymbol{\Gamma}_t^{*}\mathbf{f}_{\rho,t} - \mathbf{i}'\boldsymbol{\Gamma}_t\mathbf{f}_{\varepsilon,t}) - (\mathbf{i}'\boldsymbol{\Gamma}_{t-1}^{*}\mathbf{f}_{\rho,t-1} - \mathbf{i}'\boldsymbol{\Gamma}_{t-1}\mathbf{f}_{\varepsilon,t-1}) \tag{24}$$

$$= \frac{2\,(\mathbf{i}'\boldsymbol{\Gamma}_t^{*}\mathbf{f}_{\rho,t} - \mathbf{i}'\boldsymbol{\Gamma}_t\mathbf{f}_{\varepsilon,t}) - 2\,(\mathbf{i}'\boldsymbol{\Gamma}_{t-1}^{*}\mathbf{f}_{\rho,t-1} - \mathbf{i}'\boldsymbol{\Gamma}_{t-1}\mathbf{f}_{\varepsilon,t-1})}{2}$$

$$+ \frac{(\mathbf{i}'\boldsymbol{\Gamma}_t^{*}\mathbf{f}_{\rho,t-1} - \mathbf{i}'\boldsymbol{\Gamma}_t\mathbf{f}_{\varepsilon,t-1}) - (\mathbf{i}'\boldsymbol{\Gamma}_t^{*}\mathbf{f}_{\rho,t-1} - \mathbf{i}'\boldsymbol{\Gamma}_t\mathbf{f}_{\varepsilon,t-1}) + (\mathbf{i}'\boldsymbol{\Gamma}_{t-1}^{*}\mathbf{f}_{\rho,t} - \mathbf{i}'\boldsymbol{\Gamma}_{t-1}\mathbf{f}_{\varepsilon,t}) - (\mathbf{i}'\boldsymbol{\Gamma}_{t-1}^{*}\mathbf{f}_{\rho,t} - \mathbf{i}'\boldsymbol{\Gamma}_{t-1}\mathbf{f}_{\varepsilon,t})}{2}$$

$$= \frac{\overbrace{\{(\mathbf{i}'\boldsymbol{\Gamma}_{t-1}^{*}\mathbf{f}_{\rho,t} - \mathbf{i}'\boldsymbol{\Gamma}_{t-1}\mathbf{f}_{\varepsilon,t}) - (\mathbf{i}'\boldsymbol{\Gamma}_{t-1}^{*}\mathbf{f}_{\rho t-1} - \mathbf{i}'\boldsymbol{\Gamma}_{t-1}\mathbf{f}_{\varepsilon,t-1})\}}^{(i)} + \overbrace{\{(\mathbf{i}'\boldsymbol{\Gamma}_t^{*}\mathbf{f}_{\rho,t} - \mathbf{i}'\boldsymbol{\Gamma}_t\mathbf{f}_{\varepsilon,t}) - (\mathbf{i}'\boldsymbol{\Gamma}_t^{*}\mathbf{f}_{\rho,t-1} - \mathbf{i}'\boldsymbol{\Gamma}_t\mathbf{f}_{\varepsilon,t-1})\}}^{(ii)}}{2}$$

$$+ \frac{\overbrace{\{(\mathbf{i}'\boldsymbol{\Gamma}_t^{*}\mathbf{f}_{\rho,t-1} - \mathbf{i}'\boldsymbol{\Gamma}_t\mathbf{f}_{\varepsilon,t-1}) - (\mathbf{i}'\boldsymbol{\Gamma}_{t-1}^{*}\mathbf{f}_{\rho,t-1} - \mathbf{i}'\boldsymbol{\Gamma}_t\mathbf{f}_{\varepsilon,t-1})\}}^{(iii)} + \overbrace{\{(\mathbf{i}'\boldsymbol{\Gamma}_t^{*}\mathbf{f}_{\rho,t} - \mathbf{i}'\boldsymbol{\Gamma}_t\mathbf{f}_{\varepsilon,t}) - (\mathbf{i}'\boldsymbol{\Gamma}_{t-1}^{*}\mathbf{f}_{\rho,t} - \mathbf{i}'\boldsymbol{\Gamma}_{t-1}\mathbf{f}_{\varepsilon,t})\}}^{(iv)}}{2} \tag{25}$$

(i) The differences in NII caused by the transition of **f** from t − 1 to t while $\boldsymbol{\Gamma}$ and $\boldsymbol{\Gamma}^*$ are kept at t − 1.
(ii) The differences in NII caused by the transition of **f** from t − 1 to t while $\boldsymbol{\Gamma}$ and $\boldsymbol{\Gamma}^*$ are kept at t.
(iii) The differences in NII caused by the transitions of $\boldsymbol{\Gamma}$ and $\boldsymbol{\Gamma}^*$ from t − 1 to t while **f** is kept at t − 1.
(iv) The differences in NII caused by the transitions of $\boldsymbol{\Gamma}$ and $\boldsymbol{\Gamma}^*$ from t − 1 to t while **f** is kept at t.

