Analysis of the Inter-institutional Flow of Funds Matrix and Systemically Important Financial Institutions

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The global financial crisis put a spotlight on concerns about financial system stability. Currently, there are discussions about how to define systemically important financial institutions (SIFIs) and how to strengthen regulatory measures for these SIFIs. Against the backdrop, this study aims to identify SIFIs by measuring inter-institutional financial transactions with the flow of funds (FOF) account as a measure of interconnectedness. The empirical results show that banks or insurance companies can be SIFIs only in terms of size. However, foreign banks' branches and credit-specialized institutions can also be SIFIs in terms of interconnectedness. Therefore, more specific discussions and regulatory measures for SIFIs will be required from the perspective of capital market development and its own situation in Korea.

I. Introduction

The global financial crisis put a spotlight on concerns about financial system stability. Currently, there are discussions about how to define systemically important financial institutions (SIFI) and how to strengthen regulatory measures for these SIFIs. In particular, as seen in the recent financial crisis, we know that inter-institutional (from whom to whom) capital flows are very important and that the interconnectedness and size of financial institutions are critical factors that define SIFIs.[1)]

* All opinions expressed in this paper represent the author's personal views and thus should not be interpreted as the Korea Capital Market Institute's official position.
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1) According to the Financial Stability Board guidance (2009b), the criteria for systemic importance which can assess the potential to have serious negative impact on the financial system and the real economy include

Interconnectedness can be measured by the size of the inter-institutional transactions which can be obtained from information on transactions carried out by numerous financial institutions.[2] In order to overcome the data constraints and monitor bilateral exposure between institutions, this study utilizes the flow of funds (FOF) table which systematically records various financial activities that occur within the national economy.

Although the FOF table includes useful information, it does not provide a direct observation of interconnectedness among financial institutions. Therefore, this paper first estimates the inter-institutional FOF matrix by applying the input output technique to the FOF analysis, and then analyzes the inter-institutional capital flows based on that estimation. In addition, we utilize the inverse matrix of the inter-institutional financial transaction matrix to compute the transmission effect between institutions, and then estimate inter-connectedness. Finally, we describe some policy implications from our findings.

II. Analysis on Inter-institutional Capital Flows

1. Methodology

As mentioned earlier, the FOF table only records the amount of a transaction or the outstanding amount of financial assets and liabilities held by a financial institution. Therefore, it is difficult to directly observe inter-institutional financial transactions and their capital flows or transmission effect in this table. This limits the table's usefulness to show interconnectedness between economic sectors although the table systematically records all information on financial transactions that occur in the national economy. Furthermore, most studies related to this subject only use part of the data e.g., financial assets and liabilities and financial surplus or deficits, and do not fully capitalize on the data.

financial institutions' size, substitutability, and interconnectedness.

2) Mueller (2006) used data from the Swiss interbank market which provides complete transaction information on from whom-to-whom accounts.

Because the data limitation makes it impossible for us to directly know the actual size of inter-institutional financial transactions, this study estimates it by using bilateral exposures between institutions.[3] Similar to input-output methods, the financial structure of the FOF treats a source of funds as a necessary input for a specific use of funds. And the amount of each input (source of funds) requires a corresponding per unit of each output (use of funds) because a use of funds in one institution is equal to a source of funds in another institution. By definition of the equality of savings and investment, the total use of funds should be equal to the total source of funds for any given time. This duality enables the FOF accounts to be transformed into the inter-institutional FOF matrix, which summarizes the inter-dependence by utilizing the linear fixed relationships.

To analyze the FOF in the form of an institution by institution (inter-institutional) matrix, the first step is to construct the asset matrix (A) by extracting the assets side from the FOF table and then transposing it to an E matrix. To construct the liability matrix (L), the liabilities side is extracted. This asset matrix and liability matrix can be aggregated or disaggregated. Each column of L is a vector representing a fund raising portfolio of an economic institution (k), while each row of the transposed matrix (E) shows the asset allocation portfolio of an economic institution (i).

