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An empirical contribution to Minsky's financial fragility

Evidence from non-financial sectors in Japan

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Abstract

This study presents an empirical analysis to detect Minsky's financial fragility and its determinants in the non-financial sectors in Japan, with particular attention paid to differences between sectors and sizes. While Minsky developed theoretical analyses of financial fragility for use in economic growth models, its empirical application is limited. Based on the financial fragility indices derived from a cash flow accounting framework and Minsky's margins of safety, I detect the overall configuration and evolution of financial fragility (hedge, speculative, and Ponzi) in Japan. Then, the factors that determine the probability of being Ponzi finance are detected by using panel logistic regression. In doing so, this study reveals that although speculative finance is dominant in many sectors, the evolution of financial fragility is diversified and its determinants differ according to sector and size in Japan.

Keywords: Minsky, Financial fragility, Margin of safety, Japanese economy

JEL Classification: E12, C25, N15

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1 Introduction

This study aims to empirically detect financial fragility in the non-financial sectors of Japan on the basis of Hyman P. Minsky's argument. Minsky (1982, 1986) classified the financial fragility of firms in an economy by hedge, speculative, and Ponzi finance to categorize the stability of the economy. However, while Minsky's financial dynamics are captured by post-Keynesian theoretical models, empirical analyses of financial fragility are rare compared with theoretical ones.

Minsky emphasized the interrelationship between a firm's internal funds, investment, debt accumulation, and interest rates to explain the causes and consequences of financial fragility and instability. Because this essence of his argument especially fits the Japanese non-financial sector's behaviour, I conduct an empirical analysis based on Minskian insight for this economy. First, the Japanese economy involves financial dynamics that Minsky attempted to capture. It is traditionally classified into an economy of bank-based financial institutions (Schaberg, 1999; Allen and Gale, 2000; Hölzl, 2006). Debt finance from the main bank has played a crucial role in firms' activity in Japan. Although large Japanese firms began to be independent of banks in the 1980s, they nonetheless depend on borrowing from main banks to conduct operating activities and accumulate capital. Thus, the linkage among internal funds, capital accumulation, debt accumulation, and repayments emphasized by Minsky helps us understand Japanese financial performance. In this vein, how can Minsky's financial fragility be empirically detected in Japanese non-financial sectors? The current study tries to answer this question.

In addition, Minsky emphasized that financial factors cause business cycles. Indeed, Japan has undergone booms and depressions that are closely determined by financial factors since the 1980s. Although asset prices exploded in the late 1980s, leading to booms owing to the bubble economy, the bubble burst at the beginning of the 1990s. Consequently, the Japanese economy worsened because of the bad loan problem and was further damaged by the Asian financial crisis of 1997–98. Since the beginning of the 2000s, as the bad loan problem was gradually addressed during the Koizumi administration, the Japanese economy has slowly recovered from the stagnation of the lost decade. However, following the global financial crisis of 2008 originating in the United States, its GDP growth rate fell by -5.5% in 2009. Thus, financial factors are closely

related to the booms and depressions of the Japanese economy. In this sense, the Japanese experience is a good sample with which to investigate the mechanism of financial fragility based on Minsky's argument, which was constructed on the basis of the US economy after World War II.

This study makes three main contributions. First, in classifying the three stages of financial conditions (i.e., hedge, speculative, and Ponzi finance), I introduce the margins of safety that Minsky emphasized as an index of financial fragility. The margins of safety play an important role in his argument as the main determinants of financial fragility (Kregel, 1997). However, as I review in the next section, they have never been explicitly employed in the empirical analysis of financial fragility. By using Minsky's original text as much as possible, this study explicitly introduces the margins of safety to measure the financial fragility of non-financial sectors in the Japanese economy. The measurements presented in the current study can be applied to other countries to detect financial fragility as long as appropriate financial statistics are available.

Second, this study explores the financial fragility of the Japanese economy on the basis of different sectoral performance. In doing so, attention is also paid to sectoral size. As I show below, the stage and evolution of financial fragility actually differ according to sector and size in Japan. An aggregate analysis focusing on national economic performance, as is often employed in empirical analysis, cannot understand such diversity and therefore may cause misunderstanding about the nature of financial fragility. For example, consider an economy in which one sector is in a hedge position and the other sector is in a speculative or a Ponzi position. In this case, lending or interest rate policy should differ accordingly. A rise in interest rates may hardly affect the hedge position sector, whereas the speculative or Ponzi position sector is vulnerable to changes in interest rates, leading to financial instability for the overall economy. Minsky (1986) recognized that financial shocks differ by their different degrees of financial fragility. Sectoral analysis based on size thus enables us to understand the characteristics of financial fragility more in detail.

Third, I also shed light on the determinants of these three stages of financial fragility by using econometric analysis. Section 2 surveys empirical studies that have also detected these three stages of financial fragility. While these have contributed to the taxonomy of financial fragility in the countries examined, the determinants of each stage are unclear. Therefore, uncovering the main determinants of the degree of financial

fragility is a remaining issue. The current study complements the taxonomy by econometrically detecting the main determinants of financial fragility according to Minsky's original argument. In particular, I employ panel logistic regression models to detect the determinants of the probability of being Ponzi finance in each sector and size. In this analysis, I introduce the role of the output gap, interest rates, retention rate, and debt ratio in these models on the basis of the hypothesis deduced from Minsky's arguments.

The remainder of this paper is organized as follows. Section 2 reviews related studies of Minsky's financial fragility. After reviewing the contributions and limitations of the related literature, I explain the novelties of the current study once again. Section 3 defines the financial fragility of hedge, speculative, and Ponzi finance, based on a cash flow accounting framework and Minsky's margins of safety. This section also describes the data and its processing for the empirical analysis. Section 4 presents the empirical analysis, in which I consider the overall and dynamic properties of financial fragility according to sector and size. Section 5 complements the previous sections by detecting the determinants of financial fragility with an econometric analysis. Section 6 concludes.

2 Studies of Minsky's financial fragility

Minsky (1975, 1982, 1986) inspired current post-Keynesian financial economics. He explained fluctuations in investment in a capitalist economy by focusing on a firm's debt finance. His financial instability hypothesis consists of two theorems (Minsky, 1992). The first theorem is an economy that has both stable and unstable financial regimes, while the second theorem is that an economy transits from financial relations that make for a stable system to financial relations that make for an unstable system over periods of prolonged prosperity.[1]

Minsky described financial instability as an endogenous process and an inherent defect of a capitalist economy: a firm's investment depends on the expectations of entrepreneurs about future cash flow. With a booming economy, entrepreneurs' expectations become more optimistic, which leads to the expansion of investment. Stability then causes subsequent instability. Such an investment boom is financed by more and more firm-level debt finance. When investment is implemented beyond a firm's internal funds, excessive debt accumulation results. Consequently, the firm's cash flow cannot cover the repayment of the principal and

interest in flow terms, and its debt-capital ratio gradually rises in stock terms. Thus, the firm's finance position becomes more fragile. Further, when Ponzi finance is dominant in an economy, financial instability may be more likely to happen.[2]

Minsky's argument of financial fragility has been extended to account for several issues such as a firm's finance and investment, a household's debt and consumption, and economic growth and business cycles. The firm's financial fragility is especially relevant to the current study, as recent research in this direction can be summarized as relatively developed theoretical models compared with few empirical studies.

Post-Keynesian studies placed Minsky's description of financial fragility and instability into theoretical models. The seminal study by Foley (2003) explicitly introduced hedge, speculative, and Ponzi positions into a macroeconomic model. His model also extended Taylor and O'Connell's (1985) model of the Minsky crisis. Foley (2003) showed that a firm's finance position is close to Ponzi finance when it has a low growth rate and profit rate.

Several contributions were subsequently presented based on these models. For example, Lima and Meirelles (2007) showed that the stability of hedge finance is assured by a procyclical banking mark-up policy, whereas Ponzi finance would be unstable regardless of the interest rate policy. Charles (2008) presented a dynamic model with a Minskian financial structure that tends to be unstable. By linking a firm's capital accumulation and finance positions in a dynamic model, these studies have revealed how economic growth can be financially unstable. Vercelli (2011) described the cyclical interaction between liquidity and solvency for financial units. In his broad classification of financial fragility, including hyper speculative and highly distressed categories, the phase in which economic units suffer from liquidity and solvency problems is termed the Minsky process.

Studies have also explored the dynamic stability of not only the firm's finance position but also its growth regimes. Nishi (2012) showed the stability of debt-led and debt-burdened growth regimes while considering the firm's finance position. His results highlighted that growth under Ponzi finance is necessarily unstable regardless of the regime. Sasaki and Fujita (2014) also examined the stability of debt-led growth and debt-burdened growth regimes. They explained that a debt-burdened growth regime may present cyclical

fluctuations such that a firm's finance position changes periodically from a speculative to a Ponzi one. Further, Fazzari et al. (2008) presented a Keynes–Minsky simulation analysis that emphasizes the effect of finance on investment. On the basis of a dynamic model that endogenously determines cash flow, investment, and nominal interest rates, they reproduced a Minsky cycle in which a debt-led boom systematically led to a downturn. Nikolaidi (2014) introduced the desired margins of safety for a firm and bank into a higher dimension dynamic model. She showed that an endogenous change in the desired margins of safety is likely to transform a stable debt-burdened economy into an unstable one, thus producing cyclical investment and leverage behaviour.[3]

While these theoretical analyses have revealed the causes and consequences of Minskian financial fragility in growth and cycle models, their empirical application has been limited. It is only recently that some researchers began presenting empirical analysis. Schroeder (2009), Mulligan (2013), and Tymoigne (2014) may be pioneers in this field, and I am inspired by them in conducting the present empirical study. The empirical part of Schroeder (2009) dealt with financial fragility in New Zealand between 1990 and 2007. By extending the representative firm's financial fragility criteria developed by Foley (2003), she explained the evolution of financial fragility at the macroeconomic level. According to her results, New Zealand has exhibited an increasing degree of financial fragility by shifting from a hedge position into a speculative position in 2003, which further led to a Ponzi position in 2004. Tymoigne (2014) constructed financial fragility indices (FFIs) by weighting real and financial variables and applied them to residential housing in the United States, the United Kingdom, and France. According to his results, financial fragility in residential housing rapidly increased from the early 2000s, with a high level of fragility from 2004 in the United States. Mulligan (2013) applied Minsky's financial instability hypothesis to North American firms to investigate financial fragility at the sectoral level between 2002 and 2009. He provided direct empirical support for the financial instability hypothesis on a sector-by-sector basis.[4] He found that the number of hedge and Ponzi firms grew steadily until the recession was imminent; however, when the financial crisis of 2008 hit, numerous hedge firms entered either a speculative or a Ponzi position. Although these studies examine the financial fragility of different countries, they all show that financial fragility worsened after the 2000s.[5]

