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Yuichiro Ito*
yuuichirou.itou@boj.or.jp

Yasutaka Takizuka*
yasutaka.takizuka@boj.or.jp

Shigeaki Fujiwara*
shigeaki.fujiwara@boj.or.jp

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Bank of Japan
2-1-1 Nihonbashi-Hongokucho, Chuo-ku, Tokyo 103-0021, Japan

* Monetary Affairs Department

PORTFOLIO SELECTION BY HOUSEHOLDS: AN EMPIRICAL ANALYSIS USING DYNAMIC PANEL DATA MODELS*

Yuichiro Ito†, Yasutaka Takizuka‡, and Shigeaki Fujiwara§

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Abstract

This paper investigates the mechanisms that influence household portfolio selection using Japanese and US household survey data, based on dynamic panel data models. The results show that as the classical portfolio theory indicates, the expected value of excess return on risky assets, market volatility, and relative risk aversion are important factors in household portfolio selection, for both Japanese and US households. Moreover, entry costs such as financial literacy have an indispensable effect, as well as households' various constraints, including liquidity and precautionary saving motives. Next, we examine the difference in household portfolio selection between Japan and the USA to explore the reasons why Japanese households have a cautious investment stance. The results indicate that the difference is partly explained by the differences in the relationships between risks and return in the market along with concerns about the future, but financial literacy and structural factors are also important determinants. This suggests that further improvements in institutional aspects and an increase in financial knowledge, as well as an improvement in market performance and the mitigation of future concerns, are important factors in making investment environments in Japan more attractive.

JEL classification: C33, D14, D81, G11

Keywords: portfolio selection; household survey; dynamic GMM; portfolio selection mechanism; relative risk aversion; financial literacy

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† Monetary Affairs Department, Bank of Japan.
E-mail: yuuichirou.itou@boj.or.jp

‡ Monetary Affairs Department, Bank of Japan.
E-mail: yasutaka.takizuka@boj.or.jp

§ Monetary Affairs Department, Bank of Japan.
E-mail: shigeaki.fujiwara@boj.or.jp

1. Introduction

Japanese households hold a low share of risky financial assets such as stocks and investment trusts (approximately 10 %), while the share of cash and deposits constitute roughly half of their portfolios (Chart 1). Japanese households are much more cautious about investing in risky assets compared with households in the USA and Europe[1], and it is said that this investment behavior has been a typical characteristic of risk-averse households in Japan. Given this, there have been various initiatives in Japan to change households' behavior and promote the formation of households' assets, such as banks' being approved to sell investment trusts and the deregulation of equity trading commission. Since the recent global financial crisis, economic agents have become increasingly risk averse, and the promotion of their risk-taking has become a common issue across countries. Moreover, the importance of discussing the effects of policies and institutional frameworks, as well as of analyzing the mechanisms behind household behavior, has been increasing. In Japan, the Bank of Japan introduced quantitative and qualitative monetary easing (QQE) in 2013; however, cash and deposits are still the main financial assets of households. Considering these facts, when we discuss the policy influences, we need to clarify what keeps Japanese households remain cautious about portfolio allocations, as well as to elucidate the channels of households' portfolio rebalancing, which is one of the key transmission mechanisms of monetary policy.

Merton (1969) and Samuelson (1969), authors of the classical theory of households' portfolio selection, posit that households' optimal proportion of risky assets is determined by excess return (expected return minus return on safe assets) on risky assets, variance of return on risky assets, and relative risk aversion, with additional assumptions concerning completeness of the market and non-labor income. This theory implies that it is optimal for a household to own some risky assets when excess return is positive, no matter how cautious a household is. However, Mankiw and Zeldes (1991) pointed out that there were many households who did not own any stock, even in the USA where investors enjoyed positive excess returns in the stock market for a long period; this tendency is referred to as the "stockholding puzzle." In the extant literature, many researchers have tried to explain this puzzle, in terms of theory and empirical analyses. For example, Heaton and Lucas (2000) and Elmendorf and Kimball (2000) consider the effect of labor income, which is not considered in the classical theory.

[1] Some differences in the statistical definitions of households between Japan and the USA partly contribute to the lower proportion of risky assets attributed to Japanese households. However, there are still major differences which cannot all be explained via this technical discrepancy.

Cocco (2005) and Yao and Zhang (2005) examine the effect of liquidity constraints. Moreover, some research investigates household portfolio selection in a life-cycle framework (see, for example, Bodie et al. [1992] and Ameriks and Zeldes [2004]). In addition, there are studies that consider the existence of various entry costs to hold risky assets (see, for example, Haliassos and Bertaut [1995]). They report that structural factors, such as financial literacy (see, for example, Guiso and Jappeli [2005] and Van Rooiji et al. [2011]) and the tax system (see, for example, Dammon et al. [2004] and Gomes and Michaelides [2004]), have a large effect on household portfolio selection.

Also, in Japan, a number of authors have recently analyzed the mechanisms of household portfolio selection using survey data (see, for example, Kitamura and Uchino [2011], Shioji et al. [2013], Iwaisako et al. [2015], and Aoki et al. [2016]). In general, it is often pointed out that, based on the classical theory, the cautious attitude of Japanese households toward risk after the Heisei-bubble (an asset price bubble in Japan) burst periods was caused by depression in market performance as well as the fundamental risk-averse nature of Japanese people. However, this recent research has pointed out that households' risk averse attitudes are also caused by various constraints such as liquidity constraints, confidence in financial institutions, entry costs of market participation, financial education, and institutional aspects related to investments.

Although various reasons have been put forward to explain this cautious attitude toward risk, no consensus has been reached with regard to a decisive factor for household portfolio selection. The main purpose of this paper is to contribute to understandings of the causes of cautious investment attitudes in Japanese households. As such we analyze the mechanisms that influence household portfolio selection and investigate the causes of portfolio allocation differences between Japanese and US households, using micro data from the "Preferences and Life Satisfaction Survey" conducted by the Institute of Social and Economic Research at Osaka University. Our analysis features the three below mentioned points.

First, we analyze household portfolio selection based on the classical portfolio theory, considering various constraints and factors which represent entry costs. The survey data we utilize continuously investigates the same households regarding market outlook and characteristics of each household, as well as information about constraints. We can analyze household financial decisions based on the classical portfolio theories, because it is possible to calculate the structural parameters considered in the portfolio theories using these data. Second, we simulate household portfolio selection using dynamic panel data models. Thus far, most research in Japan regarding household portfolio

selection has employed cross-sectional data analysis[2], with only limited attention to dynamic analysis in the context of panel data[3]. It is desirable to analyze household portfolio selection in a dynamic framework, because household portfolio decisions are considered to be results of dynamic optimal behavior, as well as spending. Third, we quantitatively evaluate factors which influence household portfolio selection and the difference in these factors between Japan and the USA. In particular, we analyze the effect of changes in the investment environment and reveal what is important for the improvement of Japanese household investment circumstances.

The remainder of this paper is organized as follows. Section 2 summarizes prior literature regarding household portfolio selection. Section 3 delineates features of the "Preferences and Life Satisfaction Survey," presenting details of key questions therein which are used in our analysis. Section 4 describes our models. Section 5 provides the estimation results and reveals what is important for the improvement of Japanese household investment circumstances, investigating the causes of differences in portfolio allocation between Japanese and US households. Section 6 considers changes in Japanese households' portfolio selection since the introduction of QQE, based on the estimation results in Section 5. Finally, Section 7 concludes.

2. Literature Review

In this section, we look first at the classical theory of portfolio selection and then provide an overview of theoretical and empirical literature regarding the "stockholding puzzle," which cannot be explained by the classical theory. In addition, we summarize recent research focusing on Japanese households' cautious attitude in financial investment.

2.1 Classical theory

Merton (1969) and Samuelson (1969), known as the classical theory of household portfolio selection, posit that households' optimal proportion of risky assets is determined by excess return on risky assets, variance of return on risky assets, and relative risk aversion, with additional assumptions such as a time-additive and Constant Relative Risk Aversion (CRRA) utility function, completeness of the market, and non-labor income. Based on this theory, previous research in Japan has maintained for a

[2] See, for example, Kitamura and Uchino (2011) and Shioji et al. (2013).
[3] In the USA, Brunnermeier and Nagel (2008) investigate the relationship between asset allocations and changes in wealth and liquid assets using US household data (Panel Study of Income Dynamics).

long time that the cautious attitude of Japanese households in portfolio selection is a function of depressed market performance and prevailing cultural norms concerning risk-taking.

The optimal proportion of risky assets defined by the classical theory is described as follows:

$$\lambda^* = \frac{z - r}{\sigma^2 \cdot \gamma}$$

where λ^* is the optimal proportion of risky assets in the classical theory, z is the expected return on risky assets, r is the return on safe assets, σ^2 is variance of return on risky assets, and γ is relative risk aversion.

As mentioned above, the classical theory is based on some strong assumptions such as completeness of the market and non-labor income. Mankiw and Zeldes (1991) noted that there are many households that do not own any stock, even in the USA, where investors enjoyed positive excess returns in the stock market for a long period; this tendency is referred to as the "stockholding puzzle." It implies that other factors such as market entry costs may be important. Therefore, numerous studies have attempted to explain the "stockholding puzzle" from theoretical and empirical angles.

2.2 Precautionary saving motive

The classical theory assumes non-labor income. In reality, however, almost all households receive labor income and have income risk due to economic fluctuations and unemployment. Moreover, there is a problem that such risk cannot be hedged completely. Heaton and Lucas (2000), a typical study investigating the effects of labor income on household portfolio selection, suggest that labor income generated from human capital has uncertainty, which leads households to decrease their holdings of risky assets. In addition, Elmendorf and Kimball (2000) investigate the effect of labor income, using a theoretical model. They conclude that it is important to decrease the uncertainty of labor income in order to raise risky asset holding. These studies indicate that the increase in income risk caused by unemployment, and so on, may have an effect on household portfolio selection through precautionary saving motives. Furthermore, it has been pointed out that not only uncertainty regarding labor income but also future pension income risk will cause precautionary saving. In Japan, Murata (2003) empirically investigates how precautionary saving motives stimulated by concerns about pensions promote households to accumulate relatively low risk assets: deposits, individual pensions, and insurances.

2.3 Liquidity constraints

Although it is assumed that there is no liquidity constraint in the classical theory, many households, in reality, face borrowing constraints, which have a serious effect through liquidity constraints on portfolio allocations. Cocco (2005) illustrates that the risk of declining house prices prevents stockholdings, especially in young households and households with less financial assets. This tendency is also recognized in Flavin and Yamashita (2002) and Yao and Zhang (2005). Moreover, Faig and Shum (2002) report that the greater the investment in housing, which is expensive and illiquid, the higher the share of liquid financial assets such as deposits.