The second step is to compute the fund raising coefficient matrix (l) by dividing each element of the liability matrix by the total sum of liabilities (t_j). The asset allocation coefficient matrix (e) is computed by dividing each element of the transposed asset matrix by the total sum of the corresponding financial transactions (T_i^E) made by different institutions.

$$l_{kj} = L_{kj} / t_j$$

$$e_{ik} = E_{ik} / T_i^E$$

3) As for related research, please refer to Stone (1966), Stone and Roe (1971), Klein (1983), Tsujimura and Mizoshita (2003). A more recent study is done by Castren and Kavonius (2009) who use the inter-linkages between balance sheets.

Subsequently an inter-institutional coefficient FOF matrix (c) is converted from the asset matrix and the liability matrix by using the formulas below, which are frequently utilized for input-output analysis based on the institutional sector portfolio assumption. If the inter-institutional relationship between the sources and uses of funds in economic institutions exists under two assumptions - equilibrium in ex-ante sense is reached, and the relationships are in fact approximately linear - then the coefficient matrix will be unique and valid for any given vector corresponding to the use of funds. Under this condition, the quantities of funds supplied to institutions can be determined by any given set of quantities of the use of funds.

Where e_{ik} stands for the institution i's share of a financial instrument k in its total assets, l_{kj} stands for the institution j's share of a financial instrument k in its fund-raising portfolio. The inter-institutional FOF coefficient matrix c_{ij} indicates the ratio of fund-raising and asset-allocation between economic institutions.

$$c_{ij} = \sum_{k=1}^{n} e_{ik} l_{kj}$$

Finally the inter-institutional FOF matrix (C) is obtained by multiplying the coefficient matrix by the total sum of assets (t_j)[4] and inter-institutional financial transaction matrix is obtained by differences between periods as shown in Table 1.

$$c_{ij} t_j = C_{ij}$$

Financial sectors and real sectors are used in Table 1 to analyze the pattern of the inter-institutional financial transactions. The columns indicate the amount of funds raised from an institution (i) to the other institution (j) while the rows show the amount of asset-management from an institution (i) to the other institution (j).

4) The process of converting the flow of funds account into the inter-institutional flow of funds table entails an estimation error that results from distributing the fund raising coefficient (l_{kj}) and asset allocation coefficient (e_{ik}) to the case in which no financial transaction between sectors was made. Therefore, the cross entropy (CE) method is applied to solve this estimation problem. It is one of estimation methods to minimize the Kullback-Leibler cross entropy measure of the distance between the new and the prior estimate of probability. This method is used for balancing the social account matrix (Fofana et al, 2005).

Table 1. Inter-institutional financial transaction matrix

		Financial Sector (FS)								Real Sector (RS)					
		CB	BANK	NBANK	INS	PENS	OFI	FIAUX	Sub Total	GOV	Firm	HH	ROW	SubTotal	Total Asset Allocation
FS	CB														
	Bank														
	NBank														
	INS														
	PENS														
	OFI														
	FIAUX														
	sub-total								1)					2)	
RS	GOV														
	Firm														
	HH														
	ROW														
	sub-total								3)					4)	
	Total Fund Raising														5)

CB: Central Bank, NBANK: Non-bank, INS: Insurance, PENS: Pension, OFI: Other Financial Intermediaries, FIAUX: Financial Auxiliaries, GOV: Government, HH: Household, ROW: Rest of the World

1) Financial transactions within the financial sector (FTWFS): The total amount of financial transactions between financial institutions.
2) Asset allocation of the financial sector (AAFS): The total amount of funds the financial sector allocated to the real sector.
3) Fund raising of the financial sector (FRFS): The total amount of funds the financial sector raised from the real sector.
4) Financial transactions within the real sector (FTWRS): The total amount of financial transactions within the real sector.
5) The total amount of all financial transactions (Grand Total) = The sum of 1 to 4.

2. Empirical Results

A. The structure of inter-institutional financial transactions

The trial calculation from 2003 to 2009 shows that the total nominal amount of all financial transactions increased from 321.7 trillion won in 2004 to 1,101.5 trillion won in 2007. However, it decreased to 620 trillion won in 2008 because of falling stock prices resulting from the global financial crisis. Then, the figure increased to 811.2 trillion won thanks to the economic recovery. However, it failed to reach the pre-crisis level because the crisis substantially reduced the financial transactions within the real sector.