However, although these works explored the empirics of Minskian financial fragility, each overlooked

important empirical issues. First, none of these studies takes Minsky's margins of safety into consideration when classifying financial fragility. The margins of safety are key variables that determine financial fragility. Second, the scopes of the studies of Schroeder (2009) and Tymoigne (2014) are limited to the aggregate level. Consequently, their analyses do not capture sectoral differences in financial fragility. As diverse performances among industries play a decisive role in shaping macroeconomic performance in Japan, it is important to detect the sectoral heterogeneity of financial fragility. Third, although Mulligan (2013) focused on sectoral differences in financial fragility, the study's criteria for hedge, speculative, and Ponzi finance are somewhat ad hoc. Fragility is defined on the basis of a firm's interest coverage: greater than or equal to 4.00 represents a hedge unit, between 4.00 and zero represents a speculative finance unit, and less than zero represents a Ponzi finance unit. However, Mulligan (2013) never justified these thresholds in his study. In addition, Minsky never employed these thresholds as far as I know. Hence, more appropriate thresholds founded on Minsky's argument are required. Fourth, these studies focus only on the flow side of finance when defining financial fragility. However, Minsky also defined financial fragility in terms of stock items appearing on the balance sheet, which is overlooked in the literature. Assets and liabilities on the balance sheet are the origin of future cash flow generation, while cash flow also affects balance sheet conditions. Thus, financial fragility should be examined by focusing on not only the flow side but also the stock side. Fifth, the determinants of each finance position are unclear, because the empirical analysis in these studies remains just a taxonomy. Consequently, how financial fragility evolves is uncertain. The taxonomy should be complemented by detecting the main determinants of financial fragility.

Taking the foregoing review of Minskian financial fragility or instability into consideration, the novelties of the current study are as follows. First, the financial fragility of sectors is measured according to Minsky's original argument on the margins of safety in terms of stock and flow terms. Second, the current study explores the financial fragility of an economy on the basis of industrial sector and capital size. Third, by using panel logistic regression, I econometrically detect the determinants of financial fragility. Moreover, the current study is the first to empirically detect financial fragility in the Japanese economy.

3 Definition of financial fragility indices

3.1 Measurement of financial fragility

3.1.1 Financial fragility index 1

I employ both a cash flow accounting framework and balance sheet approaches to measure financial fragility. As mentioned in the previous section, Minskians have specified the taxonomy of the financial structure in developing macroeconomic models. These studies commonly employ a cash flow accounting framework.

Schroeder (2009) summarized this framework in the form of the equality of sources and uses of funds in a representative firm. By using her framework with a slight extension, I define the three stages of financial fragility. Let us define the sources of funds as the sum of profits and borrowings. Let us also define uses by new investments, debt service payments, and dividend payments. That is,

$$\text{Profits} + \text{Borrowings} = \text{New investments} + \text{Debt service payments} + \text{Dividend payments} \quad (1)$$

I introduce dividend payments into this framework, although Schroeder's (2009) framework assumes away this term. However, Minsky (1982, 1986) recognized that cash payments may include dividends. Indeed, in the Minskian model, Sasaki and Fujita (2014) employed the same cash flow accounting framework including dividends.

Based on this framework, I define FFI-1. By using this index, hedge, speculative, and Ponzi finance positions are classified as follows. Hedge finance is a situation where the profits of the firm are larger than or equal to its total expenditure. Hence, this is the most robust financial structure. Speculative finance is defined as a situation where the firm's profits are less than the sum of its investment, debt service, and dividend payments but larger than the sum of its debt service and dividend payments. Finally, in the Ponzi position, the firm's profits are less than the sum of its debt service and dividend payments. Ponzi finance is a situation where the financial structure is the most fragile.

Since the value of profit, borrowing, new investment, and debt and dividend payments take huge values in the data, I evenly normalize them by capital stock in the empirical analysis. Then, let r represent the profit rate, g represent the capital accumulation rate, i_D represent debt service per capita, and d represent dividend payments per capita. On this basis, the above definition can be summarized as follows:

FFI-1 (Cash flow accounting framework)

- **Hedge:** The economic unit is a hedge unit if $r - g - i_D - d \geq 0$.
- **Speculative:** The economic unit is a speculative unit if $r - g - i_D - d < 0$ and $r - i_D - d \geq 0$.
- **Ponzi:** The economic unit is a Ponzi unit if $r - g - i_D - d < 0$ and $r - i_D - d < 0$.

In light of the cash flow accounting framework in eq. (1), the theoretical implication of each position is as follows. A hedge finance unit does not necessarily rely on additional borrowing, or it can use what remains from profit to reduce borrowing. The speculative finance unit depends on borrowing to finance the investment. The Ponzi finance unit must practically depend on borrowing to pay for debt service and dividend.

3.1.2 Financial fragility index 2

I also employ Minsky's original definition based on his margins of safety. Minsky presents his arguments about financial fragility in a scattered manner in his insightful studies. Therefore, although his taxonomy for hedge, speculative, and Ponzi finance positions is frequently cited to describe financial fragility, it is not easy to identify the most significant definitions about these positions. The most formal part that defines these positions is, I believe, in Appendix A: Financing Structures of *Stabilizing an Unstable Economy*, where he employs the margins of safety, which he used to distinguish financial fragility (Minsky 1986, Appendix A). I adopt the criteria defined in this part, because these cover both flow and stock terms and the criteria are also explained formally.

Minsky (1986) characterized the financial fragility of an economic unit on the basis of three margins of safety: cash flow margin τ, capital value margin μ and margin provided by the liquid asset kicker η. Cash flow margin τ and capital value margin μ are principally derived from the cash flow of payments on debt and receipts from operations. Cash flow margin τ is closely related to capital value margin μ, and therefore I employ the latter to measure financial fragility in flow terms based on Minsky's original argument, which is established by contractual cash payment commitments on debts CC as well as average (or expected) quasi-rents $\overline{Q}$ and its variance σ_Q^2. Scalar λ is also employed to express the impact of the fluctuation in quasi-

rents; however, the role of this variable is not explained clearly in his definition.[6] He also introduced discount operator K to obtain the present value of the variables. Subscript i denotes a time period in his formalization, but I assume this away to simplify the explanation below.

In his argument (Minsky, 1986), the margin of safety in capital values is obtained by $P_k = \mu K(CC)$. P_k represents the capitalized value of expected quasi-rents, which is calculated by $P_k = K(\overline{Q} - \lambda\sigma_Q^2)$. Thus, the margin of safety in capital values is the ratio of the capitalized value of contractual cash payment commitments on debts and the capitalized value of the expected quasi-rents. That is,

$$\mu = \frac{K(\overline{Q} - \lambda\sigma_Q^2)}{K(CC)} \tag{2}$$

and the greater μ is, the greater the margin of safety is.[7]

Minsky (1986) defined financial fragility by using the margin of safety in capital values. For a hedge unit, this margin is greater than unity for all periods. For a speculative unit, this margin is also greater than unity, but it may also depend on the discount rate and periods.[8] He doubted that $P_k > K(CC)$ is satisfied in the Ponzi scheme (Minsky 1986, p. 340). From equation (2), the margin of safety in capital values μ is smaller than unity in the case of Ponzi finance. Put simply, the capitalized value of expected quasi-rents always exceeds the capitalized value of contractual cash payment commitments on debts for a hedge finance unit, but depends on the discount rate and period for a speculative finance unit. Since it is difficult to detect such periods and discount rates precisely, I define the margin of safety in capital values μ as not less than unity under hedge and speculative finance. By contrast, the capitalized value of contractual cash payment commitments on debts exceeds the capitalized value of expected quasi-rents for a Ponzi finance unit, without exceptional periods. Hence, the value of μ is smaller than unity under Ponzi finance.

Minsky also mentioned the importance of balance sheet conditions to cover accidental deterioration in cash flow. By citing Minsky's original statements, let us define the FFI in terms of the balance sheet:

> However, accidents (and recessions) can happen, and the cash flows from operations may

fall short of anticipations of and of the amount required by commitments on debts. To protect against such possibilities, a unit will own money and marketable financial assets beyond what is need for transactions. As Keynes noted, it is convenient (as an implicit insurance policy) to hold assets in the form in which debt are denominated. Thus, a balance sheet of a hedge finance investor will include $\eta K(CC)$ of money or of other liquid assets in addition to the $P_k K$ of capital assets; this money or liquid assets are not needed by the operation of the unit. The balance sheet of a hedge unit can be characterized by

$$P_k K + \eta K(CC) = K(CC) + Eq, \qquad \eta \geq 1, \text{ or } \eta \leq 1$$

where Eq is the equity and η, which will be called a liquid asset kicker, is the measure of the margin of safety in assets superfluous to operations.

(Minsky, 1986, p. 336)

As the margin of safety by the liquid asset kicker is obtained by $\eta = \dfrac{K(CC) + Eq - P_K K}{K(CC)}$ in a simple form, it measures the liquid assets-to-liabilities ratio on the balance sheet. In general, the higher this ratio for an economic unit is, the more robust it is against accidental financial shocks.

In terms of the liquid asset kicker derived on the basis of the balance sheet, the financial fragility of hedge and speculative units is defined as follows. For a hedge unit, liquid asset kicker η is between zero and unity or is greater than unity for all periods (Minsky 1986, p. 336). For a speculative unit, the liquid asset kicker is smaller than unity for some periods (Minsky 1986, p. 339).[9] With regard to Ponzi finance, Minsky did not explicitly refer to liquid asset kicker η. As for the balance sheet conditions, he only mentioned that Ponzi finance involves a continuous erosion of equality $dEq/dt < 0$ over time (Minsky 1986, p. 341). Since the criterion for a Ponzi scheme is unclear in terms of the liquid asset kicker, I distinguish a Ponzi unit by exclusively using the margin of safety in capital values instead of the liquid asset kicker.

I define financial fragility by taking both the margin of safety in capital values and the liquid asset kicker into consideration. The definition is summarized as follows:

FFI-2 (Margins of safety)

- **Hedge:** The economic unit is a hedge unit if the margin of safety in capital values is $\mu > 1$ and the liquid asset kicker is $\eta > 1$.
- **Speculative:** The economic unit is a speculative unit if the margin of safety in capital values is $\mu \geq 1$ but the liquid asset kicker is $0 < \eta \leq 1$.
- **Ponzi:** The economic unit is a Ponzi unit if the margin of safety in capital values is $\mu < 1$ regardless of the value of the liquid asset kicker.