2.4 Life-cycle models

Some studies have attempted to capture household portfolio selection in a life-cycle model, because life cycle has a close relationship with human capital, which plays an important role in households' portfolio choice through precautionary saving motives and liquidity constraints. Bodie et al. (1992) reveal that the optimal proportion of risky assets in young peoples' portfolios is higher because young people, who embody adequate human capital, can deal with the possibility of declining prices of risky assets by increasing their labor supply under certain assumptions such as completeness of the market. However, in the incomplete market, liquidity constraints and precautionary saving motives hinder mainly younger people's ownership of risky assets (Iwaisako [2012]). Therefore, the effects of age on the optimal ratio are inconclusive theoretically, having both the possibility of increasing or decreasing the ratio. In their empirical study, Ameiks and Zeldes [2004] indicate that the actual relationship between the share of risky assets and age is "quadratic (inverted U) function," based on US household data. Studies such as Campbell and Viceira [2002], however, point out the difficulty of identifying the effects of age. Shioji et al. [2013] suggested that the effect of greater financial assets in older households is more important than that of age itself.

2.5 Entry costs such as financial literacy

Haliassos and Bertaut (1995) emphasize the importance of entry costs as an explanation for the "stockholding puzzle," and point out that households' attributes such as their educational background limit their participation in the stock market. Subsequent studies have shown that barriers to entry into the stock market such as requirements of acquiring knowledge and information about financial transactions and psychological burdens impair participation in the stock market (see, for example, Abel et al. [2013]). As for financial literacy, Guiso and Jappelli (2005) and Van Rooiji et al. (2011) report

that high financial literacy increases the likelihood of participation in the stock market, and educational and economic background as well as length of a relationship with a bank have an effect on financial literacy. Moreover, some studies put emphasis on the importance of institutional aspects of portfolio selection. For instance, Dammon et al. (2002) and Gomes and Michaelides (2004) investigate the effects of tax systems such as tax-deferred accounts on household portfolio selection.

2.6 Portfolio choice of Japanese households

Many studies have also been conducted in Japan, using household survey data, in order to understand and explore the mechanisms of household portfolio selection. In recent analyses, Iwaisako (2012) and Iwaisako et al. (2015) focus on the fact that real estate prices in Japan are so high compared to income levels that Japanese households need to devote a considerable part of financial assets to purchase real estate, and they indicate that such a practice leads to a cautious stance vis-à-vis the financial investments of Japanese households, involving liquidity constraints. By contrast, Kinari and Tsutsui (2009), Kitamura and Uchino (2011), and Shioji et al. (2013) emphasize the importance of confidence in financial institutions and financial literacy as explanations for the "stockholding puzzle," and suggest that it is important for the promotion of risk-taking to provide information about financial transactions to households. Moreover, Aoki et al. (2016) analyze Japanese households' portfolios based on a life-cycle model and point out that low expected stock returns, low expected inflation, and high market entry costs are the main determinants. In addition, Fukuhara (2016) posits that in explaining the differences in portfolio selection between Japan and the USA, institutional aspects are also important such as the Defined Contribution pension system (DC).

Although previous literature has endeavored to explain the "stockholding puzzle" and pointed out various potential and plausible reasons, there is no consensus on which factors are decisively important to understanding and solving this puzzle. Therefore, we analyze the factors mentioned above in detail.

3. Data

In this paper, we utilize results of the "Preferences and Life Satisfaction Survey (hereafter, the PLSS)," conducted by the Institute of Social and Economic Research at Osaka University, to investigate the mechanisms of household portfolio selection. The PLSS, a questionnaire regarding households financial behavior, is a nationwide survey of men and women who are between 20 and 69 years of age (as of 2003 in Japan), and investigates the condition of their financial assets and attitudes toward risk, as well as

their basic characteristics, such as age and income. It was conducted annually from 2003 to 2013 in Japan (from 2005 to 2013 in the USA). The number of respondents in 2013 was 4341 (5079 in the USA), which is comparable to other well-known household surveys concerning financial behavior in Japan, such as the "Survey of Household Finances (hereafter, the SHF)." The PLSS surveys individuals while the unit of analysis in the SHF is households[4]. Table 1 and Table 2 provide overviews of both surveys.

The PLSS is characterized as follows. First, it surveys the same respondents every year; therefore, we can utilize panel data notwithstanding certain missing data issues and new entries. In this regard, we can also use dynamic panel data models for analysis. By contrast, several household surveys, which have been commonly used for the analysis of household portfolio selection in Japan, consist of repeated cross-sectional data on households and, therefore, are not suitable for dynamic estimation[5]. Second, the PLSS investigates various factors regarding household portfolio selection and can reveal the mechanisms of household portfolio selection, considering factors that are emphasized in the extant literature. Specifically, we can use data for the expected return on financial assets and individuals' attitudes toward risk, which enables us to analyze according to the classical portfolio theory framework. Moreover, we can also analyze households' various constraints such as liquidity and precautionary saving motives, as the PLSS collects data regarding future income uncertainty such as concerns about unemployment and later life, in addition to the conditions of financial debt. Third, it is possible to compare with other countries, because the PLSS is conducted in Japan, the USA, India, and China using the same question format. Therefore, through international comparison, we can analyze why Japanese households have a lower share of risky assets relative to US households, which has long been considered to be an important issue in Japan. In the following section, we explain the details of the PLSS variables, which are used in our analysis.

3.1 Proportion of risky assets

There is not necessarily a ubiquitous definition of a risky asset. Previous studies in Japan have generally regarded stocks as typical risky assets, but some include

[4] For analysis of household portfolio selection using the PLSS, see Kinari (2007). He investigates the background of the difference in the proportion of risky assets between Japan and the USA, using PLSS data in 2005. He suggests that the conventional view which emphasizes differential risk tolerance between Japanese and US households is not appropriate, and a large part of the differential depends on factors that have not been explicitly considered in classical portfolio theory.

[5] The SHF and the "Nikkei RADAR", which are widely used in the analysis of households' portfolio choice in Japan, consist of repeated cross-sectional data.

investment trusts (Kitamura and Uchino [2011]), bonds (Kinari and Tsutsui [2009]), or foreign assets (Shioji et al. [2013]). Moreover, previous literature has also analyzed risky assets including real assets such as land estate (for example, see Economic Planning Agency [1999]), in addition to financial assets. However, households' perception of risk may be different due to the purpose of holding real assets such as land or housing, and the selection mechanisms regarding real assets is probably different from those of financial assets. Therefore, we limited the scope of the analysis to financial assets and analyze the mechanisms of household portfolio selection[6].

In this paper, we utilize the response to the question about the ratio of risky financial assets in the PLSS. In particular, we regard the following as risky assets: financial assets involving the risk of principal loss such as investment trusts, stocks, futures/options, corporate bonds, and foreign assets, according to the PLSS's definition. Compared with previous studies in Japan, our definition of risky assets seems to be wide. The question regarding risky assets is phrased as follows:

■ What percentage of the financial assets of your entire household are in the following?

Group A: Bank savings, cash, government bonds……_____%

Group B: Investment trusts, stocks, futures/options, corporate bonds, foreign currency deposits, government bonds of foreign countries……_____%

Therefore, in this paper, we define the assets indicated in Group B as risky assets. It is a noteworthy characteristic of the PLSS that it investigates the proportion of risky assets, rather than the absolute magnitudes of risky assets[7].

3.2 Expected return on risky assets

In the PLSS, there are various data regarding potential determinants of household portfolio selection, and households' expected return on financial assets is one such example.

[6] However, as for the effect of real assets, we consider indirect effects through liabilities such as housing loans.

[7] In the PLSS question regarding share of risky assets, respondents do not state the market value or book value terms. Therefore, these data are mix value types.

■ What would you say is your average annual profit-earning rate of your financial assets?

_____._____% Cannot say

In the classical portfolio theory, the expected return on risky assets plays an important role in decision making processes for portfolio selection. We need to take households' heterogeneity of expected return on risky assets into consideration in analyzing micro data. However, few empirical studies in Japan explicitly consider households' heterogeneity partly due to data constraints[8]. In this regard, the PLSS investigates households' expectations vis-à-vis returns on financial assets.

3.3 Relative risk aversion

Similar to the expected return, relative risk aversion is an important variable in classical portfolio theory. Although it is impossible to capture relative risk aversion directly, we can estimate it by using questionnaire responses and assuming a household utility function (see Barsky et al. [1997] and Cramer et al. [2002]). The PLSS investigates a household's attitude toward lottery tickets, insurance, and monthly salary payments; we can calculate relative risk aversion using these data. In this paper, we regard a household's attitude toward monthly salary payments as a proxy for relative risk aversion and estimate it by the method proposed by Barsky et al. (1997). The Appendix provides details of the estimation method and the rationale for using monthly salary payments.

The survey question about attitudes toward monthly salary payments, which is used in calculating relative risk aversion, differs each year in contents and the number of selections. For this reason, when estimating relative risk aversion using their responses to questions in each year, it is impossible to maintain continuity with respect to this variable. Thus, we calculate relative risk aversion using the responses from 2012 to 2013 which use the same format and apply the same value to the same individuals throughout the analysis period[9]. This means we are assuming that relative risk aversion is constant for each individual over the entire analysis period[10].

[8] Kinari and Tsutsui (2009) utilize Japan's Post questionnaire to analyze households' portfolio choice considering households' heterogeneous expectations for returns on risky assets. They explain household portfolio selection considering expectations and variance of returns on risky assets.

[9] When data is available both in 2012 and 2013, we applied the average values. There is no noticeable difference in the data over both years.

[10] Although relative risk aversion may vary according to changes in economic conditions and aging in the long run, individual parameters probably do not change substantively in the short run. Therefore, this

3.4 Liquidity constraints

The PLSS also elicits information about liabilities such as conditions of borrowing and amount of financial debt, in addition to asset-oriented questions including the conditions of holding financial assets. We can use liability information as a proxy for liquidity constraints. In our analysis, we utilize past experience with loan rejection and a ratio of financial debt to financial assets as a proxy for liquidity constraints. In particular, we regard households whose ratio of financial debt to financial assets is over one as those facing liquidity constraints.

3.5 Precautionary saving motives

The PLSS also includes questions related to precautionary saving motives such as concerns about unemployment and later life.

- Do you think there is a possibility that you will be unemployed (in the case of running your own business, the possibility of discontinuing business) within 2 years?
- Do the following statements hold true for you?
  I have anxieties about my “life after I am 65 years old” (for those who are already aged 65 or above, “life in future”).