On the other hand, Figure 2 shows that the crisis did not affect the total real amount of all financial transactions, which reflect the adjustment from the changes in the foreign exchange rate and the prices of stocks and bonds. However, an interesting point is that total financial transactions declined from 800.3 trillion won in 2005 to 593 trillion won in 2006 because of the changes in the price of bonds held by the insurance sector. Contrary to market value estimates, financial transactions within the real sector increased in 2008, but declined substantially in 2009.

Figure 1. Financial transactions of the financial and real sector (market value)

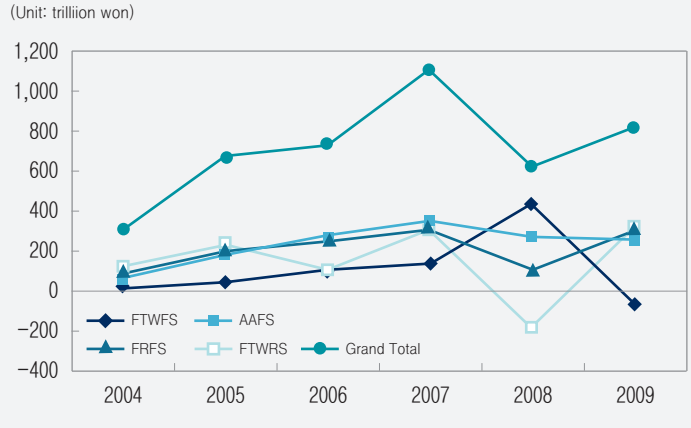
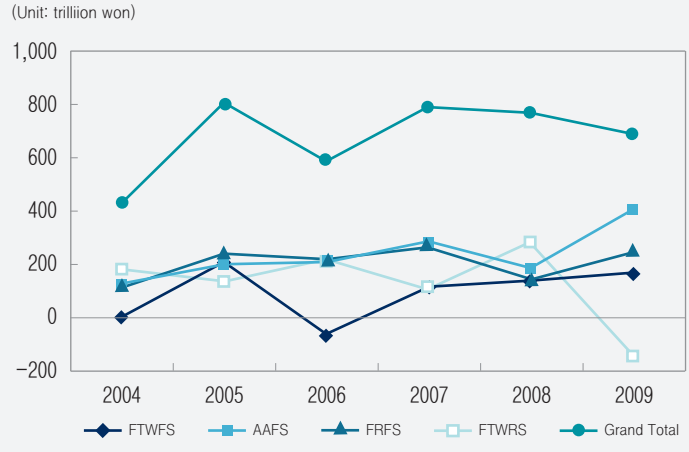


Figure 2. Financial transactions of the financial and real sector (1 trillion won)



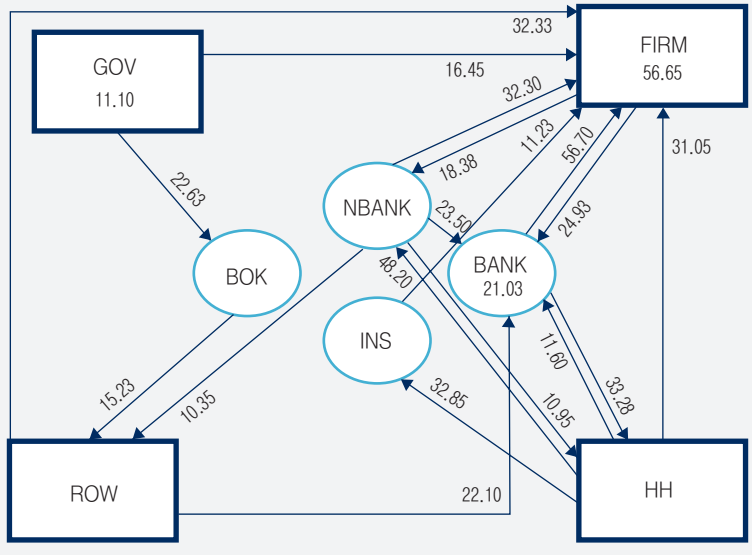
B. Inter-institutional capital flows analysis