To calculate the margin of safety, I make two assumptions for simplicity. First, I define financial fragility for each year without considering future periods. For example, Minsky (1986) defined hedge finance as the position that quasi-rents are sufficiently larger than the contractual cash payment commitments on debts for all periods. He also considered different discount rates and the time periods during which the financing units expect cash payments on debt to exceed cash receipts from operations to define speculative and Ponzi positions. Since it is not possible to ascertain these periods and calculate different discount rates on the basis of sectoral statistics, I simply capture the financial fragility of a sector by focusing on the financial statements each year. Second, he employed the capitalized value (present value) of expected quasi-rents and the cash payment commitments by capitalizing operator K in his theory of financial fragility taxonomy. By contrast, I consider finance position on the basis of the definition of current and realized value. In empirical analysis, the capitalized value cannot be calculated because distinguishing what types of capital assets and debt items generate future profit and debt service and the length of the periods is impossible. Moreover, Minsky did not give an exact form of capitalizing operator K. Thus, these assumptions mean that the FFIs in this study provide information based on the past and present situations of sectoral financial fragility.

3.2 Data and definition of the variables

To analyse the Japanese economy empirically, the current study employs *the Financial Statements Statistics of Corporations* by industry, which is established by the Policy Research Institute, Ministry of Finance, Japan. These official statistics are one of the most credible sources in Japan when investigating sectoral economic

performances. In these statistics, sectors are defined in accordance with the Japan Standard Industrial Classification and based on the largest sales of the relevant corporations. The annual survey data include important financial information from the balance sheet and profit and loss statement. Hence, these statistics enable us to capture the finance position of sectors in both flow and stock terms. *The Financial Statements Statistics of Corporations* also include quarterly survey data; however, these data lack some important financial information for some sectors and are not used herein.

In these statistics, I use financial data on all industries (except Finance and Insurance) and divide them into manufacturing and non-manufacturing sectors (each with 16 subsectors). I also classify a firm's capital into three sizes: small (10 million to 100 million yen), medium (100 million to 1 billion yen), and large (1 billion yen and over). The sector classification is summarized in Table 1.[10]

[Insert Table 1]

The samples are taken from 1975–2014 for the following reasons. First, Japan enjoyed a high economic growth era from 1955, especially driven by the real side of the economy such as a virtuous circle of investment, growth, and productivity improvement (Yoshikawa, 2002). This era ended in 1973, after which Japan began to suffer from occasional financial panic. Second and most importantly, *the Financial Statements Statistics of Corporations* before 1975 did not record some of the important financial variables mentioned above for some sectors. Hence, limiting the sample to data from 1975 provides sufficient information about the important financial variables to investigate financial fragility.

[Insert Table 2]

To obtain the financial variables defined in the FFI, I conduct data processing on the basis of Table 2. In this table, the variables in part (A) are employed to calculate FFI-1. These variables are normalized by capital stock. The number in parentheses after the data item is the ID number in *the Financial Statements Statistics of*

Corporations. By applying these variables to calculate FFI-1, the three stages of financial fragility are detected. The variables in part (B) are employed to calculate FFI-2. In this calculation, the margin of safety in capital values is approximately obtained as the current value term by $\mu = \frac{\overline{Q} - \sigma_Q^2}{CC}$, for the reasons mentioned above. σ_Q^2 is calculated as the variance in operating profits during 1975–2014 in each sector. The margin of safety in the liquid asset kicker is obtained by $\eta = \frac{K(CC) + Eq - P_K K}{K(CC)}$. Minsky's employment of $K(CC)$ seems to denote not the capitalized value of contractual cash payment commitments on debts but rather liabilities on the balance sheet (Minsky 1986, p. 339). By using these variables, I conduct the taxonomy of financial fragility on the basis of the FFIs above. The next section investigates the results in detail.

4 Configuration of financial fragility in Japan

4.1 Overall configuration of financial fragility

Figures 1 and 2 show the scatter plot of the financial fragility values according to sector and size during 1975–2014. In Figure 1, the values calculated by $r - g - i_D - d$ that distinguish hedge and speculative positions are defined on the horizontal axis and the values calculated by $r - i_D - d$ that distinguish speculative and Ponzi positions are defined on the vertical axis. The horizontal and vertical axes are scaled to cross at the origin, indicating that the plots in the first quadrant represent hedge finance, those in the second quadrant represent speculative finance, and those in the third or fourth quadrants represent Ponzi finance. Figure 2 defines financial fragility in terms of the margins of safety. The margin of safety about liquidity asset kicker η is defined on the horizontal axis and that of capital value margin μ is defined on the vertical axis. The horizontal and vertical axes are scaled to cross at unity, indicating that the plots in the first quadrant are hedge finance, those in the second quadrant are speculative finance, and those in the third or fourth quadrants are Ponzi finance.

[Insert Figures 1 and 2]

Table 3 summarizes the frequency of these financial fragilities. Part (A) shows the frequency rates of financial fragility per sector and size based on FFI-1 and part (B) shows these rates based on FFI-2. According to these figures and table, speculative finance presents the highest frequency of the three regardless of size, sector, or index. Figures 1 and 2 illustrate that the plots are intensive in the second quadrants, while Table 3 shows that speculative finance is realized with the highest frequency rate. In this sense, speculative finance is the most dominant finance position across different industries and sizes.

[Insert Table 3]

Comparing the two indices in the same size and sector, FFI-1 generally distinguishes hedge finance more than FFI-2 does for each item, whereas FFI-2 distinguishes Ponzi finance more than FFI-1 does. Therefore, FFI-2 based on the margins of safety index is severer than FFI-1 based on a cash flow accounting framework index for distinguishing financial fragility.

In terms of size, the small sector realizes hedge finance the least of all sectoral sizes. For example, the distribution of FFI-1 shows that hedge finance represents 12.19% in manufacturing and 10.00% in non-manufacturing for small sectors. Similarly, the distribution of FFI-2 shows that hedge finance represents only 6.88% in manufacturing and 2.54% in non-manufacturing sectors for small sectors. The frequency rates of hedge finance are smaller compared with the other two sizes. On the contrary, the small sector realizes Ponzi finance with relatively high frequency rates. For example, for FFI-2, Ponzi finance represents 28.44% and 43.72% in manufacturing and non-manufacturing sectors of small size, respectively. The frequency rates of Ponzi finance are larger compared with the other two sizes. In terms of FFI-1, the manufacturing sector has a frequency rate of 21.56% for Ponzi finance for the large sector compared with 21.41% for the small sector. Although the large sector has a higher frequency rate for Ponzi finance than the small sector, the gap between these two rates is small. Taking these results into account, the small sector is relatively financially fragile.

In terms of sector, the manufacturing sector is generally more financially robust than the non-manufacturing sector. First, the manufacturing sector has a higher frequency rate of hedge finance than the

non-manufacturing sector in most cases. For instance, when measured by FFI-1, the manufacturing sector of small and medium sizes has hedge finance values of 12.19% and 20.78%, respectively compared with 10.00% and 20.16% for the non-manufacturing sector. The large sector is an exception when measured by FFI-1, in which case hedge finance is more frequently realized in the non-manufacturing sector (23.91%) than in the manufacturing sector (17.19%). The distribution of FFI-2 indicates that the frequency rate of hedge finance in the non-manufacturing sector is monotonically lower than that in the manufacturing sector regardless of sectoral size.

Second, the non-manufacturing sector is more financially fragile in terms of the frequency rate of Ponzi finance regardless of sectoral size. For instance, when measured by FFI-1, the manufacturing sector has Ponzi finance values of 21.41%, 16.72%,, and 21.56% for small, medium, and large sectors, respectively compared with 36.83%, 34.84%, and 21.88 for the non-manufacturing sector. The distribution of FFI-2 shows the same result. Thus, the non-manufacturing sector is more financially fragile than the manufacturing sector.

Taking account of both size and sector, small firms in the non-manufacturing sector are the most financially fragile. Overall, the small sector records the lowest frequency rate for hedge finance and the highest frequency rate for Ponzi finance. In addition, hedge finance is more often realized in the manufacturing sector than in the non-manufacturing sector in most cases, whereas Ponzi finance is more often realized in the non-manufacturing sector than in the manufacturing sector.

4.2 Evolution of financial fragility

Figures 3 and 4 present the number of manufacturing and non-manufacturing subsectors that underwent hedge, speculative, and Ponzi finance in each year of the sample period. The figures also present business cycles with a recession period (peak to trough) in shadows, as reported by the *Reference dates of business cycles* produced by the Cabinet Office. Figure 3 employs FFI-1 and Figure 4 employs FFI-2 to count the number of subsectors. This time series presentation shows the configuration in Figures 1 and 2 in more detail.

[Insert Figures 3 and 4]

Overall, as indicated above, speculative finance is realized in many sectors. In addition, Figures 3 and 4 present the following observations. First, the number of subsectors realizing hedge finance increases during expansion. Specifically, many subsectors realize hedge finance regardless of size and sector after 2002. Indeed, the number of subsectors that experience hedge finance is especially large after 2002 compared with previous expansion periods.

Second, on the contrary, the number of sectors undergoing Ponzi finance increases during recession. This phenomenon is common, especially in 1991–1993 (bursting of the bubble) and 2008 (global financial crisis). In particular, the recession of 2008 was so severe that the number of subsectors realizing speculative or hedge finance and Ponzi finance suddenly reverses in many subsectors.

Third, before the late 1990s, the finance positions mainly change between speculative and Ponzi finance regardless of sector or size, whereas the number of subsectors realizing hedge finance is relatively stable. On the contrary, especially after the expansion of 2002, the number of subsectors realizing hedge finance begins to increase. This trend is common for most observations except for large firms in the non-manufacturing sector measured by FFI-2 (Figure 4 part F). That is, firms in each subsector and size began to be more financially prudent after experiencing the severe depression of the 1990s.[11]

Financial fragility is an evolutionary process, and each stage of fragility is not an equilibrium but part of a dynamic process (Tymoigne, 2010). Minsky's financial fragility depicts a gradual process of financial fragility as the finance position of firms undergoes change from hedge to riskier speculative and ultimately to a Ponzi finance position. Figures 3 and 4 show the evolution of the number of subsectors that underwent each finance position over time, but how does each position change from one stage to another? By calculating a transitional probability matrix that depicts the probability of moving from one position to another in one time step during 1975–2014, I explain the evolution of finance position. Table 4 shows the result by FFI-1 and Table 5 shows

that by FFA-2.

[Insert Tables 4 and 5]

First, the number of observations for which the speculative finance position is realized is the highest regardless of size, sector, or index. In addition, the evolution from speculative position to speculative position is the most likely to happen. Hence, the speculative position has persistent characteristics.