Although these questions may not directly represent precautionary saving motives, they are considered to be factors that raise precautionary saving motives, and prior studies have utilized them as proxy variables for precautionary saving motives (for example, see Murata [2003]). As for the question about later life concerns, usable questions are limited to 2004, 2005, 2006, 2012, and 2013. Therefore, we average the entire data and apply it to the same respondents for each year; thus, again, we are assuming that these concerns do not change for individuals at least in the short term.

3.6 Financial literacy

The PLSS also enquires into the financial literacy of households in 2010, through four questions.

assumption seems to be reasonable.

- Suppose you had ¥10,000 ($100) in a savings account and the interest rate is 2% per year and you never withdraw money or interest payments. After 5 years, how much would you have in this account in total?
- Imagine that the interest rate on your savings account was 1% per year and the inflation was 2% per year. After 1 year, how much would you be able to buy with the money in this account?
- Please indicate whether the following statement is True or False? “Buying a company stock usually provides a safer return than a stock mutual fund.”
- If the interest rate falls, what should happen to bond prices?

The above questions adhere reasonably with international research into financial literacy, which testifies to their construct validity[11]. Further, observing the relationships between the number of correct answers and the occupation of respondents, those employed in the finance/insurance industry tended to score highly (Table 3). For this reason, we also consider whether or not respondents are engaged in the finance/insurance industry as a proxy variable for professional financial knowledge[12].

3.7 Differences between Japan and the USA

a) Proportion of risky assets, expected return, concerns about unemployment and later life, and financial literacy

As already noted, the PLSS is conducted internationally in Japan, the USA, India, and China using the same questionnaire format. Therefore, an international comparison, using the same framework, of the mechanisms of household portfolio selection is possible. In this paper we also focus on US households whose proportion of risky assets is relatively high compared with Japanese households. In this section, we compared both of these countries in terms of several variables related to portfolio selection (Table 4).

Statistical analyses confirm that the proportion of households holding risky assets in

[11] Sekita (2011) investigates the relationship between financial literacy and asset formation for retirement, using the PLSS. She reveals that financial literacy is significantly related to sex, age, income, and education. Moreover, she indicates that households who have substantive financial literacy tend to save more financial assets for use in retirement.

[12] The PLSS investigates financial literacy only in 2010. Therefore, we apply the data in 2010 to all other years, thus assuming that financial literacy of households does not change over the entire analysis periods.

Japan is significantly lower than that in the USA, and the ratio of risky assets in households holding risky assets in Japan is also significantly smaller than that in USA. These results thus testify to the relatively cautious stance of Japanese households vis-à-vis financial investment. As for factors which have a significant effect on portfolio selection, the expected return on risky assets is relatively low in almost all Japanese households compared to US households. In addition, concerns about later life are clearly higher in Japanese households, and the proportion of correct answers to financial literacy questions tends to be low for every question[13]. On the other hand, the ratio of financial debt to financial assets and past experience with loan rejections in the USA tends to be relatively high. It is likely that these differences between Japan and the USA explain the differences in risk-taking of Japanese and US households through the mechanism of portfolio selection.

b) Relative risk aversion

In determining relative risk aversion, we use risk attitudes toward monthly salary payments. This is because the estimation error of relative risk aversion calculated from attitudes toward monthly salary payments is smaller relative to the errors calculated from risk attitude toward lottery tickets and insurance. Furthermore, the relationship between risky asset holding and relative risk aversion based on attitudes toward monthly salary payments seems to be consistent with the theory of portfolio selection[14]. Using statistical analysis, we confirmed that relative risk aversion in Japan is moderately but significantly smaller than that in the USA.

However, estimation results of relative risk aversion can obviously vary depending on measurement methods employed and the nature of the risk. Indeed, while Japanese households seem to be risk tolerant when we consider risk attitudes toward monthly salary payments and lottery tickets, compared to US households, they are relatively risk averse when we consider risk attitudes for insurance (Chart 2). In addition, even if we could specify the measurement method or the nature of risk, another problem also exists.

[13] Klapper et al. (2015) present results showing that Japanese households score lower than US households in terms of financial literacy. The financial literacy survey conducted by the Central Council for Financial Services Information (the secretariat is the Public Relations Department at the Bank of Japan) in 2016 also indicates that the proportion of correct answers to questions regarding financial literacy in Japanese households is relatively low compared with US households.

[14] See the Appendix. The relationship between the proportion of households holding risky assets and relative risk aversion calculated from risk attitudes toward monthly salary payments or lottery tickets is consistent with portfolio theory which posits that households whose relative risk aversion is high are reluctant to hold risky assets. On the other hand, it is not consistent with portfolio theory when we use relative risk aversion calculated from risk attitudes toward insurance; households whose relative risk aversion is high show significant tendencies to hold risky assets in this case (Table 5).

For instance, when we discuss the differences in the national characters of Japan and the USA, there may also be a definitional problem about how much consideration should be given to differences in the demographic characteristics and the social security systems of the two countries. Considering these points, our analyses cannot necessarily deny the view that "Japanese households are risk averse."

4. Model

4.1 Model framework

When analyzing the mechanisms of household portfolio selection, previous literature has often separately analyzed the issue as to (i) how much to invest in risky assets when assuming possession of risky assets (Conditional Share of households holding risky assets, hereafter, CS) and (ii) whether or not to own risky assets (Participation Rate of all households, hereafter, PR) (Shioji et al. [2013], Iwaisako et al. [2015]). Looking at the relationship between the factors related to household portfolio selection such as the ratio of financial debt to assets (liquidity constraints), concerns about later life (precautionary saving motive), whether or not they are engaged in the finance/insurance industry (financial literacy) and CS or PR, we recognize that the determinants of CS and PR may be different. Although, for instance, there is no clear relationship between whether or not to work for the financial/insurance industry and CS, a significant relationship is confirmed between all factors and PR (Table 6). Given that it is not clear which factors are decisively important for household portfolio selection, it is desirable to analyze CS and PR separately, in accordance with the previous literature.

4.1.1 Conditional share (CS)

When investigating the mechanisms determining CS, we need to separate the issue of what households think is an optimal ratio of risky assets and how they adjust their actual portfolio allocation to achieve this optimal ratio. This is based on the idea that it is difficult for households to adjust their portfolios to optimal levels quickly, for various reasons such as transaction costs, time constraints, and liquidity constraints[15], when their optimal ratio of risky assets changes according to changes in the market environment.

[15] Tanaka and Baba (2003) introduce a dynamic, theoretical decision making model for investors under the existence of transaction costs, and indicate that the setting/cancellation cost that occurs in trading affects the investor's behavior such as postponing investment decisions that the theory of CAPM (Capital Asset Pricing Model) does not consider.

As an example of empirical literature that has investigated household portfolio adjustments using a dynamic data model framework, Calvet et al. (2009) employed a partial adjustment model using Swedish household survey data. They assumed that fluctuations in the ratio of risky assets can be divided into passive change due to market price dynamics and active change due to household adjustment. They tested household portfolio selection using a partial adjustment model and concluded that households, themselves, gradually adjust their positions toward the ratio that they consider to be optimal.

In Japan, dynamic analysis of household portfolio selection has not progressed sufficiently. In this paper, we focus on holders of risky assets and use a partial adjustment model to explain households' decisions for determining CS. In the analysis, we model households' behavior, according to classical portfolio theory as closely as possible.

Specifically, to discuss the issue of how much to invest in risky assets, we model households' behavior, assuming that the unobservable optimal proportion depends on expected returns on risky assets, returns on safe assets, market volatility, relative risk aversion, liquidity constraints, precautionary saving motives, and fixed effects as follows[16]:

$$\ln\left(\lambda_{i,t}^{*}\right) = \beta_1 \ln\left(\frac{z_{i,t} - r_t}{{\sigma_t}^2 \cdot \gamma_i}\right) + \beta_2 L_{i,t} + \beta_3 P_{i,t} + d_i + u_{i,t} \quad (1)$$

where $\lambda_{i,t}^{*}$ is the optimal ratio of risky assets, $z_{i,t}$ is the expected return on risky assets, r_t is the return on safe assets, ${\sigma_t}^2$ is the variance of return, γ_i is the relative risk aversion, $L_{i,t}$ is a liquidity constraint, $P_{i,t}$ is the precautionary saving motive, d_i is the fixed effects, $u_{i,t}$ is an error term. By introducing fixed effects, we considered the heterogeneity of households that could not be captured by these explanatory variables. Moreover, we use a natural logarithm of the optimal ratio and assume restriction of short selling.

Consequently, to examine how households adjust their positions, we assume that they partially adjust their ratio of risky assets, reducing the gap between their optimal ratio and their present ratio:

[16] Bodie et al. (1992) discuss household portfolio selection, considering labor income risk, and investigate a theoretical equation in which the optimal proportion of risky assets varies linearly according to the labor income risk such as the fluctuation of wages. In this paper, we formulated various constraints linearly and additively according to extant empirical studies, for the ease of handling and interpretation.

$$\ln(\lambda_{i,t}) - \ln(\lambda_{i,t-1}) = \alpha\left(\ln(\lambda_{i,t}^{*}) - \ln(\lambda_{i,t-1})\right) + \varepsilon_{i,t} \quad (2)$$

$$\ln(\lambda_{i,t}) = \alpha \ln(\lambda_{i,t}^{*}) + (1-\alpha)\ln(\lambda_{i,t-1}) + \varepsilon_{i,t} \quad (3)$$

Equation (3) indicates that the present proportion is determined by the proportion of the previous ratio and the optimal ratio. If we confirm that α is significant between 0 and 1, this testifies to the validity of the partial adjustment model vis-à-vis household portfolio selection.

In dynamic panel data models, if the lagged dependent variable is correlated with the error term, we cannot estimate consistent parameters by the ordinary least squares method. To estimate consistent parameters, we need to calculate differences in order to remove the fixed effects or to estimate in terms of GMM (Generalized Method of Moments) using instrumental variables. Herein, we analyze using the system GMM method, proposed by Blundell and Bond (1998).

4.1.2 Participation rate (PR)

Next, we expand the scope of analysis to all households and estimate in accordance with the previous model to examine the mechanisms of determining PR. Specifically, we introduce a probit model that is commonly used in existing research. Considering the characteristics of panel data in the PLSS, we estimate a random effects panel probit model as follows:

$$y_{i,t}^{*} = \alpha_1 \frac{z_{i,t} - r_t}{{\sigma_t}^2 \cdot \gamma_i} + \alpha_2 L_{i,t} + \alpha_3 P_{i,t} + \alpha_4 E_{i,t} + d_i + c + u_{i,t} \quad (4)$$

$$y_{i,t} = \begin{cases} 1 & (y_{i,t}^{*} > 0) \\ 0 & (y_{i,t}^{*} \leq 0) \end{cases}$$

where $y_{i,t}$ is a dummy variable that takes the value of unity for households who own risky assets and zero otherwise. $y_{i,t}^{*}$ is a potential variable regarding the probability of holding risky assets, $z_{i,t}$ is the expected return on risky assets, r_t is the return on safe assets, ${\sigma_t}^2$ is the variance of return on risky assets, γ_i is the relative risk aversion, $L_{i,t}$ is the liquidity constraint, $P_{i,t}$ is the precautionary saving motive, $E_{i,t}$ is the entry cost, d_i is the disturbance term for individual *i*, *c* is a constant, and $u_{i,t}$ is an error term.