This section overviews the major characteristics of inter-institutional capital flows before and after the crisis. For the annual average of capital flows during 2004 to 2007, the bank sector borrowed 22.1 (20.98)[5] trillion won and the firm sector borrowed 32.33 (40.95) trillion won respectively from overseas. Meanwhile, the household sector allocated 48.2 (49.1) trillion won to the non-bank sector and 11.6 (10.8) trillion won to the bank sector because the household sector preferred equity funds to bank deposits during this period. Consequently, capital flows shifted to the non-bank sector which includes asset management companies (mainly investment trust companies). Out of the capital which went to the non-bank sector, 10.35 (12.6) trillion won was invested in overseas assets during the overseas fund boom while the bank sector borrowed 22.1 (20.98) trillion won from overseas. In addition, the household sector allocated 32.85 (33.6) trillion won annually to the insurance sector from 2004 to 2007.

5) The figures in parenthesis stand for the transaction amount based on market value.

Figure 3. The annual average amount of capital flows during 2004-2007

(10 trillion won, book value)



(10 trillion won, market value)

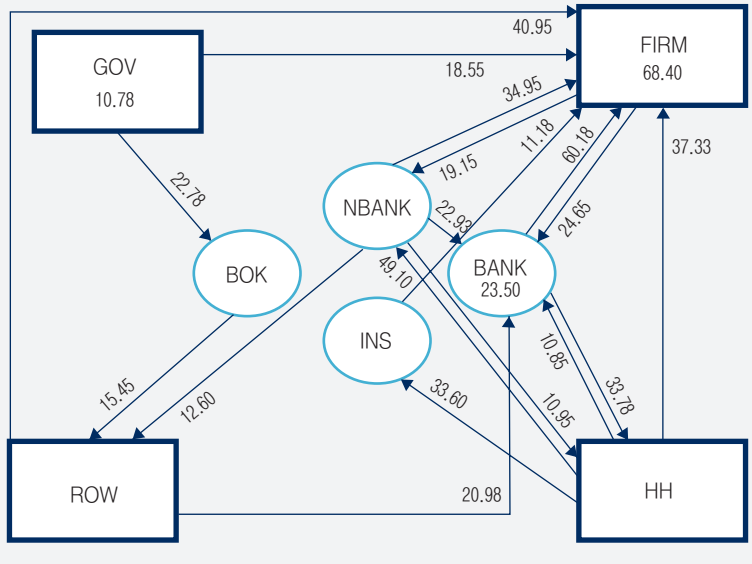


Figure 4. The annual average amount of capital flows in 2008

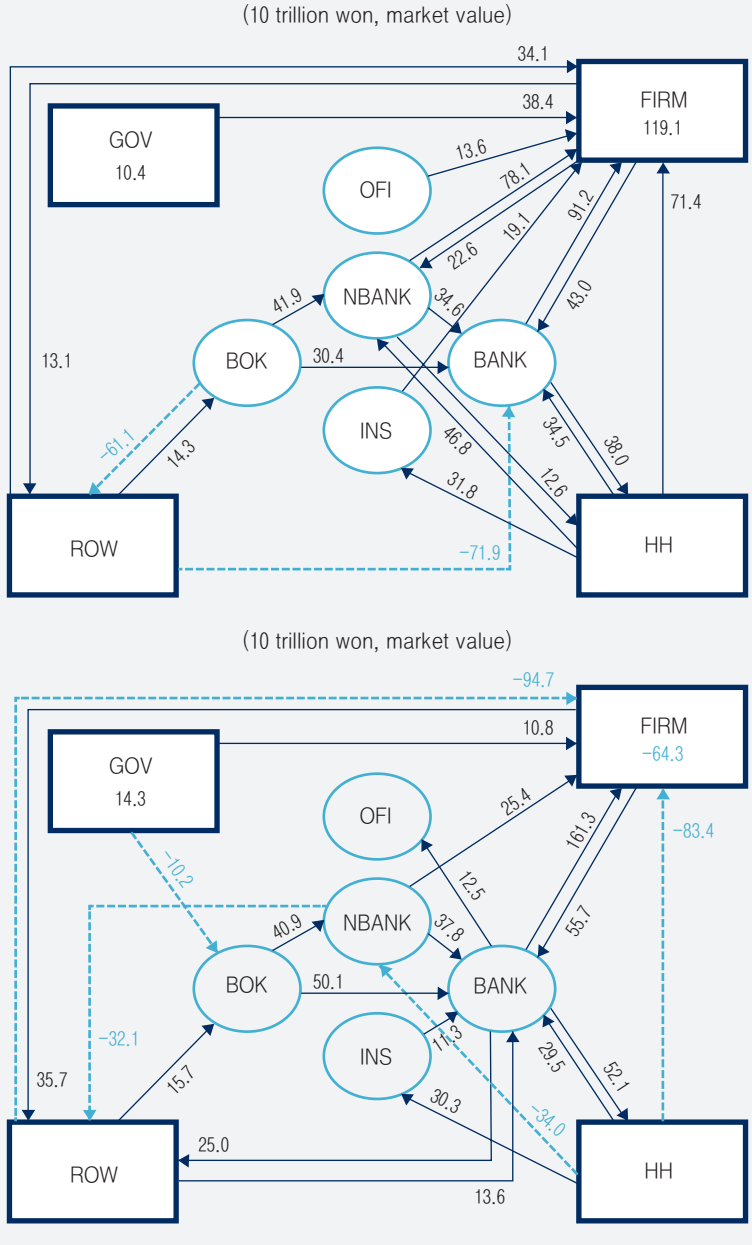
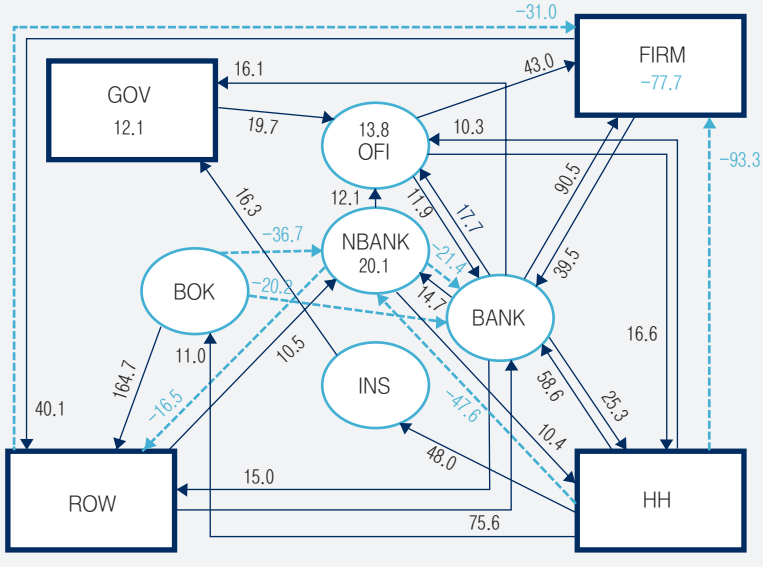
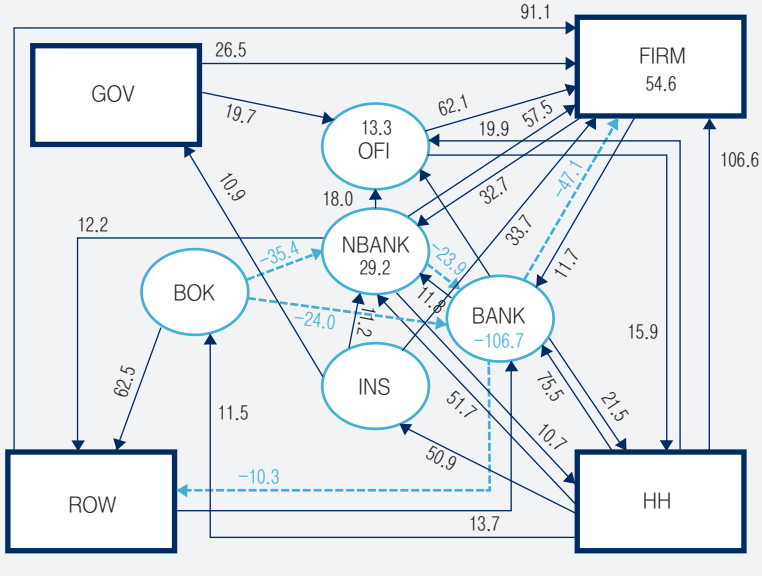