Second, the evolution of financial fragility is generally an incremental rather than a radical process. When starting from a hedge finance position, financial fragility tends to shift to a speculative finance position more than to a Ponzi finance position. Conversely, when starting from a Ponzi finance position, it tends to shift to a speculative finance position more likely than to a hedge finance position. Part (A) in Table 4 indicates that when a small sector realizes hedge finance in a period, its finance position shifts to a speculative finance position in the next period with a probability of 69.74%, whereas it shifts to a Ponzi finance position in the next period with a probability of only 3.95%. Thus, from a hedge position, the probability of shifting to a speculative position is higher than that to Ponzi finance. By contrast, when this sector realizes Ponzi finance in a period, its finance position shifts to a speculative finance position in the next period with a probability of 42.96%, whereas it shifts to Ponzi finance in the next period with a probability of only 2.96%. Regardless of index, sector, or size, similar characteristics can thus be observed.

Third, in terms of sectoral size, even slightly, the larger the size is, the longer the duration of financial fragility is. When starting from a Ponzi finance position, the transitional probability of remaining in the same position is generally the highest for the large sector, followed by the medium and small sectors in that order. For example, parts (A), (B), and (C) in Table 4 indicate that the transitional probability of remaining in a Ponzi finance position is 60.29% for the large manufacturing sector compared with 57.01% for medium and 54.07% for small. The non-manufacturing sector measured by FFI-1 is an exception in this regard; nevertheless, the

large sector records a high probability of remaining in the same position (71.74%). The same result is also obtained by using FFI-2. Overall, the larger the size is, the longer the duration of financial fragility is.

However, when starting from a hedge finance position, the transitional probability of remaining in the same position is the highest in the large sector followed by the medium and small sectors in that order. FFI-1 shows that this transitional probability for the large manufacturing sector is 54.72%, followed by 45.31% for medium and 26.32% for small manufacturing sectors. The same result is obtained for the non-manufacturing sector, also obtained by using FFI-2. Therefore, size also matters to sustain financial stability.

Lastly, in terms of sector, the non-manufacturing sector is more financially fragile than the manufacturing sector in dynamic terms, too. First, the non-manufacturing sector records Ponzi finance more frequently than the manufacturing sector. According to FFI-1 in Table 4, the manufacturing sector realizes a Ponzi finance position of 135 in the small sector, 107 in the medium sector, and 136 in the large sector compared with 229, 223, and 138, respectively for the non-manufacturing sector. Second, on this basis, the transitional probability of remaining in a Ponzi finance position is also higher in the non-manufacturing sector than in the manufacturing sector. FFI-1 indicates that once both sectors realize a Ponzi finance position, the transitional probability of remaining in the same position in the next period is 54.07% (in manufacturing) and 71.62% (in non-manufacturing) in the small sector, 57.01% and 76.23% in the medium sector, and 60.29% and 71.74% in the large sector. These characteristics can also be observed by using FFI-2.[12]

To summarize, the larger the capital size is, the more dynamically stable and fragile its financial structure is. The probability of remaining in hedge finance is larger as the size of the sector rises. Although paradoxical, the probability of remaining in Ponzi finance is larger as the size of the sector rises. In terms of sector, the non-manufacturing sector is the more financially fragile in dynamic terms, too. The non-manufacturing sector records a higher frequency for the Ponzi finance position; once this sector records a Ponzi finance position in a period, it is more likely to remain in this position over time than in the manufacturing sector.

5 Econometric analysis for the determinants of financial fragility

5.1 Data description and main hypothesis

In this section, I present an econometric analysis to detect the determinants of financial fragility for each sector and size by using panel logistic regression. A logistic model is useful to predict the probability of which category will happen. I focus on the probability of being in Ponzi finance and detect the main determinants of financial fragility for different sectors and sizes. I employ *the Financial Statements Statistics of Corporations* by Industry in this section, too. The sample is the same as used in the previous section (see Table 1).

Panel logistic regression models are estimated according to the following procedure. First, to focus on the change in financial fragility, I integrate hedge and speculative finance into the same category and define two categories for a binary response model: hedge/speculative finance and Ponzi finance. This is carried out by using FFI-1 and FFI-2. Second, as the potential determinants of financial fragility, I introduce fluctuation in the output gap, the interest rate on borrowing, the retention rate, and the debt ratio as explanatory variables into the panel logistic regression model. Then, I relate the probability of being Ponzi to these variables. The output gap represents the impact of business cycles, which represent good market conditions. The interest rate is introduced as a proxy of monetary market conditions. The retention rate and debt ratio represent the solvency of firms in flow and stock terms, respectively. Hence, these variables explain financial fragility according to Minsky (1986). Let me elaborate the hypotheses under these explanatory variables.

The output gap in each sector captures the effect of economic booms and depressions on financial fragility. For example, Minsky (1986) found that during an economic boom, an economy transits from a stable system to an unstable system through more optimistic expectations. Instability emerges as a period of relatively tranquil growth is transformed into a speculative boom, thus allowing us to analyse the period of boom that leads to the emergence of a fragile and unstable financial structure (Minsky 1986, p. 173). If this prediction holds, an economic boom should induce more financial fragility, which is procyclical from Minsky's perspective. By letting the output gap represent economic booms and depressions, I check whether there is a

contemporaneous relationship between the output gap and financial fragility.[13]

Changes in the interest rate on borrowing may either decelerate or accelerate the degree of financial fragility. Minsky indicated that the impact of short- and long-term interest rates affects the prices of capital assets and investment. Specifically, an extreme rise in interest rates may drop the present value of capital assets and induce declining estimates of the profitability of investment projects. Then, even investment projects underway will be abandoned (Minsky 1986, p. 195). Cutting investment expenditure improves firms' cash flow as shown in Section 3. Thus, in the face of a rise in interest rates, firms may attempt to establish a more prudent financial structure. However, the reverse effect is also plausible. Minsky also argued that a rise (fall) in interest rates accelerates (deaccelerates) financial fragility. Increases in interest rates raise cash flow commitments without increasing prospective receipts. Minsky (1986) therefore stated that "[a] speculative financing arrangement can be transformed into a Ponzi finance scheme by a rise in interest or other cost or a shortfall in income. On the contrary, if earnings are better or costs, especially interest rates, fall, Ponzi financing may be transformed into speculative financing" (p. 208). Thus, the impact of a change in interest rates can be double-edged for financial fragility.

Retained earnings are the fundamental funds available for a firm's economic activity. It thus plays an important role in Minsky's graphical model that determines investment, dependence on external funds, and thus financial fragility. The retention rate concerns these degrees, since the more available the retained earnings are, the less external funds firms need. Minsky (1986, p. 216) mentioned that the overall financial impact of investment in excess of internal funds is equivalent to an increase in the weight of speculative and Ponzi finance in liability structures. That is, a fall in the retention rate indicates a decrease in the firm's ability to repay debt capital and interest payment, leading to a more financial fragile situation.

The debt ratio is employed to measure debt dependence in stock terms. This serves as a proxy of solvency since a high debt ratio implies high debt dependence, which imposes an interest payment burden, meaning financial stability is low and vice versa. A change in liability structure affects the firm's payment

commitments and financial structure. The debt ratio normally increases as a result of debt finance. Especially for Ponzi units, the debt ratio on the balance sheet deteriorates as interest or even dividends are paid by increasing debt (Minsky 1986, p. 208). Therefore, when the debt ratio is high, the firm's solvency is low and more likely to have a fragile financial structure.

These variables are obtained from *the Financial Statements Statistics of Corporations*. The output gap is calculated on the basis of value added (item number 73). It is defined as the ratio of the cyclical and trend components of value added, both of which are extracted by using the Hodrick–Prescott filter. Thus, a boom is measured by an increase in the output gap and a depression by a decrease in the output gap. Interest rates are defined as the interest rate on borrowing (item number 135). The retention rate is defined by the ratio of after-tax net profit (item number 135) and the sum of after-tax net profit and total dividends (item number 60). The debt ratio is the ratio of total liabilities (item numbers 224 and 230) and equity capital. Equity capital is obtained by total assets (item numbers 22 and 179) multiplied by the equity ratio (item number 122).[14] Finally, outliers with regard to the retention rate and debt ratio are removed. Some of these values take negative values in the above calculation, because after-tax net profit or total liabilities are negative. As these values are not economically meaningful, I removed them from the panel data logistic regression models.

[Insert Table 6]

After processing the data, the descriptive statistics of the variables employed in the estimation are listed in Table 6. As this table shows, the FFIs are transformed into a dummy variable that takes zero if the financial fragility of an economic unit is hedge or speculative finance and unity if the financial fragility is Ponzi finance. The panel logistic regressions relating the probability of being Ponzi finance to the explanatory variables are conducted for both FFI-1 and FFI-2.

5.2 Discussion

Tables 7 and 8 report the results of the panel logistic regression for the manufacturing and non-manufacturing sectors. All models are assumed to include a subsector-specific effect, namely a fixed or random effects on the basis of the Hausman test at the 5% significance level. This test employs chi square statistics. When the model fitted on the data fails to meet the asymptotic assumptions of the Hausman test, the chi square statistics cannot be obtained in an appropriate manner; hence, this test cannot be used to select the model. In this case, I estimate both the fixed and the random effects models and select the model on the basis of Akaike's information criterion.

[Insert Tables 7 and 8]

In these tables, the coefficient represents the result for the latent variable and APE is the average partial effect of each explanatory variable on the probabilities of being Ponzi finance.[15] The APE summarizes the estimated marginal effect across the population (Wooldridge, 2010). In other words, it is the average of total marginal effects. Prob. < chi 2 reports the result of the likelihood ratio test of which the null hypothesis is all coefficients are zero. This hypothesis is rejected for all models at the 1% significance level. When the selected model is fixed one, STATA 14 reports McFadden's pseudo R-square.

The first row in Tables 7 and 8 shows the coefficient in the panel logistic regression and APE of the output gap for the probability of being Ponzi finance. The estimated values show the sharply contrasting result between the manufacturing and non-manufacturing sectors. In the estimations for the manufacturing sector (Models 1–6 in Table 7), the coefficients of the output gap in the regression are negative and significant at the 1% level in most models. In model 4, it is negative and significant at the 10% level. In addition, the APEs of the output gap for the probability of being Ponzi finance are also negative and significant at least at the 10% level. That is, a rise in the output gap (i.e., economic boom) leads to a lower probability of being Ponzi finance. Thus,

there is a negative and statistically significant relationship between the contemporaneous increase in the output gap and the probability of being Ponzi finance. Financial fragility is a countercyclical phenomenon in the manufacturing sector in Japan, meaning that business cycle expansions decrease the probability of being Ponzi finance, whereas business cycle downturns increase this probability. On the contrary, the estimations for the non-manufacturing sector (Models 7–12 in Table 8) indicate that the coefficients of the output gap in the regression are negative except for model 10, but they are all non-significant. Further, the APEs of the output gap for the probability of being Ponzi finance are not significant in all models. Thus, there is no statistically significant relationship between the contemporaneous change in the output gap and the probability of being Ponzi in the non-manufacturing sector in Japan.[16]

A change in interest rates has double-edged effects for financial fragility depending on sector and size. The coefficients are negative and significant for small firms in the manufacturing sector (Models 1 and 2). This means that a rise (fall) in interest rates decreases (increases) the probability of being Ponzi in this sector. A rise in interest rates may drop the present value of capital assets, decreasing the profitability of investment projects. Since the investment under this environment is not profitable, firms may become more prudent on debt finance. Thus, these mechanisms may induce cut in investment with debt dependence, and the firm's financial fragility gradually decreases.