Compared to our analysis of the mechanisms for determining CS, we newly add entry

costs as an explanatory variable. This is because previous studies regarding the "stockholding puzzle" point out that entry costs have an important effect on participation in the stock market. In detail, we utilize information about households' financial literacy and whether or not they are employed in the finance/insurance industry as entry costs.

4.2 Data selection

As discussed in section 2, we utilize data from the PLSS as proxy variables for the proportion of risky assets, expected return on risky assets[17], relative risk aversion, liquidity constraints, precautionary saving motives, and financial literacy. We use available macro data for explanatory variables which cannot be obtained from the PLSS. Specifically, we regard deposit rate as return on safe assets, and we apply the same value to all households[18]. For variance of return on risky assets, we use Nikkei VI[19], considering the fact that in Japan, the weight of equity and investment trusts in risky assets is high (equity: 9.2%, investment trusts: 5.4%, bonds: 1.6%)[20]. In this regard, since the variance of the return on risky assets for households is highly heterogeneous and it can be considered that there is a correlation with the expected return on risky assets, it is desirable to take such heterogeneity into account. However, due to data constraints, we use observed macro data for all households for the variance of the return on risky assets in this paper.

5. Numerical Results

This section reports results elucidating the mechanisms of households' portfolio choice, based on our model.

5.1 Mechanisms determining conditional share

Table 7 shows the results pertaining to CS determinants. First, we confirm that α exists between zero and one significantly in all models, which indicates risky asset

[17] Considering the fact that the distribution of the expected return on financial assets is biased upward, we winsorize 3% of the upper data at the end of the distribution; we replace the upper 3% data of the distribution with the upper limit of the remaining data for each survey year.

[18] For return on safe assets in the USA, we used the US Treasury's 3 month rate.

[19] We use the average from January to March in each year according to the investigation period. In addition to Nikkei VI, VXJ published by the Osaka University Mathematical Laboratory is also available as a proxy variable for market volatility. However, our testing suggests no significant differences between them. For market volatility in the US estimation, we used VIX of S&P as a proxy variable.

[20] These figures are as of 2016 in the SHF and are based on households with two or more people. The figure is the proportion in total financial assets.

holders partially adjust their proportion of risky assets to their optimal proportion. In addition, the results show that the optimal proportion depends significantly on classical portfolio theory factors in all models such as expected return on risky assets, return on safe assets, market volatility, and relative risk aversion[21]. As for households' constraints such as liquidity constraints and precautionary saving motives, the explanatory variables such as past experience with loan rejection and concerns about unemployment do not significantly influence portfolio selection, whereas the optimal ratio of households with excess debt is negatively affected through liquidity constraints. These analyses indicate that classical portfolio theory factors have an important role to play in determining CS.

5.2 Mechanisms determining participation rate

Next, Table 8 shows the estimation results of using a random effects panel probit model to test PR determinants. Similar to the estimation results for CS, the classical portfolio theory factors such as expected return on risky assets, return on safe assets, market volatility, and relative risk aversion also have significant effects on participation in the risky asset markets. In contrast, it is confirmed that various variables such as liquidity constraints, precautionary saving motives, and entry costs have a significant impact on the probability of holding risky assets. As for the average marginal effects, the values of the financial literacy and financial/insurance industry dummies are large, as are those associated with liquidity constraints and precautionary saving motives. This indicates that entry costs including financial literacy and households' constraints play an important role in the mechanisms of determining PR.

These estimation results are summarized as follows. Although the factors of the classical theory perform an especially important role in the mechanisms of determining CS, not just the classical theory but also various households' constraints such as liquidity, precautionary saving motives, and entry costs have important effects in determining PR.

5.3 Differences between Japan and the USA

Here, we expand the scope of analysis to US households and consider the background of the differences in portfolio selection between Japanese and US households. Table 9 shows estimation results from dynamic testing of the mechanisms determining CS in Japan and the USA. These results can be summarized as follows. First, households

[21] The results of Sargan tests and Arellano-Bond tests suggest that model specifications satisfy hypothesized requirements.

partially adjust their proportion of risky assets both in Japan and the USA. Second, the factors of the classical portfolio theory have a significant impact on the optimal proportion of risky assets in both Japanese and US households. Third, liquidity constraints with excess debt decrease the optimal proportion in households in both countries. Assuming the same mechanisms of portfolio selection in Japan and the USA, we calculate optimal proportions in Japanese and US households using the median of explanatory variables and investigate the background of their differences. This indicates that differences in the expected value of excess return on risky assets and market volatility, and relative risk aversion subsequently influence differences in portfolio selection between Japan and the USA (Chart 3). In addition, it is confirmed that the factor other than explanatory variables, captured by constant term in our model also has a large effect.

Next, we investigate mechanisms determining PR (Table 10). The results indicate that the factors of the classical theory, liquidity constraints, and precautionary saving motives have a significant effect on participation rates both for Japanese and US households. In addition, it is confirmed that financial literacy, especially regarding investment diversification and bond prices, is strongly related to the possession of risky assets.

Chart 4 shows the breakdown of the difference in the probability of holding risky assets between Japanese and US household, using the estimated marginal effects and the difference of averages in their explanatory variables. It indicates that while the factors of the classical theory and concerns about later life have subsequent effects on the probability of holding risky assets, the major difference is explained by financial literacy and the factor captured by constant term. It is difficult to specify the factor of the constant term, however, there is a possibility that the difference in institutional aspects of portfolio selection between Japan and the USA, which is one of factors that is not explicitly considered in our model, may be affecting, given that US households have invested in risky assets through the Defined Contribution pension system. In addition, structural factors such as differences in values and cultures may have some influence.

In summary, although differences in portfolio selection between Japan and the USA can be explained to some extent by the risk-return relationship in the markets and by concerns about later life, other factors are also indispensable, particularly financial literacy. Importantly, structural factors such as differences in institutional aspects of portfolio selection in Japan and the USA, which are not explicitly considered in this paper, could conceivably exert an important influence. This implies that it is important to improve not only the risk-return relationship of the market, mitigate various

constraints on households, but also the institutional aspects and promote financial education in order to improve the investment environments of Japanese households[22].

6. Household Portfolio Selection since the Introduction of Quantitative and Qualitative Monetary Easing (QQE)

From our analysis so far, it is evident that the risk-return relationship of risky assets is important with respect to the household portfolio selection mechanism. It is also important to consider the various constraints of households, including liquidity and precautionary saving motives. In addition, the influence of entry costs including financial literacy is indispensable. Based on these mechanisms, how can we interpret recent developments vis-à-vis household portfolio selection? Considering that the PLSS has not been conducted since 2014, we examine some recent developments in Japanese household portfolio selection using various data sources such as the SHF, based on the premise that the mechanisms articulated in the previous section are still valid.

First, we summarize changes in the situation surrounding household portfolio selection since the introduction of QQE in order to explore the background of households' portfolio choice behavior. The stock market has been steady since around 2013 (Chart 5). This paper does not cover how the expected rate of return on risky assets is formed. However, based on the assumption of a conforming expectation formation mechanism, whereby expectations are a function of past results, the expected rate of return is considered to have increased with the upturn in the equity market[23]. Concomitantly, the other hand, interest rates on safe assets such as insurance and government bonds have continued to decline as ordinary deposit and long-term interest rates decline. As a result, the expected excess return on risky assets is thought to have improved. Considering the fact that there has been no major change in market volatility, the risk-return relationships of risky assets expected by households should have improved, and as suggested by classical portfolio theory, the optimal proportion seems to have risen[24].

[22] Awareness of financial education is increasing around the world. In Japan, a "Financial literacy survey" was conducted in 2016 by the central council for financial services information (which is administered by the Bank of Japan) to capture the status of financial literacy in the population. It is the first large-scale survey of its type in Japan, sampling around 25,000 people across different socio-economic and demographic strata.

[23] Looking at the relationships between the expected rate of return on financial assets in the PLSS and past equity prices (1, 2, and 3 year moving averages), long-term equity price performance (3 year moving averages) shows a strong correlation with the expected return.

[24] Based on the assumption that the individual parameters such as relative risk aversion do not change significantly in the short term.

Such an increase in the optimal ratio could have promoted risk-taking mainly in households already holding risky assets.

The proportion of risky assets in Japanese households has been increasing since the introduction of QQE, but the pace of the increase is moderate and remains lower than that of US households (Chart 6). However, households already holding risky assets exhibit an increased desire to retain risky assets and actively undertake risks (Chart 7). Based on the estimation results, such a movement can be interpreted in line with classical portfolio theory[25].

On the other hand, in households that have not held risky assets so far, although there is some wish to invest in such assets, this change is incremental gradual on the whole. Looking at recent developments in terms of concerns about later life that evoke the precautionary saving motive, young people in particular still worry about later life since the introduction of QQE. The influence of these factors hindering risk-taking seems to be still considerable (Chart 8).

7. Conclusion

In this paper, we examined the portfolio selection mechanism of households by using household data from Japan and the USA on financial behavior, and consider their implications. In order to reveal the selection mechanism, we first analyzed based on classical portfolio theory, considering the influence of various constraints on households. We used the results of the "Preferences and Life Satisfaction Survey" conducted in Japan and the USA by Osaka University to explain household portfolio selection, considering market environments and respondents' characteristics. We also formulated the portfolio selection of households using the framework of dynamic analysis (partial adjustment model) based on panel data, quantitatively evaluated the mechanism of portfolio selection, and then highlighted what is needed to improve the investment situation of households.