Therefore the first term of (25) represents the differences in NII caused by the transition of **f** from t − 1 to t, equally arithmetically weighted by $\boldsymbol{\Gamma}$ and $\boldsymbol{\Gamma}^*$ at t − 1 and t. Likewise, the second term of the equation indicates the differences in NII caused by the transitions of $\boldsymbol{\Gamma}$ and $\boldsymbol{\Gamma}^*$ from t − 1 to t, equally arithmetically weighted by **f** at t − 1 and t.

Appendix 2

Equation (30) in the main text is obtained through the following manipulation of (29):

$$\delta H_{Nt} = \frac{\mathbf{i}'\boldsymbol{\Gamma}_t^{*}\mathbf{f}_{\rho,t} - \mathbf{i}'\boldsymbol{\Gamma}_t\mathbf{f}_{\varepsilon,t}}{\mathbf{i}'\boldsymbol{\Gamma}_{t-1}^{*}\mathbf{f}_{\rho,t-1} - \mathbf{i}'\boldsymbol{\Gamma}_{t-1}\mathbf{f}_{\varepsilon,t-1})} \tag{29}$$

$$= \sqrt{\frac{(\mathbf{i}'\boldsymbol{\Gamma}_t^{*}\mathbf{f}_{\rho,t} - \mathbf{i}'\boldsymbol{\Gamma}_t\mathbf{f}_{\varepsilon,t})^2}{(\mathbf{i}'\boldsymbol{\Gamma}_{t-1}^{*}\mathbf{f}_{\rho,t-1} - \mathbf{i}'\boldsymbol{\Gamma}_{t-1}\mathbf{f}_{\varepsilon,t-1})^2} \times \frac{(\mathbf{i}'\boldsymbol{\Gamma}_t^{*}\mathbf{f}_{\rho,t-1} - \mathbf{i}'\boldsymbol{\Gamma}_t\mathbf{f}_{\varepsilon,t-1})}{(\mathbf{i}'\boldsymbol{\Gamma}_t^{*}\mathbf{f}_{\rho,t-1} - \mathbf{i}'\boldsymbol{\Gamma}_t\mathbf{f}_{\varepsilon,t-1})} \times \frac{(\mathbf{i}'\boldsymbol{\Gamma}_{t-1}^{*}\mathbf{f}_{\rho,t} - \mathbf{i}'\boldsymbol{\Gamma}_{t-1}\mathbf{f}_{\varepsilon,t})}{(\mathbf{i}'\boldsymbol{\Gamma}_{t-1}^{*}\mathbf{f}_{\rho,t} - \mathbf{i}'\boldsymbol{\Gamma}_{t-1}\mathbf{f}_{\varepsilon,t})}}$$

$$= \sqrt{\underbrace{\frac{(\mathbf{i}'\boldsymbol{\Gamma}_{t-1}^{*}\mathbf{f}_{\rho,t} - \mathbf{i}'\boldsymbol{\Gamma}_{t-1}\mathbf{f}_{\varepsilon,t})}{(\mathbf{i}'\boldsymbol{\Gamma}_{t-1}^{*}\mathbf{f}_{\rho,t-1} - \mathbf{i}'\boldsymbol{\Gamma}_{t-1}\mathbf{f}_{\varepsilon,t-1})}}_{(i)} \times \underbrace{\frac{(\mathbf{i}'\boldsymbol{\Gamma}_t^{*}\mathbf{f}_{\rho,t} - \mathbf{i}'\boldsymbol{\Gamma}_t\mathbf{f}_{\varepsilon,t})}{(\mathbf{i}'\boldsymbol{\Gamma}_t^{*}\mathbf{f}_{\rho,t-1} - \mathbf{i}'\boldsymbol{\Gamma}_t\mathbf{f}_{\varepsilon,t-1})}}_{(ii)}}$$