Except for the small sector, the coefficients and APEs are positive and significant in the manufacturing sector. That is, a fall in this rate mitigates financial fragility, whereas a rise accelerates financial fragility. Hence, a fall in interest rates serves to mitigate the cash flow squeeze by reducing interest payments in this sector. As for the non-manufacturing sector, Table 8 shows that the coefficients of this variable are significant when they are positive, which can be observed for the small and medium sectors (Models 7–10). On the contrary, they are not significant when negative, which can be observed for the large sector (Models 11 and 12). The APEs are only significant for models 9 and 10 for medium firms in the non-manufacturing sector. In terms of the probability of being Ponzi finance, a rise in interest rates statistically significantly

deteriorates the financial fragility of medium firms in the non-manufacturing sector. The role of interest rates is thus not unique within and between the manufacturing and non-manufacturing sectors.

The third row in these tables reports the coefficients and APEs for the probability of being Ponzi finance for the retention rate. The impact of the retention rate on the probability of being Ponzi finance is common between sectors and sizes. The coefficients are all negative and significant regardless of sector or size. The APEs of the retention rate for the probability of being Ponzi finance are also uniquely negative and significant except for model 11 for large firms in the non-manufacturing sector. Although the APE of model 11 is not significant, the coefficient is negative and significant at the 5% level. Model 12 is also for large firms in the non-manufacturing sector, showing a negative and significant coefficient and APE. Thus, a rise in the retention rate serves to restrain financial fragility. Since the retention rate is the ratio of after-tax net profit and the sum of after-tax net profit and dividends, a rise in after-tax net profit or a reduction in dividend payments contributes to stabilizing the financial structure of the economy. Given the volume of after-tax net profit, an increase in this ratio enables firms to use internal funds to conduct investment and other operating activities. In other words, they do not necessarily depend on external funds and thus can avoid a deterioration of financial fragility.

The last row presents the impact of the debt ratio in the panel logistic regression and the APEs for being Ponzi finance. The coefficients of this variable in the manufacturing sector are all positive, but not significant in models 3 and 4 for medium firms in the manufacturing sector. The APEs of the debt ratio for being Ponzi finance show the same configuration with the coefficient. A rise in the debt ratio for small and large firms in the manufacturing sector significantly increases the probability of being Ponzi finance. On the contrary, in the non-manufacturing sector, the coefficients of this variable are all positive and significant at the 1% level. The APEs of this variable are also positive and significant at the 1% level in most cases (5% level for model 7). That is, a rise in the debt ratio uniquely leads to an increase in the probability of being Ponzi finance in the non-manufacturing sector regardless of size. Comparing the two sectors, the negative impact of a rise in

the debt ratio is a broader phenomenon in the non-manufacturing sector than in the manufacturing sector. This impact can also be found in the manufacturing sector, but it depends on the sector's size.

Comparing the results obtained above with the financial fragility in Minsky's argument, let us summarize the results of the econometric analysis presented in this section. The determinants of financial fragility differ by sector and size, which cannot be captured by an aggregate analysis. Financial fragility in the manufacturing sector is countercyclical, while that in the non-manufacturing sector is independent of the business cycle. Both these results contrast with Minsky's argument that financial fragility is procyclical. A rise in interest rates increases the probability of financial fragility in the manufacturing sector for medium and large firms and in the non-manufacturing sector for medium firms, which is consistent with Minsky's argument that a rise in interest rates may transform the financial fragility of an economic unit into Ponzi finance. Conversely, although the magnitude is very small, a fall in interest rates significantly increases the probability of small manufacturing firms being financially fragile. The retention rate uniquely restrains the probability of being Ponzi finance regardless of sector or size. As Minsky remarked, the more available retained earnings are, the less external funds firms need. Therefore, a rise in the retention rate contributes to establishing a more stable finance position. Finally, a high debt ratio uniquely deteriorates the finance position of the non-manufacturing sector, meaning solvency in stock terms is important. This result is also consistent with Minsky's argument. A rise in this ratio also accelerates the finance position of the manufacturing sector except for medium size sector.

6 Conclusion

While Minskians have developed a theoretical analysis of Minsky's financial fragility argument, its empirical application is scarce. To bridge the gap between theory and reality, this study estimated financial fragility in non-financial sectors in Japan during 1975–2014 by constructing FFIs based on a cash flow accounting framework and the margins of safety.

The current empirical analysis found the following evidence. During 1975–2014, the speculative finance position is the most dominant and persistent in the Japanese economy. This evidence is observed regardless of sector or size. When focusing on hedge and Ponzi finance, the small sector is the most financially fragile. Further, the small sector realizes Ponzi finance more frequently than the medium and large sectors do in most cases, whereas the former realizes that the less frequently than the latter. In terms of sector, the non-manufacturing sector is generally more financially fragile compared with the manufacturing sector. Moreover, the manufacturing sector realizes hedge finance more frequently than the non-manufacturing sector in most cases, whereas the non-manufacturing sector realizes Ponzi finance more frequently than the manufacturing sector.

From a dynamic perspective, first, the number of subsectors undergoing hedge finance increases during expansion and that of subsectors undergoing Ponzi finance increases during recession. Second, financial fragility is a gradual process; hedge finance rarely suddenly transforms Ponzi finance or vice versa. Third, size matters for the sustainability of financial stability and fragility. Once starting from a hedge finance position, the transitional probability of remaining in the same position is the highest in the large sector. At the same time, the transitional probability of remaining in the Ponzi finance position is generally the highest for the large sector. Fourth, in terms of sector, the non-manufacturing sector also involves dynamic financial fragility. Once this sector realizes Ponzi finance, the probability of remaining the same position is higher than that in the manufacturing sector.

Finally, the panel logistic regression analysis reveals both the common and the specific determinants of financial fragility according to sector and size. For example, a rise in the retention rate contributes to establishing a more stable financial structure for all sized firms both in the manufacturing and in the non-manufacturing sector, while a rise in the debt ratio deteriorates the financial structure of most sectors and sizes except for medium firms in the manufacturing sector. On the contrary, the effect of economic booms contributes to a stable financial structure in the manufacturing sector, whereas the financial fragility of the

non-manufacturing sector is statistically independent of business cycles. A rise in interest rates increases the probability of financial fragility for medium and large firms in the manufacturing sector and medium firms in the non-manufacturing sector. Conversely, a fall in interest rates, although the magnitude is small, increases the probability of financial fragility for small firms in the manufacturing sector.

Thus, the evolution of financial fragility is a much diversified phenomenon and its determinants differ according to sector and size in Japan, which cannot be sufficiently captured by existing theoretical or empirical studies. The presented evidence also offers an important implication that a uniform macroeconomic policy across all sectors does not necessarily bring about the intended recovery of a stable financial structure. For example, for the non-manufacturing sector, where the financial structure is more fragile than that in the manufacturing sector, fiscal or monetary policy boosting the economy is ineffective, as its financial fragility is statistically independent of business cycles. In addition, for the small sector that is also rather financially fragile, a rise in the interest rate on borrowing may restrain financial fragility. Conversely, this contributes to accelerating financial fragility in other sized sectors. The evidence presented in this study thus confirms the importance of sectoral and size differences in recognizing financial fragility and therefore considering policy to prevent financial instability.

Notes

[1] Minsky (1986, p. 173) also stated the fundamental proposition of the financial instability hypothesis as (i) capitalist market mechanisms cannot lead to a sustained, stable-price, full-employment equilibrium and (ii) serious business cycles are due to financial attributes that are essential to capitalism.

[2] In this study, financial fragility is measured by hedge, speculative, and Ponzi finance. Financial instability refers to the propensity of financial fragility to affect overall economic performance. Thus, financial fragility is a precondition for financial instability. For example, Minsky (1986, p. 209) stated, “The mixture of hedge, speculative, and Ponzi finance in an economy is a major determinant of its stability. The existence of a large component of

positions financed in a speculative or Ponzi manner is necessary for financial instability."

[3] The current study deals with firms' financial fragility in terms of Minskian insight. However, theoretical studies have also examined the financial fragility of households since the 2007–2008 subprime crisis and Lehman shock. Dutt (2006), for example, investigated the role of consumer debt in a growth and distribution model. Bhaduri (2011) modelled a Keynesian debt-financed consumption boom and its endogenous collapse. Cynamon and Fazzari (2008) observed that the United States has experienced consumption expansion accompanied by significant household debt accumulation since the 1980s, which was the seed for consequent financial instability. These studies typically find that debt-financed household spending may stimulate economic growth in the short run, but that the debt accumulation of households eventually causes a negative impact on consumption and output level in the long run, because the excessive accumulation of debt and debt service squeezes a household's disposable income.

[4] Isenberg (1988) investigated the financial fragility of the US economy in the 1920s from a sectoral perspective, finding that financial fragility is concentrated in more rapidly expanding sectors, whereas no financial weakening is seen at the aggregate level.

[5] The empirical analysis of financial fragility is not restricted to the private sector. Argitis and Nikolaidi (2014) applied Minskian analysis to the Greek government sector. This study also showed that since 2003 the Greek government sector has shifted to an ultra-Ponzi regime in which the government runs a primary deficit. Ferrari-Filho et al. (2010) applied Minsky's financial fragility analysis to the Brazilian public sector after 2000. By using total revenue and total expenditure in the public sector, their research detected that the finance position of the Brazilian public sector remained speculative throughout the 2000s.

[6] Therefore, I set $\lambda = 1$ to calculate $\overline{Q} - \lambda\sigma_Q^2$ in the empirical analysis.

[7] Cash flow margin τ is the inverse of capital value margin μ if one does not consider the discount. The margin of safety in cash flow τ is obtained by $CC = \tau(\overline{Q} - \lambda\sigma_Q^2)$, which is arranged as follows:

$$\tau = \frac{CC}{\overline{Q} - \lambda\sigma_Q^2}$$

Thus, cash flow margin τ represents the inverse of capital value margin μ in the current and realized value terms. The smaller the cash flow margin is, the financially safer the economic unit is.

[8] He also noted that $CC > \overline{Q} + \lambda\sigma_Q^2$ is established for some periods (e.g., for the earlier periods of a project), but thereafter (e.g., for the latter periods of a project) $CC \leq \overline{Q} - \lambda\sigma_Q^2$ is established under speculative finance. However, detecting the exact period that causes such a change in finance position in the empirical analysis is challenging. Therefore, I exclusively focus on $\overline{Q} - \lambda\sigma_Q^2$ to calculate the margin of safety in capital values.