The following implications are noteworthy. First, we tested the portfolio selection mechanism of households based on dynamic panel analysis, and the results showed that the factors of the classical theory (such as expected return on risky assets, interest rate of safe assets, market volatility, and relative risk aversion) have a significant effect for

[25] Improvements of institutions surrounding household portfolio selection such as the introduction of NISA (Nippon Individual Savings Account) also support risk-taking by households. For households' understanding and recognition of NISA, see Financial Services Agency (2016).

both Japanese and US households. Second, in addition to the various constraints on households, including liquidity and precautionary saving motives, it was found that the influence of entry costs such as financial literacy is indispensable for both Japanese and US households. In particular, when analyzing whether to own risky assets or not, it was confirmed that various constraints and entry costs significantly influence the decision to hold risky assets, and the factors of the classical theory, which were confirmed to be important factors determining how much to invest in risky assets for households already holding risky assets, were applicable in this case as well. Third, we found that differences in the ratio of risky assets in Japan and the USA can be reasonably explained by differences both in risk-return relationships and concerns about the future, but it is likely that differences in the financial literacy of households and structural factors such as institutional aspects of Japan and the USA regarding portfolio selection are also of influence. Based on these results, it is also necessary for the improvement of Japanese household investment circumstances to further improve institutional aspects and enrich the dissemination of financial education, in addition to improving the risk-return relationships in the market and mitigating various household constraints. In this regard, steady efforts to promote the dissemination of financial literacy have been undertaken alongside the enhancement of institutions such as NISA (Individual Savings Account in Japan) and Defined Contribution pension systems in Japan. These measures are expected to encourage households to invest in risky assets in the future.

In testing determinants of portfolio selection, this paper assumed that relative risk aversion, financial literacy, and concerns about the future are constant throughout the analysis period due to data constraints. For the variance of return, we used observed macro data as proxy variables. Moreover, we calculated relative risk aversion based on attitudes toward monthly salary payments. There may be room for exploration of the validity of these methodological choices and thus the estimates presented in this paper should be interpreted with some caution.

Furthermore, in the testing framework of this paper, we do not analyze the asset selection mechanism of real assets and the long-term impact that changes in demographics such as aging have on household portfolio selection. The acquisition of real assets and the life cycle of the households are important decisive factors in household portfolio selection. Elucidating their influence is potentially a fruitful exercise for future research. Moreover, it is also important to clarify the underlying mechanisms that form the factors influencing household portfolio selection behavior such as the expected return. Finally, in this paper, although structural factors explain much of the difference between Japan and the USA, it is necessary to understand what

these factors specifically indicate in order to augment the explanatory power of the analyses conducted herein.

Appendix. Estimating Relative Risk Aversion

In this Appendix, we delineate the estimation methods used to capture relative risk aversion from risk attitudes toward monthly salary payments, lottery tickets, and insurance. Then, we explain our rationale for utilizing attitudes toward monthly salary payments in our analysis.

a. Estimation method using attitude toward monthly salary payments

Barsky et al. (1997) propose an estimation method for relative risk aversion using a questionnaire, such as the data shown in Table A; this also exists in the PLSS. Here we explain the estimation method, according to Kimball et al. (2008), which investigates relative risk aversion using the method of Barsky et al. (1997).

Table A. Attitude toward monthly salary payments: Elicitation example

- In which of the following two ways would you prefer to receive your monthly salary? Assume that your job assignment is the same for each scenario. If you are a dependent (e.g., student, housewife, etc.) and not working, please answer based on the assumption that your monthly income equals your current actual living expenses.

Selection 1	A doubling or decreasing by 60%	B Increasing by 0.5%
Selection 2	A doubling or decreasing by 50%	B Increasing by 0.5%
Selection 3	A doubling or decreasing by 45%	B Increasing by 0.5%
Selection 4	A doubling or decreasing by 30%	B Increasing by 0.5%
Selection 5	A doubling or decreasing by 10%	B Increasing by 0.5%
Selection 6	A doubling or decreasing by 5%	B Increasing by 0.5%
Selection 7	A doubling or decreasing by 1%	B Increasing by 0.5%

Choice A in Table A means unstable revenue with a 50% chance of the salary doubling and a 50% chance of the salary decreasing by π times. On the other hand, choice B means stable revenue guaranteed to increase by 0.5%. We can describe the realized utility levels of choice A or choice B as follows, using individual's utility function U_i and constant consumption level c_i[26].

A: $$0.5U_i(2c_i) + 0.5U_i(\pi c_i)$$

[26] Barsky et al. (1997) suppose that constant consumption levels coincide with constant income levels, in addition to the assumption that labor income accounts for a sufficiently large proportion of total income.

B: $U_i(1.005c_i)$

Respondents choose A if their utility level from A is higher than that of choice B, and vice versa. Here, we define U_i as a utility function with CRRA ($^1/_{\theta_i}$).

$$U_i(c) = \frac{c^{1-1/\theta_i}}{1-1/\theta_i}$$

Then, the condition of selection for choice A is

$$0.5U_i(2c_i) + 0.5U_i(\pi c_i) > U_i(1.005c_i)$$

This is equivalent to

$$\frac{1}{2}(2^{1-1/\theta_i} + \pi^{1-1/\theta_i}) > 1.005^{1-1/\theta_i}$$

And the condition of selection for choice B is

$$\frac{1}{2}(2^{1-1/\theta_i} + \pi^{1-1/\theta_i}) < 1.005^{1-1/\theta_i}$$

$$\frac{1}{2}(2^{1-1/\theta} + \pi^{1-1/\theta}) - 1.005^{1-1/\theta} = 0$$

Here, we define $\theta(\pi)$ as the solution to the equation above, for risk tolerance θ at π, and π_j as π at the selection $j \in \{1,2,3,\dots,7\}$. $\theta(\pi)$ is a decreasing function of π. Therefore, the following proposition can be established.

For any individual i, there exists $k_i \in \{0,1,2,\dots,7\}$, such that

$$\theta_i \in (\theta(\pi_{k_i+1}), \theta(\pi_{k_i})) \tag{A1}$$

Equation (A1) indicates an interval which contains relative risk tolerance (inverse of relative risk aversion) for individual i. Barsky et al. (1997) propose calculating the representative value for each individual i by a maximum likelihood method. At first, we assume that relative risk tolerance θ follows a log-normal distribution, $\ln\theta \equiv x \sim N(\mu, \sigma_x^2)$, and we calculate the probability of $k_i = l \in \{0,1,2,\dots,7\}$.

$$P(k_i = l) = P(\ln\theta(\pi_{l+1}) < x < \ln\theta(\pi_l))$$
$$= \Phi\left(\frac{\ln\theta(\pi_l) - \mu}{\sigma_x}\right) - \Phi\left(\frac{\ln\theta(\pi_{l+1}) - \mu}{\sigma_x}\right)$$

Here, Φ is a cumulative distribution function of a standard normal distribution. We define N as a collection of questionnaire respondents, and F as a result of questionnaire answers. Then, we can describe a log-likelihood function, using μ and σ_x.

$$\mathcal{L}(\mu, \sigma_x|F) = \sum_{i\in N}\sum_{l} 1[k_i = l\,|F]\ln P(k_i = l) \tag{A2}$$

1[] denotes 1 when the value of k_i in the response result F and l coincide and 0 otherwise. We can calculate μ and σ_x, estimating Equation (A2) by maximum likelihood. Then, we can calculate relative risk tolerance from the following equation.

$$E(\theta|k_i = l) = E(x|\ln\theta(\pi_{l+1}) \le x < \ln\theta(\pi_l))$$
$$= \exp(\mu + \frac{\sigma_x^2}{2})\frac{\Phi\left(\frac{\ln\theta(\pi_l) - \mu - \sigma_x^2}{\sigma_x}\right) - \Phi\left(\frac{\ln\theta(\pi_{l+1}) - \mu - \sigma_x^2}{\sigma_x}\right)}{\Phi\left(\frac{\ln\theta(\pi_l) - \mu}{\sigma_x}\right) - \Phi\left(\frac{\ln\theta(\pi_{l+1}) - \mu}{\sigma_x}\right)}$$

The relative risk aversion is the reciprocal of this relative risk tolerance $E(\theta|k_i = l)$.

b. Estimation method using attitude toward buying lottery tickets

The previous study also proposes a method which estimates relative risk aversion of individuals using a questionnaire which elicits data such as data shown in Table B; this also exists in the PLSS. Following Cramer et al. (2002), we explain an estimation method for relative risk aversion using attitudes toward buying lottery tickets.

Table B. Attitude toward buying a lottery ticket: Elicitation example

- Suppose that there is a "speed lottery" with a 50% chance of winning ¥100,000. If you win, you get the prize right away. If you lose, you get nothing. How much would you spend to buy this lottery ticket? Choose option "1" if you would buy it at the price, or option "2" if you would not buy the ticket at the price.

	Which one do you prefer?	
	Buy	Not buy
Price of the lottery ticket ¥10	1	2
¥2,000	1	2
¥4,000	1	2
¥8,000	1	2
¥15,000	1	2
¥25,000	1	2
¥35,000	1	2
¥50,000	1	2

Although Cramer et al. (2002) propose a method to obtain relative risk aversion based on a value function, we replace it with a utility function in our estimation.

Selection 1 in Table B denotes that a respondent selects to purchase "speed lottery" with a 50% chance of winning ¥100,000 at a price of Z, whereas selection 2 in Table B denotes choosing not to purchase it at a price of Z.

The utility levels of selection 1 and 2 can be described as follows using the utility function U_i and the present assets W_i.

1: $$0.5U_i(W_i + 100{,}000 - Z) + 0.5U_i(W_i - Z)$$

2: $$U_i(W_i)$$

Specifically, the condition to select 1 is

$$0.5U_i(W_i + 100{,}000 - Z) + 0.5U_i(W_i - Z) > U_i(W_i)$$

We compute the Taylor expansion of the left-hand side to second order terms about U_i, and subtract $U_i(W_i)$ from both sides.

$$0.5(100{,}000 - 2Z)U_i'(W_i) + 0.25((100{,}000 - Z)^2 + Z^2)U_i''(W_i) > 0$$

Then, we transpose and multiply by W_i.

$$\frac{2W_i(100{,}000 - 2Z)}{(100{,}000 - Z)^2 + Z^2} > \frac{-W_iU_i''(W_i)}{U_i'(W_i)}$$

The right-hand side is equal to the relative risk aversion $1/\tilde{\theta}_i$.

$$\frac{2W_i(100{,}000-2Z)}{(100{,}000-Z)^2+Z^2} > \frac{1}{\tilde{\theta}_i}$$

Likewise, the condition for selecting the selecting 2 is

$$\frac{2W_i(100{,}000-2Z)}{(100{,}000-Z)^2+Z^2} < \frac{1}{\tilde{\theta}_i}$$

Now, as per Barsky et al. (1997), it is possible to determine the relative risk aversion $1/\tilde{\theta}_i$ of each individual by defining the interval where $\tilde{\theta}_i$ exists, using the maximum likelihood method.

c. Estimation method using attitude toward insurance

We can also calculate relative risk aversion from attitudes toward insurance in the same way as estimating relative risk aversion from attitudes toward lottery tickets proposed by Cramer et al. (2002).

Table C. Attitude toward insurance: Elicitation example

- Assume that you know there is a 50% chance of losing ¥100,000 on a given day. You can take out insurance to cover this amount in case of loss. If an insurance policy is sold as listed below, would you purchase it? Choose option "A" to purchase the insurance, or option "B," not to purchase the insurance.