Figure 5. The annual average amount of capital flows in 2009

(10 trillion won, market value)



(10 trillion won, market value)



As for changes in inter-institutional capital flows, 34.5 trillion won was injected to the bank sector due to fund redemption and investors' preference over safe assets, and 71.9 trillion won flowed out of the bank sector to overseas. In response to the global financial crisis, the Bank of Korea injected 41.9 (40.9) trillion won to the non-bank sector and 30.4 (50.1) trillion won to the bank sector. Meanwhile, households allocated 38 (52.1) trillion won to the bank sector and 12.6 trillion won to the non-bank sector in 2008. However, as the crisis subdued in 2009, the Bank of Korea decreased its asset allocation to the bank sector by 20.2 (24) trillion won and to the non-bank sector by 36.7 (35.4) trillion won respectively. On the other hand, financial transactions within the bank sector and the non-bank sector increased by 99.6 trillion won and 20.1 trillion won respectively. Financial transactions between the Bank of Korea and overseas also increased to 164.7 (62.5) trillion won, and transactions between the household sector and other financial institutions such as credit specialized financial institutions went up because of increasing consumer financing. In general, the size of financial transactions has increased and become more complicated compared with the pre-crisis situation.

III. Analysis to Identify Systemically Important Financial Institutions

A. Methodology

The biggest advantage of the input output analysis is what helps analyze the effect of one sector's demand on another sector's demand by using the Leontief inverse matrix. Likewise, converting the FOF table into a square matrix enables us to analyze the effect of a specific institution's financing demand on other institution's financing demand.[6] Therefore, this study analyzes the inter-connectedness and the transmission effect of the financial system, which includes the real sector such as firms, households, the government, overseas sector, and the financial sector. Through the analysis, we

6) While the input output table indicates the relationship between the input-output of various goods and industries, the flow of funds table indicates the relationship between funds traded via financial instruments. To analyze the transmission effect between institutions, we can use the Leontief inverse matrix from the perspective of demand and the Goshian inverse matrix from the perspective of supply. This study focuses on the demand (liability) side rather than the supply (asset) side.

attempt to propose a new method to identify which financial institution exerts a bigger transmission effect than others as a systemically important financial sector.

The total assets (liabilities) of an institution j, t_j consists of inter-institutional transactions ($c_{ij} = c_{ij}t_j$) and excessive liabilities (ε_j). By solving the equation for t_j, we can obtain the Leontief inverse matrix of the FOF version, $(1 - c_{ij})^{-1}$, which shows the direct and indirect impact that one unit of extra financing demand from one institution imposes on other institutions' demand.

$$c_{ij}t_j + \varepsilon_j = t_j$$

$$t_j = (1 - c_{ij})^{-1}\varepsilon_j$$

$$\Gamma = (I - c)^{-1} = \begin{bmatrix} \gamma_{11} & \cdots & \gamma_{1m} \\ \vdots & \cdots & \vdots \\ \gamma_{m1} & \cdots & \gamma_{mm} \end{bmatrix}$$

In the financial system, the power-of-dispersion index (PDI, ω_j^C) indicates the direct as well as indirect financing demand in total induced by one unit of shock, which is an extra financing demand from a certain institutional sector (j). As ω_j^C becomes higher, the direct and indirect impact of the additional shock on the whole financing demand increases.

$$\omega_j^C = \frac{\sum_{i=1}^{m}\gamma_{ij}}{\frac{1}{m}\sum_{j=1}^{m}\sum_{i=1}^{m}\gamma_{ij}}$$

On the other hand, the sensitivity-of-dispersion index (SDI, ω_j^C) indicates the direct as well as indirect financing demand from a certain institutional sector (i) induced by one unit of shock, which means an extra financing demand from all of each institutional sector. As ω_j^C becomes higher, the direct as well as indirect financing demand induced by a certain institutional sector increases.