[9] Minsky (1986) emphasized the time periods during which speculative financing units expect cash payments on debt to exceed cash receipts from operations. For such time periods from $i = 0$ to n, the balance sheet of speculative financing units is

$$P_k K + \eta \sum_{i=0}^{n} (CC_i) = K(CC) + Eq, \qquad \eta < 1.$$

This is Minsky's original definition. However, as it is difficult to detect such time periods, I simply use the basic definitions mentioned above.

[10] Although this study focuses on financial issues, the Finance and Insurance sector is excluded, because this sector has only been included in the survey since 2008. Consequently, important statistics cannot be calculated for this sector to sufficiently consider the evolution of financial fragility.

[11] Hedge finance is realized more often since 2002 than before because firms might become as prudent as to be independent of borrowing from banks. This is a lesson from the financial crisis of 1997, when large banks such as Hokkaido Takushoku Bank and Yamaichi Securities went bankrupt due to accumulated bad loans. The bursting of the bubble also attacked firms' cash management because of the severe credit crunch. Consequently, firms changed their attitude from borrowing to accumulating internal funds through realized profits in order to decrease dependency on banks. Although the financial crisis was eventually solved by the injection of public money in large banks such as Risona Bank in 2003, firms' behaviour, which was once prudent, did not change drastically. As the result, the net savings of corporate firms became positive in 1998 at the macroeconomic level, whereas they had

been negative throughout the postwar period up to 1997 (Yoshikawa, 2007).

[12] Caballero et al. (2008) argued that the financial problems and stagnation in the 1990s in Japan were caused by zombie firms (unprofitable firms that should exit the market but remain because of government support). They indicated that zombie firms increased more in the non-manufacturing sector such as wholesale and retail, services, and real estate firms than in the manufacturing sector. In addition, by using an econometric analysis, they found that investment and employment for healthy firms falls as the percentage of zombies in their industry rises.

[13] Davis et al.'s (2016) draft attempted to capture the relationship between aggregate and sectoral output gaps and firms' likelihood of being in a fragile finance regime in the US economy by using linear probability models. They found a negative and statistically significant relationship between the contemporaneous cyclical component of output and the probability of being Ponzi finance. That is, business cycle expansions decrease the probability that a firm falls into Ponzi finance.

[14] *The Financial Statements Statistics of Corporations* include total liabilities and total assets at both the beginning and the end of the period. Therefore, when calculating these values, I employed the average value of each period.

[15] In the logistic regression for the binary response model, the estimated coefficients of the explanatory variables represent the positive or negative effect on the latent variable that distinguishes which of the two categories is realized. Therefore, they do not directly represent their impacts on the probability that a category is realized. To understand these impacts on that probability, the marginal effect of the explanatory variables must be presented. Therefore, I report not only the estimated coefficients, but also the marginal effects by APE.

[16] Although it is not Ponzi finance but the leverage ratio, Lavoie and Seccareccia (2001) argued that this ratio could rise or fall during an economic expansion and presented empirical evidence for this in advanced countries. Focusing on both micro- and macroeconomic aspects, they explained that since an economic expansion also increases firms' profits at the macro level, it does not necessarily depend on debt finance.

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Table 1: Industrial classification

Manufacturing		Non-manufacturing	
ID and name	**Original ID**	**ID and name**	**Original ID**
1. Food	109	17. Agriculture, Forestry and Fisheries	105
2. Textile and Apparel	110, 163, 111	18. Mining and Quarrying of Stone and Gravel	106
3. Lumber and Wood Products	112	19. Construction	107
4. Pulp, Paper and Paper Products	113	20. Electricity Service	135
5. Printing and Allied Industries	114	21. Gas, Heat and Water Distribution	136
6. Chemical and Allied Products	115	22. Information and Communication	142
7. Petroleum and Coal Products	116	23. Transport Service	131
8. Ceramic, Stone and Clay Products	117	24. Water Transport	132
9. Iron and Steel	118	25. Miscellaneous Transport	133
10. Non-ferrous Metals and Products	119	26. Wholesale Trade	127
11. Fabricated Metal Products	120	27. Retail Trade	128
12. Productive Machinery	154, 121, 124	28. Real Estate	130
13. Electric and IC Machinery	122, 145	29. Accommodations and Meal Services	139, 148
14. Motor Vehicles, Parts and Accessories	123	30. Services for Personal and Hobbies	140, 141
15. Miscellaneous Transportation Equipment	125	31. Miscellaneous Services 1	138, 158, 159
16. Miscellaneous manufacturing industries	126	32. Miscellaneous Services 2	143

Note: Original ID refers to the ID number of the web data. Some of the original sectors closely related are combined to obtain sufficient data: Textile and apparel consists of textile (110, 111) and the manufacture of apparel and other finished products made from fabrics and similar materials (163). Productive machinery includes general-purpose machinery (154), production machinery (121), and business-oriented machinery (124). Electric and IC machinery consists of electric machinery (124) and information and communication electronics equipment (145). Accommodations and meal services consists of accommodations (139) and eating and drinking services (148). Services for personal and hobbies consist of living-related and personal services (140) and services for amusement and hobbies (141). Miscellaneous Service 1 unifies adverting (138), pure holding company (158), and miscellaneous scientific research, professional and technical services (159).

Table 2: Definition of the variables and data source

(A) FFI-1 based on a cash flow accounting framework		
Variable	Definition in Sec. 3.1	Data item in the *Financial Statements Statistics of Corporations*
r	Profit rate	Operating profits (48) divided by capital stock
g	Capital accumulation rate	Investment divided by capital stock
i_D	Debt service per capital	Interest expense (68) divided by capital stock
d	Dividends payments per capital	Cash dividends (60) divided by capital stock
(B) FFI-2 based on the margins of safety		
Variable	Definition in Sec. 3.1	Data item in the *Financial Statements Statistics of Corporations*
$\overline{Q}$	Quasi-rents	Operating profits (48)
σ_Q^2	Variance of quasi-rents	Variance of operating profits during 1975–2014 in each sector
CC	Contractual cash payment	Interest expense (68) plus cash dividends (60)
$P_k K$	Capital assets	Fixed assets (147) (205)
$K\,(CC\,)$	Debt	Liabilities (224) (230)
Eq	Equity	Net assets (157) (215)

Note: In part (A), capital stock is defined as the average value of tangible fixed assets (148) (206) minus land (12) (169). Investment is defined as the sum of the increase in capital stock and depreciation expenses (221). In part (B), the values of capital stock, capital assets, debt, and equity are the average of the beginning and the end of the period.

Table 3: Frequency rates of financial fragility per sector and size (1975–2014)

(A) FFI-1		Size		
Sector	Fragility	10 – 100 mill.	100 mill. – 1 bill. yen	1 bill. yen or over
Manufacturing	Hedge	12.19%	20.78%	17.19%
	Speculative	66.41%	62.50%	61.25%
	Ponzi	21.41%	16.72%	21.56%
Non-manufacturing	Hedge	10.00%	20.16%	23.91%
	Speculative	53.17%	45.00%	54.22%
	Ponzi	36.83%	34.84%	21.88%

(B) FFI-2		Size		
Sector	Fragility	10 – 100 mill.	100 mill. – 1 bill. yen	1 bill. yen or over
Manufacturing	Hedge	6.88%	9.38%	17.97%
	Speculative	64.69%	70.78%	56.56%
	Ponzi	28.44%	19.84%	25.47%
Non-manufacturing	Hedge	2.54%	7.19%	4.06%
	Speculative	53.74%	53.91%	62.81%
	Ponzi	43.72%	38.91%	33.13%

Table 4: Transitional probability matrix of financial fragility (1975–2014) by FFI-1

Manufacturing sector

(A) Size: 10–100 mill.		T+1 (next year)			
		Hedge	Speculative	Ponzi	No. of Obs.
T (initial year)	Hedge	26.32%	69.74%	3.95%	76
	Speculative	12.83%	74.33%	12.83%	413
	Ponzi	2.96%	42.96%	54.07%	135
(B) Size: 100 mill.–1 bill.		T+1 (next year)			
		Hedge	Speculative	Ponzi	No. of Obs.
T (initial year)	Hedge	45.31%	50.00%	4.69%	128
	Speculative	17.22%	75.06%	7.71%	389
	Ponzi	7.48%	35.51%	57.01%	107
(C) Size: 1 bill. yen or over		T+1 (next year)			
		Hedge	Speculative	Ponzi	No. of Obs.
T (initial year)	Hedge	54.72%	41.51%	3.77%	106
	Speculative	12.83%	75.92%	11.26%	382
	Ponzi	2.21%	37.50%	60.29%	136

Non-manufacturing sector

(D) Size: 10–100 mill.		T+1 (next year)			
		Hedge	Speculative	Ponzi	No. of Obs.
T (initial year)	Hedge	44.83%	43.07%	12.07%	58
	Speculative	8.33%	75.93%	15.74%	324
	Ponzi	3.49%	24.89%	71.62%	229
(E) Size: 100 mill.–1 bill.		T+1 (next year)			
		Hedge	Speculative	Ponzi	No. of Obs.
T (initial year)	Hedge	66.94%	28.93%	4.13%	121
	Speculative	14.29%	72.86%	12.86%	280
	Ponzi	2.69%	21.08%	76.23%	223
(F) Size: 1 bill. yen or over		T+1 (next year)			
		Hedge	Speculative	Ponzi	No. of Obs.
T (initial year)	Hedge	72.97%	20.27%	6.76%	148
	Speculative	10.95%	82.84%	6.21%	338
	Ponzi	5.07%	23.19%	71.74%	138

Table 5: Transitional probability matrix of financial fragility (1975–2014) by FFI-2

Manufacturing sector

(A) Size: 10–100 mill.		T+1 (next year)			
		Hedge	Speculative	Ponzi	No. of Obs.
T (initial year)	Hedge	46.15%	41.03%	12.82%	39
	Speculative	5.17%	78.82%	16.01%	406
	Ponzi	2.79%	39.11%	58.10%	179
(B) Size: 100 mill.–1 bill.		T+1 (next year)			
		Hedge	Speculative	Ponzi	No. of Obs.
T (initial year)	Hedge	72.00%	22.00%	6.00%	50
	Speculative	4.47%	87.02%	8.50%	447
	Ponzi	3.15%	37.01%	59.84%	127
(C) Size: 1 bill. yen or over		T+1 (next year)			
		Hedge	Speculative	Ponzi	No. of Obs.
T (initial year)	Hedge	84.68%	9.01%	6.31%	111
	Speculative	3.98%	83.81%	12.22%	352
	Ponzi	4.35%	32.92%	62.73%	161