Insurance fee	Which one do you prefer?	
	Purchase	Not purchase
¥1,000	A	B
¥5,000	A	B
¥10,000	A	B
¥15,000	A	B
¥20,000	A	B
¥30,000	A	B
¥40,000	A	B
¥45,000	A	B
¥50,000	A	B

Selection A in Table C denotes that a respondent selects to purchase "insurance" to cover a 50% chance of losing ¥100,000 at a price of Z, whereas selection B in Table C denotes choosing not to purchase it at a price of Z.

The utility levels of the selection A and B can be described as follows, using the utility function U_i and the present assets W_i.

A: $$0.5U_i(W_i - 100{,}000) + 0.5U_i(W_i)$$

B: $$U_i(W_i - Z)$$

Then, relative risk aversion can be calculated in the same way that is used to estimate the attitude toward lottery tickets.

As explained above, there are various methods to estimate relative risk aversion, such as from risk attitudes toward monthly salary payments, lottery tickets, and insurance. In particular, the methods focusing on lottery tickets and insurance require the present asset amount in the process of calculating relative risk aversion, but it is difficult to determine what kind of assets should be defined as the present assets. In addition, if we defined financial assets, real assets, human capital, and so on, as the present assets, there would arise a problem about whether they could be accurately calculated from a questionnaire or not, so estimation error could be unduly large. For this reason, we analyzed using relative risk aversion estimated from the attitude toward monthly salary payments, which does not need the present assets amount in the process of calculating relative risk aversion. As mentioned in this paper, estimation results of relative risk aversion could depend on what kind of risk we are focusing on. Moreover, there is an issue that an estimation error is large arising from differences in the assumptions of calculation methods such as the definition of the utility function in estimating relative risk aversion. Therefore, the estimates of relative risk aversion presented in this paper should be interpreted with some caution.

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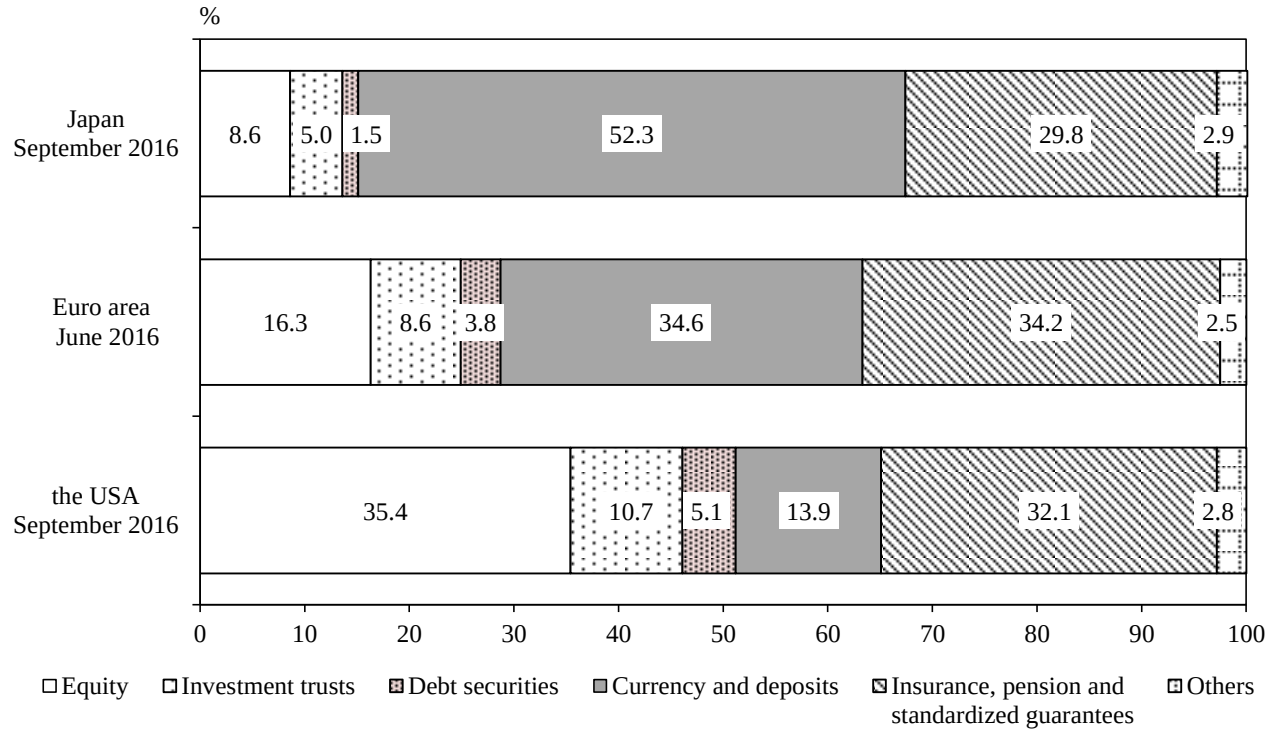
Chart 1. Comparison of Household Financial Assets

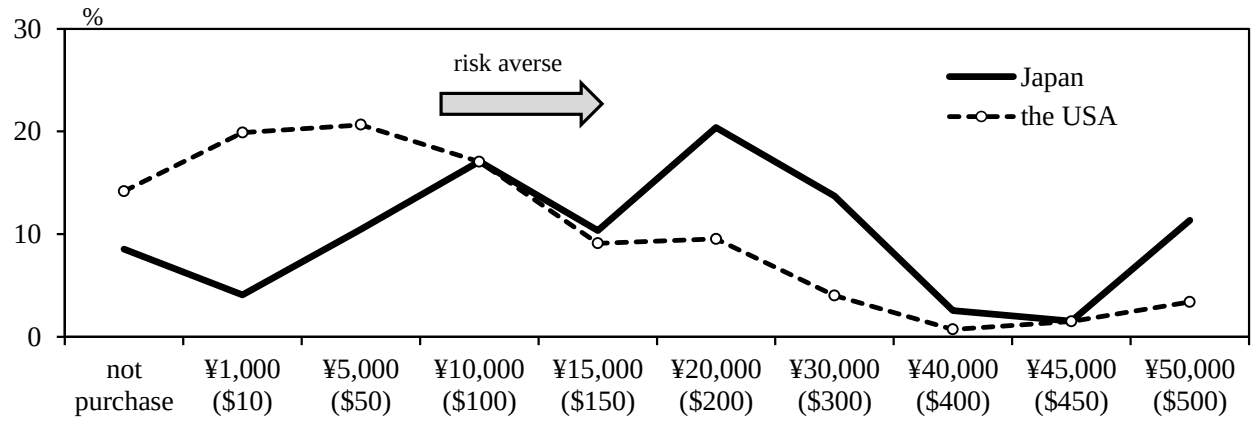


Source: Bank of Japan, “Flow of Funds - Overview of Japan, the United States, and the Euro area -.”

Chart 2. Differences in risk attitudes toward insurance, lottery tickets, and monthly salary payments between Japanese and US households

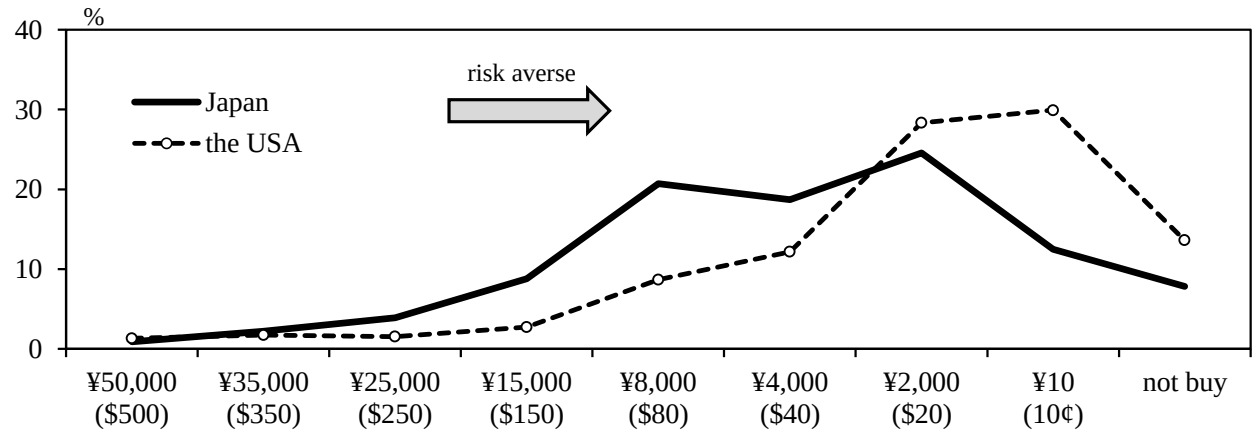
a. Risk attitude toward insurance

— How much would you spend to purchase insurance for the case of loss with a 50% chance of losing ¥100,000 ($1000)?



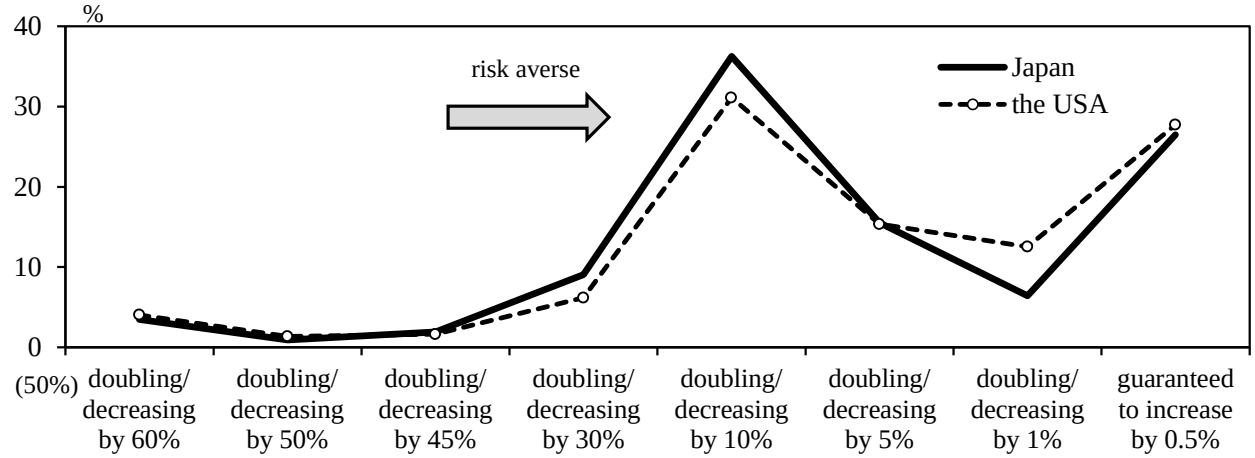
b. Risk attitude toward lottery tickets

— How much would you spend to buy a ticket for the speed lottery with a 50% chance of winning ¥100,000 ($1000)?