$$\omega_i^C = \frac{\sum_{j=1}^{m}\gamma_{ij}}{\frac{1}{m}\sum_{j=1}^{m}\sum_{i=1}^{m}\gamma_{ij}}$$

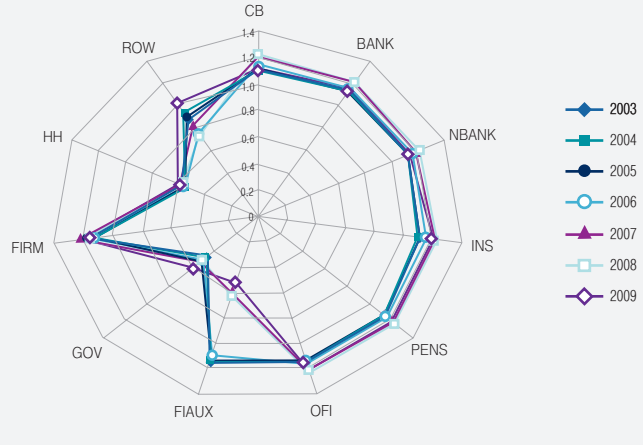
B. Analysis to identify systemically important financial sectors

While Figure 6 indicates that PDIs were evenly distributed from 0.45 to 1.15 in 2003 (0.58~1.21 in 2009), Figure 7 demonstrates that SDIs varied widely ranging from 0.45 to 1.15 in 2003 (0.03~3.40 in 2009).

Looking at individual institutions, firms and financial institutions have PDIs bigger than 1, which means their financing demands have a larger impact on the financial system. In the case of the government and overseas sectors, their PDIs increased from 0.45 to 0.58 and 0.87 to 1.02 respectively, which also suggests that their financing demand exerts a bigger impact on the financial system.

However, as financial auxiliaries shrank their liabilities side such as equity financing and bank borrowing while expanding their asset side such as investments in bonds and derivatives, they converted from borrowers to lenders. Their PDIs changed substantially from 1.15 in 2003 to 0.52 in 2009, which means that the impact of their financing demands on the financial system declined sharply.

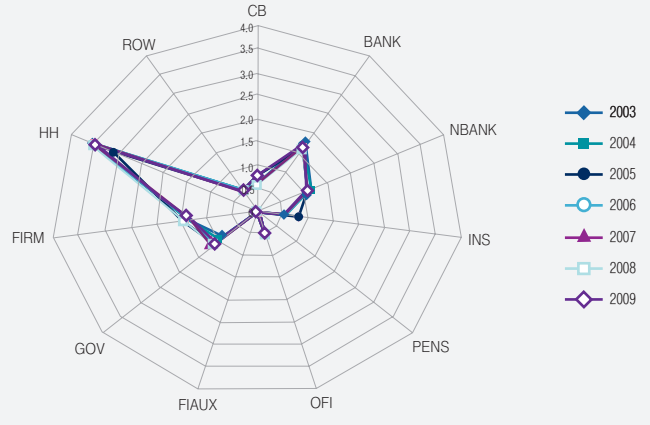
Figure 6. Power-of-dispersion index in liability



Households who are capital suppliers have an SDI bigger than 3 while their PDI is below 1. As for banks and non-banks, the SDI is bigger than 1. However, institutional investors, such as pension funds and insurers, raise funds primarily from households

although their asset allocation is limited. As a result, their PDI is smaller than the SDI.[7)]

Figure 7. The sensitivity-of-dispersion index in liability



To identify SIFIs (sectors), the whole financial sector is disaggregated further into 17 sectors, and SIFIs are ranked according to the inter-connectedness based on their PDI, SDI, and the size of liabilities as shown in Table 2. In terms of size, firms and households are classified as SIFIs in the real sector while banks, special banks, and insurers are defined as SIFIs in the financial sector. However, in terms of inter-connectedness based on PDIs, foreign banks' branches and credit-specialized institutions can be classified as SIFIs. The results imply that Korea needs to take account of its own situation and its financial market development in devising unique standards and regulatory measures that are appropriate to determine which institutions should be classified as SIFIs.