Non-manufacturing sector

(D) Size: 10–100 mill.		T+1 (next year)			
		Hedge	Speculative	Ponzi	No. of Obs.
T (initial year)	Hedge	50.00%	41.67%	8.33%	12
	Speculative	2.75%	76.76%	20.49%	327
	Ponzi	0.37%	27.04%	72.59%	270
(E) Size: 100 mill.–1 bill.		T+1 (next year)			
		Hedge	Speculative	Ponzi	No. of Obs.
T (initial year)	Hedge	73.81%	23.81%	2.38%	42
	Speculative	3.89%	82.63%	13.47%	334
	Ponzi	0.81%	22.18%	77.02%	248
(F) Size: 1 bill. yen or over		T+1 (next year)			
		Hedge	Speculative	Ponzi	No. of Obs.
T (initial year)	Hedge	84.00%	12.00%	4.00%	25
	Speculative	1.29%	91.26%	7.46%	389
	Ponzi	0.00%	18.57%	81.43%	210

Table 6: Descriptive statistics (1975–2014)

Manufacturing sector

	(A) 10 million – 100 million					(B) 100 million – 1 billion					(C) 1 billion or over				
Variables	Obs.	Mean	Std. Dev.	Min	Max	Obs.	Mean	Std. Dev.	Min	Max	Obs.	Mean	Std. Dev.	Min	Max
FFI-1	639	0.2144	0.4107	0	1	639	0.1659	0.3723	0	1	640	0.2156	0.4116	0	1
FFI-2	639	0.2848	0.4517	0	1	639	0.1972	0.3982	0	1	640	0.2547	0.4360	0	1
Output gap	639	-0.0096	0.1450	-0.6070	0.7008	639	-0.0055	0.1796	-0.6497	1.3719	640	-0.0094	0.1672	-1.0678	0.6559
Interest rate	639	4.5930	2.6811	1.0000	10.700	639	4.4523	2.8244	0.9000	11.600	640	4.5538	3.0568	0.6000	16.500
Retention rate	512	0.7862	0.1591	0.0131	0.9789	506	0.7058	0.1864	0.0108	0.9795	462	0.5688	0.1836	0.0171	0.9284
Debt ratio	639	4.3163	13.293	0.5781	327.17	639	4.5007	13.564	0.7241	325.51	640	2.7092	3.2707	0.6633	34.555

Non-manufacturing sector

	(D) 10 million – 100 million					(E) 100 million – 1 billion					(F) 1 billion or over				
Variables	Obs.	Mean	Std. Dev.	Min	Max	Obs.	Mean	Std. Dev.	Min	Max	Obs.	Mean	Std. Dev.	Min	Max
FFI-1	590	0.3389	0.4738	0	1	622	0.3328	0.4716	0	1	640	0.2188	0.4137	0	1
FFI-2	589	0.4058	0.4915	0	1	622	0.3746	0.4844	0	1	640	0.3313	0.4710	0	1
Output gap	567	-0.0318	0.3884	-3.0750	4.0505	622	0.0019	1.5555	-28.484	13.475	640	-0.1589	1.8133	-31.732	9.3865
Interest rate	589	4.5898	2.6595	0.6000	10.900	622	4.4154	2.6498	0.5000	18.400	640	4.5301	2.7931	0.2000	13.600
Retention rate	432	0.7560	0.1687	0.0335	1.0000	434	0.6779	0.2067	0.0054	1.0000	450	0.5341	0.2077	0.0214	1.0000
Debt ratio	589	18.095	86.881	0.0182	998.61	622	7.1935	9.8879	0.6014	141.42	640	3.4773	2.7007	0.2910	18.968

Table 7: Econometric analysis using the panel logit regression model (Manufacturing sector: 1975–2014)

	(A) 10 million – 100 million				(B) 100 million – 1 billion				(C) 1 billion or over			
	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
Dep. Var.	FFI-1		FFI-2		FFI-1		FFI-2		FFI-1		FFI-2	
Method	Random		Fixed		Fixed		Random		Fixed		Random	
	Coefficient	APE	Coefficient	APE	Coefficient	APE	Coefficient	APE	Coefficient	APE	Coefficient	APE
Output gap	-3.296***	-0.192**	-2.988***	-0.102*	-7.217***	-1.007***	-2.663*	-0.181*	-8.256***	-0.612***	-6.290***	-0.343***
	(-2.64)	(0.081)	(-2.84)	(0.058)	(-3.06)	(0.270)	(-1.83)	(0.102)	(-4.63)	(0.158)	(-4.57)	(0.076)
Interest rate	-0.150*	-0.009*	-0.227***	-0.008**	0.620***	0.087***	0.334***	0.023***	0.377***	0.028***	0.282***	0.015***
	(-1.65)	(0.005)	(-2.81)	(0.004)	(4.28)	(0.014)	(2.70)	(0.008)	(2.82)	(0.011)	(3.04)	(0.005)
Retention rate	-5.032***	-0.294***	-5.199***	-0.178***	-3.950**	-0.551***	-7.328***	-0.499***	-9.837***	-0.729***	-10.738***	-0.586***
	(-7.67)	(0.044)	(-5.93)	(0.047)	(-2.37)	(0.194)	(-5.83)	(0.052)	(-5.28)	(0.077)	(-8.03)	(0.060)
Debt ratio	0.383***	0.022***	0.369***	0.013**	0.062	0.009	0.130	0.009	0.732***	0.054***	0.529***	0.029***
	(3.84)	(0.007)	(3.95)	(0.006)	(1.41)	(0.006)	(1.55)	(0.006)	(4.48)	(0.013)	(4.87)	(0.006)
Sample size	512		475		230		506		362		462	
Log likelihood	-108.73		-120.46		-28.193		-76.027		-34.436		-82.944	
Prob. > chi 2	0.000		0.000		0.000		0.000		0.000		0.000	
AIC	227.46		248.91		64.386		162.05		76.871		175.89	
Pseudo R2	NA		.2217		0.517		NA		0.662		NA	

Note: To estimate the panel logistic regression, I employed STATA 14. Fixed means the fixed effects model and Random means the random effects model. The coefficient represents the result of the logistic regression and APE is the average partial effect of each variable on the probabilities of Ponzi finance. The z-values are in parentheses below all coefficients or APEs. Pseudo R2 is McFadden's R2 in the fixed effects model, which is not computed for the random effects models estimated by using the maximum likelihood method in STATA 14. AIC is Akaike's information criterion. To estimate the fixed effects model, STATA 14 drops groups with all positive or all negative outcomes. Therefore, sample size included in the estimation may be largely reduced in such a case (e.g., model 3). * p<0.1, ** p<0.05, *** p<0.01.

Table 8: Econometric analysis using the panel logit regression model (Non-manufacturing sector: 1975–2014)

	(A) 10 million – 100 million				(B) 100 million – 1 billion				(C) 1 billion or over			
	Model 7		Model 8		Model 9		Model 10		Model 11		Model 12	
Dep. Var.	FFI-1		FFI-2		FFI-1		FFI-2		FFI-1		FFI-2	
Method	Fixed		Fixed		Random		Fixed		Fixed		Fixed	
	Coefficient	APE	Coefficient	APE	Coefficient	APE	Coefficient	APE	Coefficient	APE	Coefficient	APE
Output gap	-0.604	-0.089	-0.502	-0.072	-0.004	-0.000	0.034	0.005	-0.086	-0.008	-0.181	-0.020
	(-1.16)	(0.080)	((-1.06)	(0.071)	(-0.04)	(0.008)	(0.41)	(0.012)	(-0.71)	(0.012)	(-0.99)	(0.022)
Interest rate	0.107*	0.016	0.107*	0.015	0.507***	0.037***	0.466***	0.066***	-0.002	-0.000	-0.023	-0.003
	(1.67)	(0.011)	(1.82)	(0.010)	(5.03)	(0.009)	(5.24)	(0.010)	(-0.01)	(0.012)	(-0.23)	(0.011)
Retention rate	-3.660***	-0.537***	-3.806***	-0.546***	-4.407***	-0.323**	-2.698***	-0.381***	-2.272**	-0.221	-2.470***	-0.277*
	(-4.16)	(0.058)	(-4.50)	(0.053)	(-4.28)	(0.134)	(-3.10)	(0.136)	(-2.04)	(0.168)	(-2.65)	(0.144)
Debt ratio	0.143***	0.021**	0.163***	0.023***	0.211***	0.015***	0.195***	0.028***	1.029***	0.100***	1.060***	0.119***
	(3.22)	(0.008)	(3.56)	(0.008)	(4.61)	(0.005)	(4.07)	(0.006)	(4.53)	(0.029)	(4.56)	(0.021)
Sample size	385		385		434		330		289		327	
Log likelihood	113.82		-133.17		-124.13		-88.792		-57.174		-75.749	
Prob. > chi 2	0.000		0.000		0.000		0.000		0.000		0.000	
AIC	235.64		274.34		258.26		185.58		122.35		159.50	
Pseudo R2	0.168		0.169		NA		0.380		0.452		0.336	

Note: To estimate the panel logistic regression, I employed STATA 14. Fixed means the fixed effects model and Random means the random effects model. The coefficient represents the result of the logistic regression and APE is the average partial effect of each variable on the probabilities of Ponzi finance. The z-values are in parentheses below all coefficients or APEs. Pseudo R2 is McFadden's R2 in the fixed effects model, which is not computed for the random effects models estimated by using the maximum likelihood method in STATA 14. AIC is Akaike's information criterion. To estimate the fixed effects model, STATA 14 drops groups with all positive or all negative outcomes. Therefore, sample size included in the estimation may be largely reduced in such a case (e.g., models 10–12). * p<0.1, ** p<0.05, *** p<0.01.