c. Risk attitude toward monthly salary payments

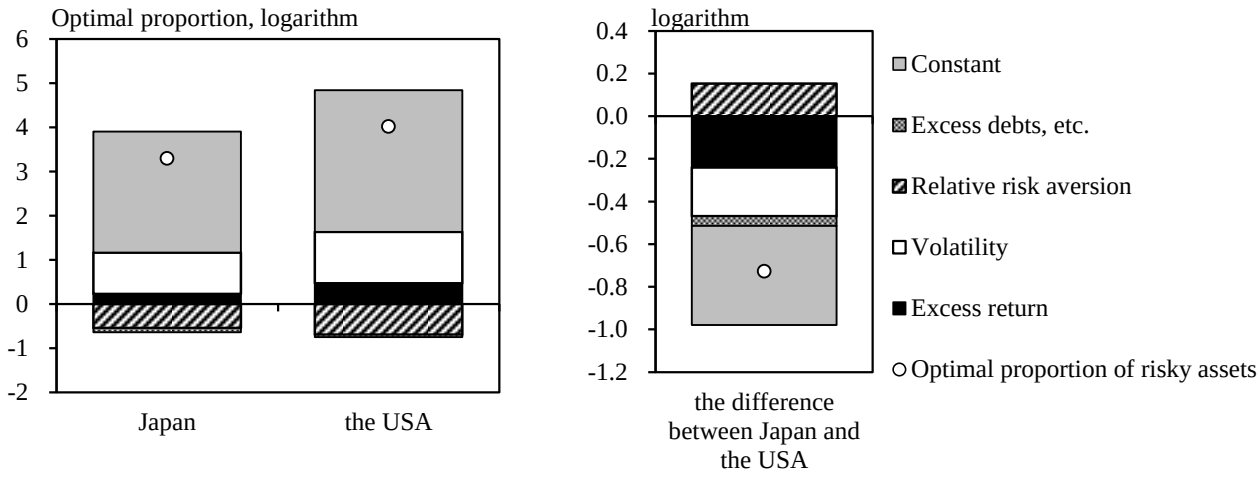
— In which of the following ways would you prefer to receive your monthly salary?



Note: Figures are as of 2013.

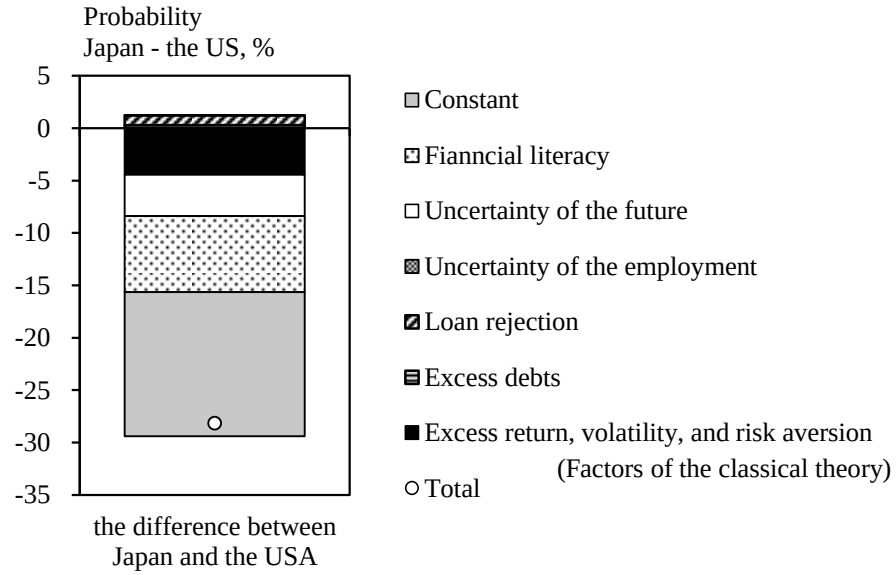
Source: Osaka University, “Preferences and Life Satisfaction Survey.”

Chart 3. Difference in the estimated optimal proportion of risky assets between Japanese and US risky asset holders



Notes: 1. Figures are calculated using the parameters of model 2 in Table 9.
2. The figures are averages from CY 2005 to CY 2011.

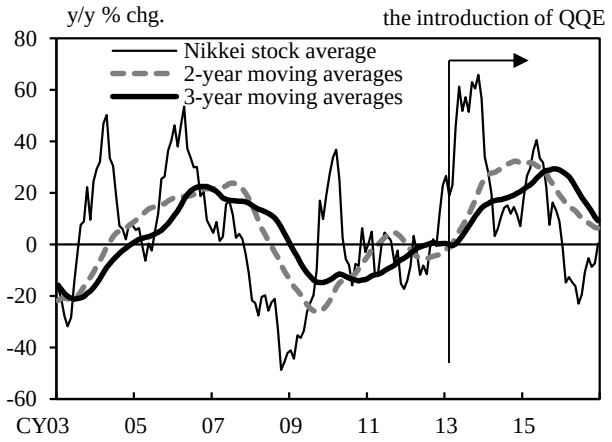
Chart 4. Breakdown of the differences in the probability of holding risky assets between Japanese and US households



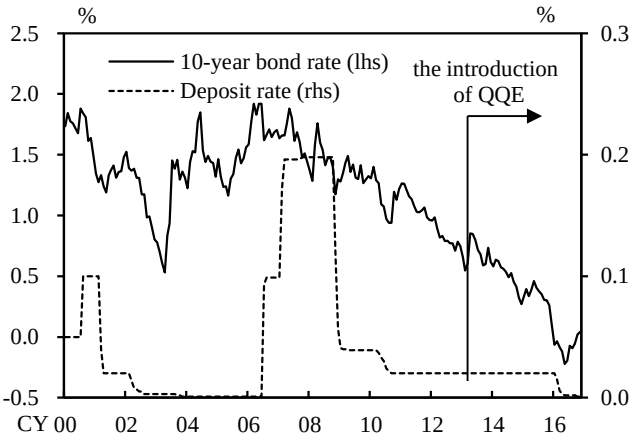
Notes: 1. Figures are calculated using the marginal effects of model 1 in Table 10 and the difference in averages of explanatory variables between Japan and the USA.
2. Figures are averages from CY 2005 to CY 2011.

Chart 5. Contextual dynamics of asset purchasing in Japanese financial markets pre- and post-QQE

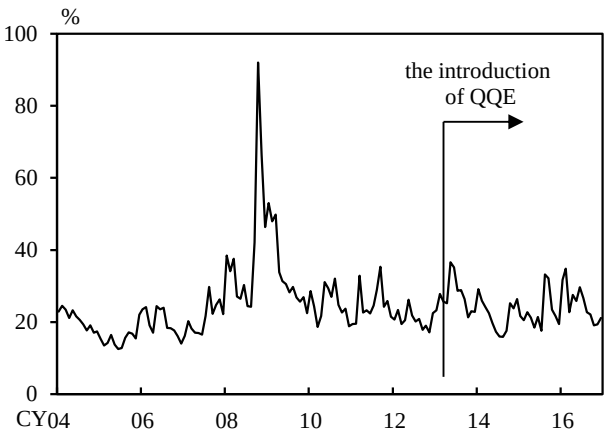
(1) Stock market performance



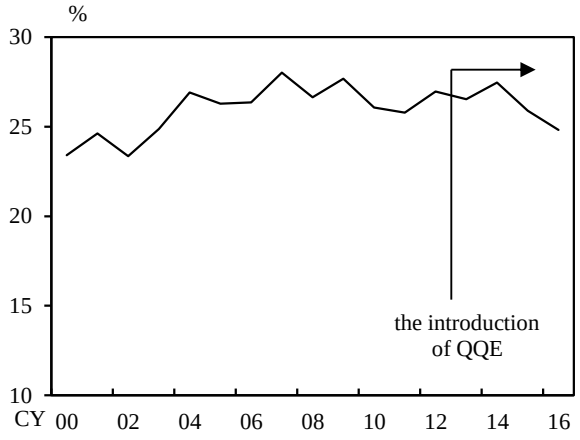
(2) Interest rate on safe assets



(3) Volatility (Nikkei VI)

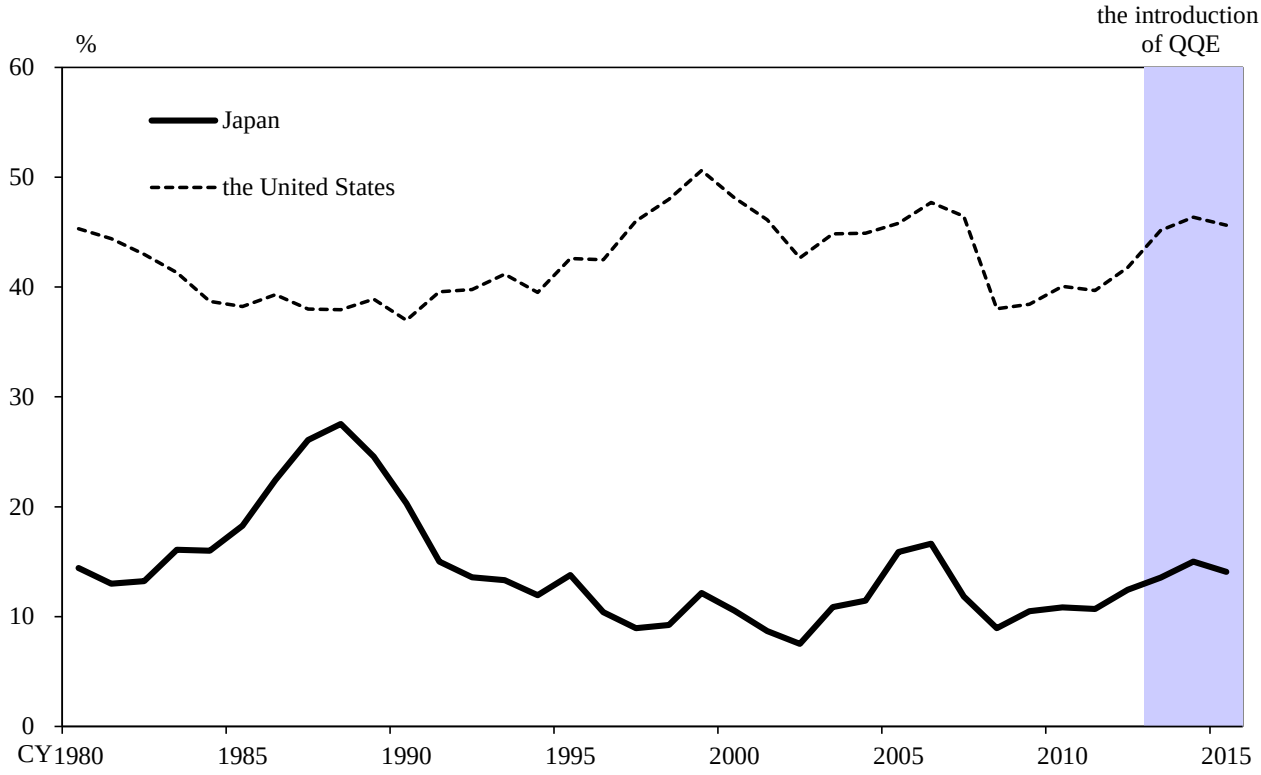


(4) Proportion of households with excess debts



Sources: Bloomberg, the Central Council for Financial Services Information, "the Survey of Household Finances," Bank of Japan.