$$\times \sqrt{\underbrace{\frac{(\mathbf{i}'\boldsymbol{\Gamma}_t^{*}\mathbf{f}_{\rho,t-1} - \mathbf{i}'\boldsymbol{\Gamma}_t\mathbf{f}_{\varepsilon,t-1})}{(\mathbf{i}'\boldsymbol{\Gamma}_{t-1}^{*}\mathbf{f}_{\rho,t-1} - \mathbf{i}'\boldsymbol{\Gamma}_{t-1}\mathbf{f}_{\varepsilon,t-1})}}_{(iii)} \times \underbrace{\frac{(\mathbf{i}'\boldsymbol{\Gamma}_t^{*}\mathbf{f}_{\rho,t} - \mathbf{i}'\boldsymbol{\Gamma}_t\mathbf{f}_{\varepsilon,t})}{(\mathbf{i}'\boldsymbol{\Gamma}_{t-1}^{*}\mathbf{f}_{\rho,t} - \mathbf{i}'\boldsymbol{\Gamma}_{t-1}\mathbf{f}_{\varepsilon,t})}}_{(iv)}} \tag{30}$$

(i) The rate of change in NII caused by the transition of **f** from t – 1 to t while **Γ** and **Γ*** are kept at t – 1.
(ii) The rate of change in NII caused by the transition of **f** from t – 1 to t while **Γ** and **Γ*** are kept at t.
(iii) The rate of change in NII caused by the transitions of **Γ** and **Γ*** from t – 1 to t while **f** is kept at t – 1.
(iv) The rate of change in NII caused by the transitions of **Γ** and **Γ*** from t – 1 to t while **f** is kept at t.

Therefore the first term of (30) represents the rate of change in NII caused by the transition of **f** from t – 1 to t, equally geometrically weighted by **Γ** and **Γ*** at t – 1 and t. Likewise, the second term of the equation indicates the rate of change in NII caused by the transitions of **Γ** and **Γ*** from t – 1 to t, equally geometrically weighted by **f** at t – 1 and t.

Appendix 3

We apply the techniques of cointegration tests developed by Engle and Granger (1987) to examine the casual relationship between the rate of change in the GDP and the NII. For simplification, the former is noted as RGDP. Table A–1 reports the summary of augmented Dickey-Fuller (ADF) test using the annual data from March 1980 to March 2004[14]. (a) is the null hypothesis that a single unit root exists in RGDP and ΔRGDP. Based on the ADF – t statistics, the null hypothesis of a unit root in RGDP is not rejected at 1 percent significance level, while that in ΔRGDP is rejected. (b) is the null

Table A–1: ADF test statistics for RGDP and NII

(a) ADF test statistics for RGDP		
	with time trend	**without time trend**
RGDP	–2.891439 (0.1822)	–1.679476 (0.4284)
Lags	0	0
ΔRGDP	–4.975085** (0.0030)	–5.069016** (0.0005)
Lags	0	0
(b) ADF test statistics for NII		
	with time trend	**without time trend**
NII	–2.250718 (0.4419)	–0.834724 (0.7908)
Lags	1	0
ΔNII	–4.850579** (0.0043)	–4.477876** (0.0021)
Lags	1	1

Values in parentheses are MacKinnon (1996) one–sided p–values.
** indicate that the null hypothesis that a single unit root exists can be rejected at 5% significance level. Optimal lag length was chosen based on the Schwarz Information criterion (SIC).

[14] End of Japanese fiscal year 1979–2003.

Table A–2: Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.468696	15.76984	15.49471	0.0455
At most 1	0.051833	1.224157	3.841466	0.2685

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
** MacKinnon–Haug–Michelis (1999) p–values

Table A–3: Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max–Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.468696	14.54569	14.2646	0.0451
At most 1	0.051833	1.224157	3.841466	0.2685

Max–eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
** MacKinnon–Haug–Michelis (1999) p–values

hypothesis that a single unit root exists in NII as well as in ΔNII. The result is that the null hypothesis of a unit root in NII is not rejected, while that in ΔNII is rejected. Then, it suggests that both RGDP and NII are characterized by I(1) process. Table A–2 and A–3 present the results of VAR-based cointegration tests developed by Johansen (1991, 1995). The results indicate that the null hypothesis of no cointegration is rejected at 5 percent significance level. The results indicate that RGDP and NII are cointegrated and have a long run equilibrium relationship.

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