Figure 1: Distribution of FFI-1 (Manufacturing sector: A–C and Non-manufacturing sector: D–F)

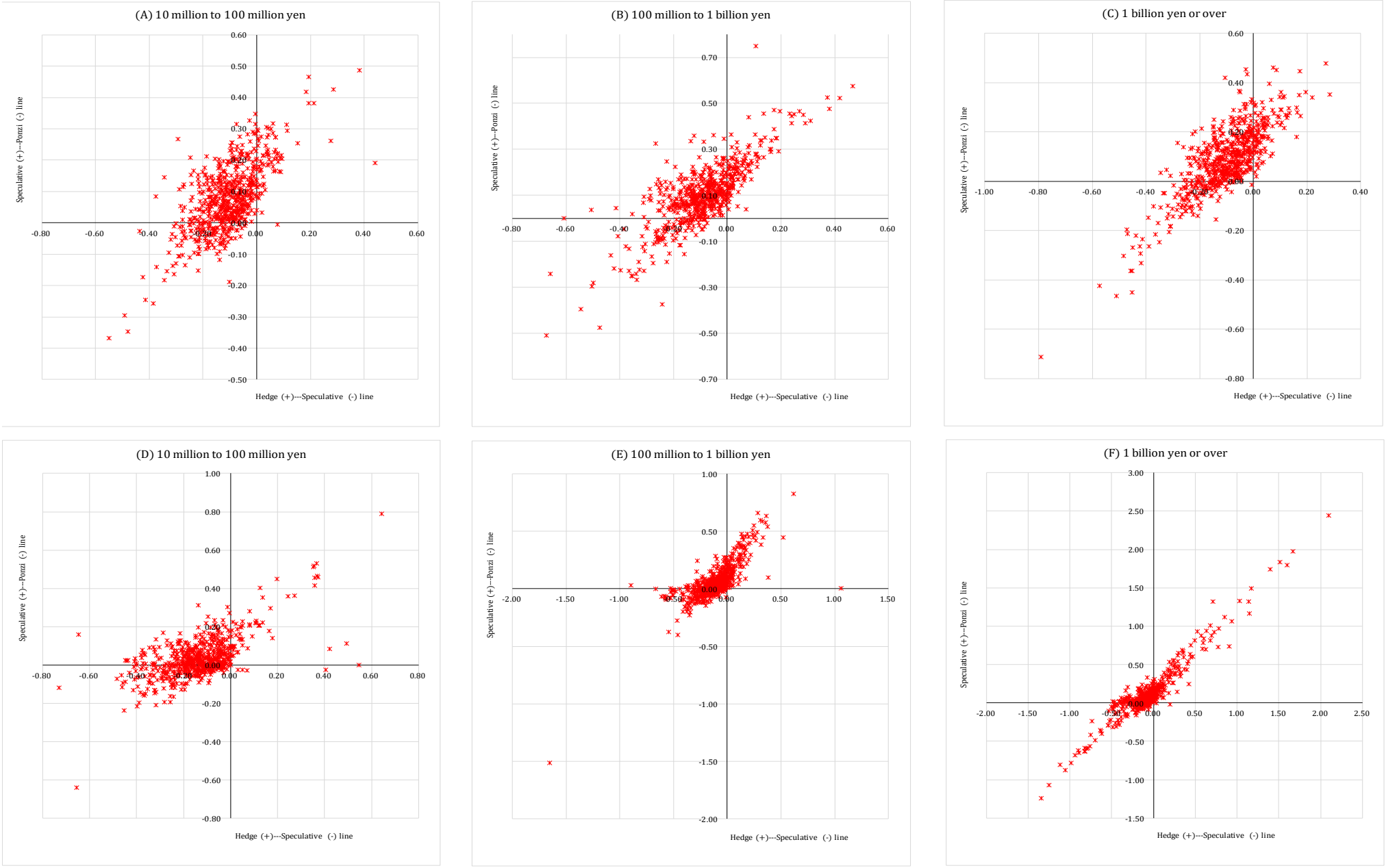
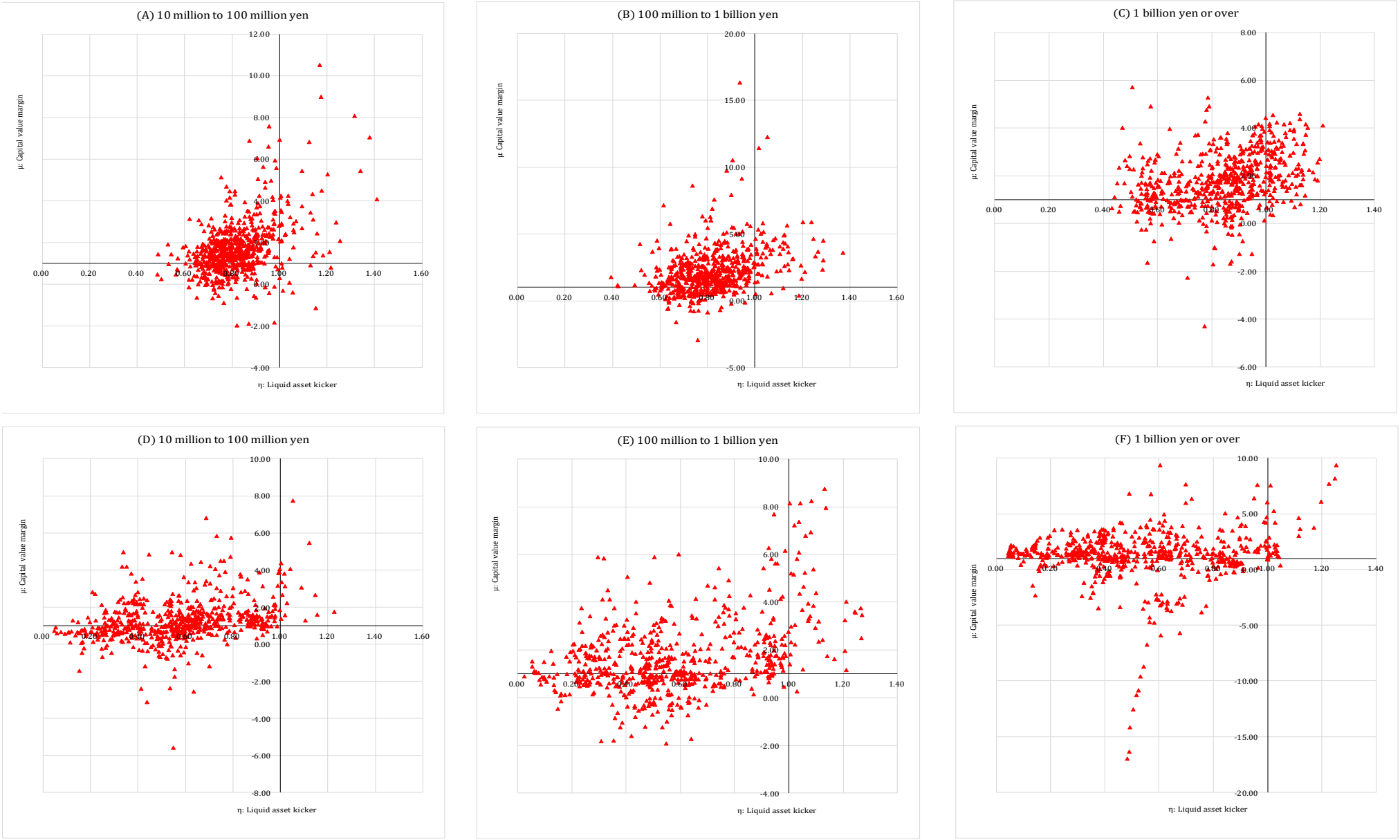


Figure 2: Distribution of FFI-2 (Manufacturing sector: A–C and Non-manufacturing sector: D–F)



Note: Agriculture, forestry and fisheries (17) of 1 billion yen or over in 2010 is excluded in this plot, because it may take an outlier (0.60, 115.8).

Figure 3: Evolution of each sector's financial fragility based on FFI-1 (Manufacturing sector: A–C and Non-manufacturing sector: D–F)

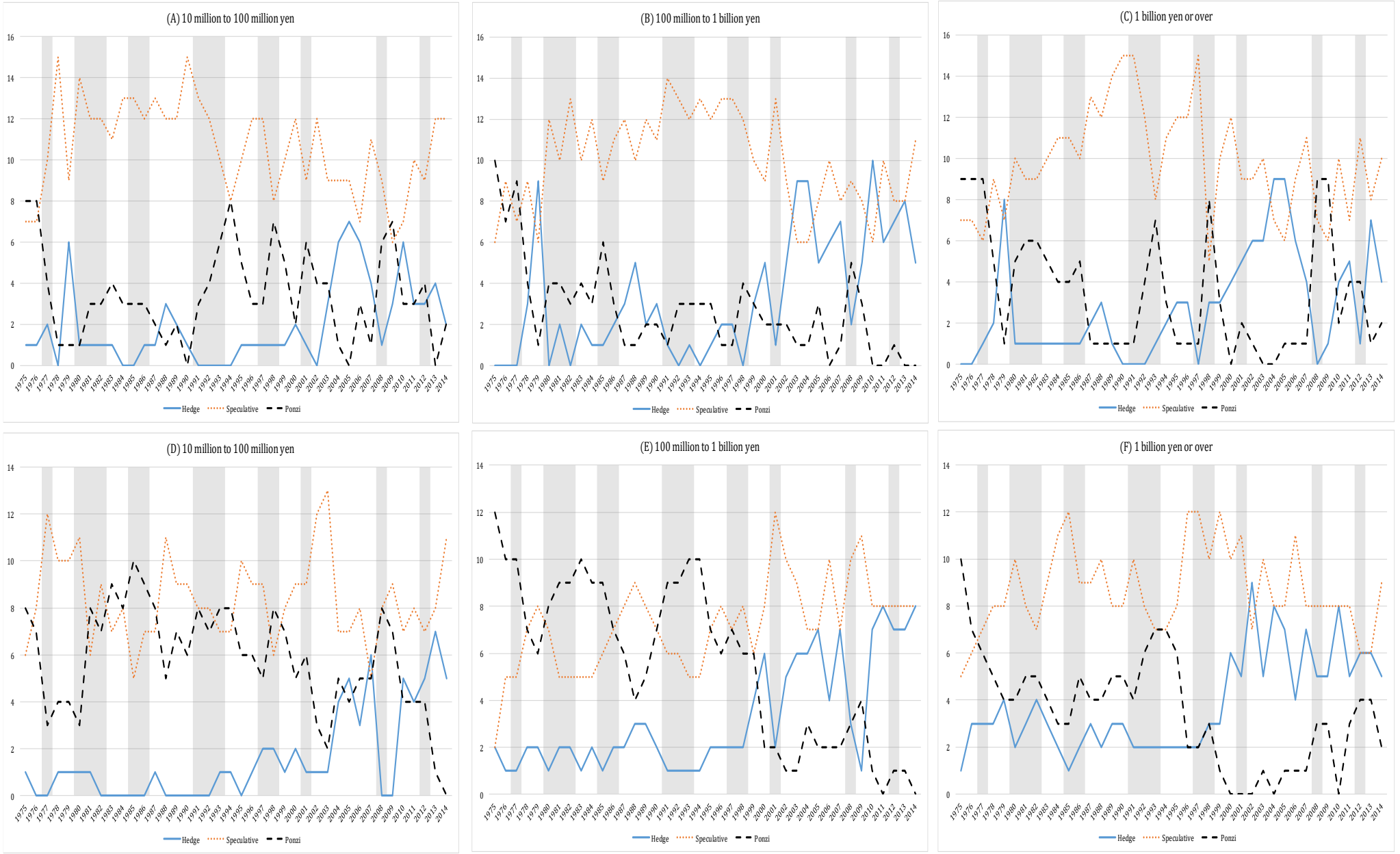


Figure 4: Evolution of each sector's financial fragility based on FFI-2 (Manufacturing sector: A–C and Non-manufacturing sector: D–F)