7) In the input output table, the goods of the industry with a high sensitivity-of-dispersion index are widely used as intermediate goods in other industries. If interpreted according to the flow of funds table, financial goods of the household sector and the bank sector are widely used as intermediate goods in other institutions. However, institutions such as pension and financial auxiliaries have lower SDIs due to their limited asset allocations.

Table 2. Rank of Systemically Important Financial Setors (Institutions)

	Inter-connectedness								Size			
	SDI				PDI				Total Liabilities			
Year	02	03	08	09	02	03	08	09	02	03	08	09
HH	1	1	1	1	20	20	20	19	3	3	3	3
Firm	2	2	2	2	2	3	4	3	1	1	1	1
Bank	3	3	3	3	12	12	8	8	2	2	2	2
GOV	4	4	5	5	21	21	21	21	11	11	10	10
ROW	5	5	4	4	15	16	11	13	5	4	4	4
SPBank	6	6	6	7	13	14	9	11	4	5	5	6
INS	7	7	7	6	19	19	17	18	6	6	6	5
INVINS	8	10	9	9	9	10	12	14	7	9	8	9
MFI	10	9	10	10	17	17	14	16	8	7	9	7
CB	9	8	8	8	11	13	13	12	10	8	7	8
Trust	11	11	13	13	8	7	3	4	12	12	14	14
CSI	12	16	14	15	1	1	2	2	13	16	15	16
OFI	13	14	17	17	4	5	6	7	14	13	17	18
PFI	14	15	15	14	10	11	15	15	9	10	13	11
FBB	16	12	11	12	5	2	1	1	16	14	11	12
SECU	15	13	12	11	6	9	5	5	15	15	12	13
ODI	17	17	16	16	16	15	10	9	17	17	16	17
PENS	18	18	19	19	18	18	16	17	18	18	19	19
FIAUX	19	19	20	20	3	4	19	20	19	19	21	21
BHC	20	20	18	18	14	6	18	6	20	20	18	15
MUTUAL	21	21	21	21	7	8	7	10	21	21	20	20

CB: Central Bank, NBANK: Non-bank, INS: Insurance, MFI: MicroFinance Institution, PENS: Pension, OFI: Other Financial Intermediaries, FIAUX: Financial Auxiliaries, GOV: Government, HH: Household, ROW: Rest of the World, BHC: Bank Holding Company, MUTUAL: Mutual Fund, SECU: Securities Company, FBB: Foreign Bank Branch, CSI: Credit Specialized Institution, TRUST: Trust Company, PFI: Public Finance Institution, SPBank: Special Bank, INVINS: Investment Institution, ODI: Other Depository Institution.

IV. Summary and Policy Implications

Most studies on FOF analysis have only covered limited areas by using partial data linked to individual institutions in the FOF account. However, this study proposes a quantitative framework to comprehensively analyze the overall inter-connectedness of the financial system based on inter-institutional financial transactions. In reality, it is very difficult to supervise and regulate all financial institutions. Therefore, this analysis framework should help regulators identify which financial institutions should be subject to tighter supervision. In addition, the methodology adopted in this study is expected to contribute to the wider use of the flow of funds table and the estimation of inter-connectedness which helps study systemic risks.

According to the estimates in this study, the bank sector which has been generally considered as systemically important is important only in terms of size. However, foreign banks' branches or credit-specialized institutions[8] can be SIFIs if their inter-connectedness and Korea's economic situation is taken into account. Therefore, Korea needs to devise its appropriate regulatory measures for these financial institutions.

In order to identify elaborately systemic risks in the financial sector and individual SIFIs, more specific segments to classify financial institutions and a shorter analysis period i.e., on a quarterly basis, may be necessary. Furthermore, a consolidated analysis framework to link the FOF table and the SNA as well as the input-output table will allow a better understanding of the interaction between the real sector and the financial sector.[9]

8) Credit specialized institutions refer to financial institutions which give out loans, but do not receive deposits. This includes credit card companies, finance companies, lease companies, and new technology financing companies.

9) Please refer to Klein (2003) and Hyun (2010) for more details.

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