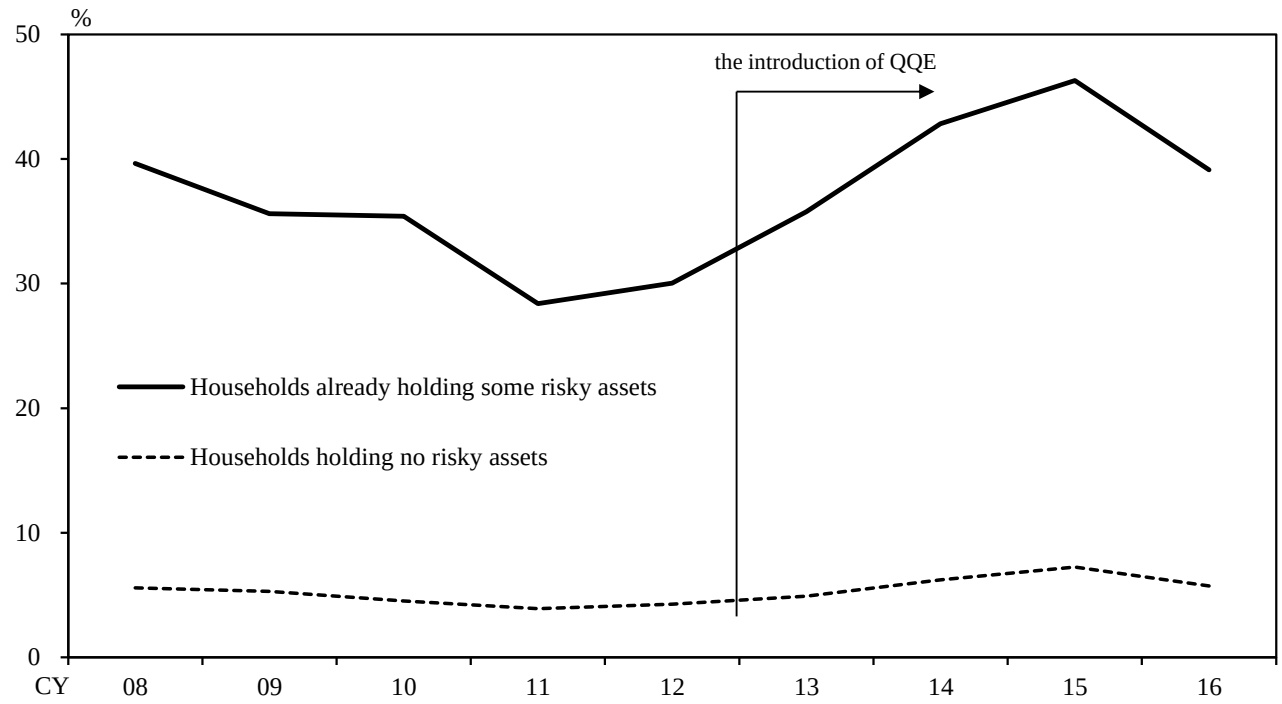
Chart 6. Long-term trends of shares of risky assets in Japanese and US households



Notes: 1. The figures are based on household data in the Flow of Funds Accounts.
2. Risky assets are composed of equity and investment trusts.

Sources: FRB, "Flow of Funds Accounts," Bank of Japan, "Flow of Funds Accounts."

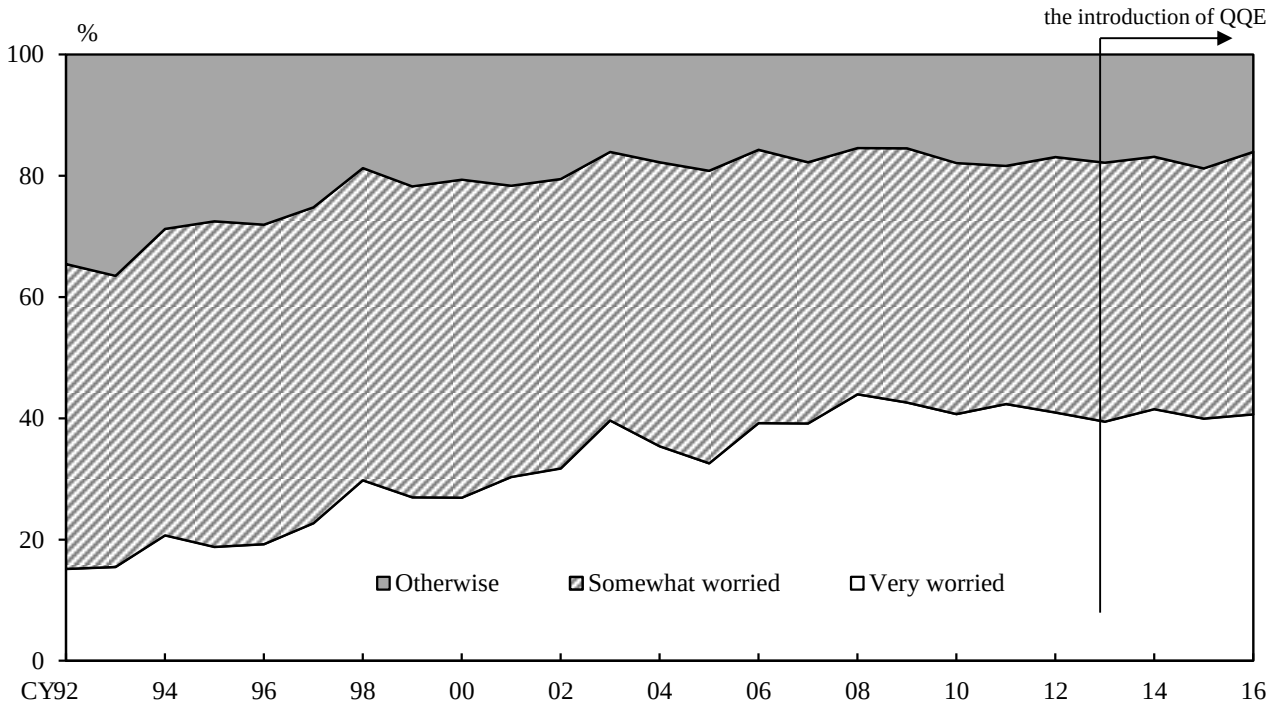
Chart 7. The changing proportion of households who wish to hold risky assets in the future



Notes: 1. Figures show the proportions of households who wish to hold risky assets or to accumulate risky assets in the future such as equity, investment trusts of equity and real estate, and foreign assets.
2. Figures are based on households with two or more people.

Source: The Central Council for Financial Services Information, "the Survey of Household Finances."

Chart 8. Japanese households' concerns about later life



Source: The Central Council for Financial Services Information, "the Survey of Household Finances."

Table 1. Overview of the Preferences and Life Satisfaction Survey and the Survey of Household Finanices

	Preferences and Life Satisfaction Survey (PLSS)	Survey of Household Finances (SHF)
Survey Conductor	Osaka University	The Central Council for Financial Services Information
Target	From 20 to 69 years of age (in Japan, as of 2003) From 18 to 99 years of age (in the US, as of 2005)	Households who are at least 20 years of age
Sampling Frame	Resident Registration System (in Japan) Population Census (in the US)	Resident Registration System
Data Type	Panel data	Repeated cross-sectional data
Sample Size	4,341 (in Japan, as of 2013) 5,079 (in the US, as of 2013)	6,397 (in Japan, as of 2013)
Survey Period	From 2003 to 2013 (in Japan) From 2005 to 2013 (in the US)	From 1963 to 2016
Frequency	Annually (From January to March)	Annually (From June to July)

Table 2. Descriptive statistics for Japanese data

	PLSS				SHF			
	Mean	25th percentile	Median	75th percentile	Mean	25th percentile	Median	75th percentile
Age (years)	53.6	44	54	64	50.6	38	51	63
Annual Income (million yen)	n.a.	2-4	4-6	6-8	3.9	2.0	3.4	5.0
Financial Wealth (million yen)	n.a.	2.5-5.0	5.0-7.5	15.0-20.0	15.0	2.4	7.1	18.0
Proportion of risky assets (Risky asset holders, %)	26.4	10	20	40	33.2	10.8	25.0	50.0
Proportion of households holding risky assets (All households, %)	29.4	—	—	—	22.4	—	—	—

Notes: 1. Figures are as of 2013.
2. Pre- and post-tax household are counted in the PLSS and the SHF, respectively.
3. Households with no financial assets are counted in the proportion of households holding risky assets.
4. Households with no financial assets are not counted in the financial wealth figures.

Table 3. Correct answer rates vis-à-vis questions about financial literacy by types of business

	Financial Literacy (Correct answer rate, %)			
	1. Compound interest	2. Inflation	3. Investment diversification	4. Bond prices
Agriculture and related industries	63.9	56.3	29.2	5.7
Construction	68.4	57.5	35.6	7.5
Manufacturing	76.1	65.0	42.7	12.3
Wholesale trade/Retail trade	75.0	60.9	41.3	10.8
Finance and Insurance	84.9	73.1	69.2	46.8
Transportation/Telecommunications	64.7	59.0	36.3	7.0
Professional and business services	66.7	53.4	36.1	8.8

Note: Figures are as of 2010.
Source: Osaka University, “Preferences and Life Satisfaction Survey.”

Table 4. Situations surrounding household portfolio selection in Japan and the USA

	Japan				the United States				Difference in proportion	Difference in median
	Mean	25th percentile	Median	75th percentile	Mean	25th percentile	Median	75th percentile		
Proportion of households holding risky assets (all households, %)	27.1	—	—	—	40.9	—	—	—	-13.8 ***	—
Share of risky assets (Risky asset holders, %)	26.1	10	20	40	46.9	15	50	80	—	-30 ***
Age (years)	50.1	40	51	61	49.2	36	49	61	—	2 ***
Expected value of the return on financial assets (%)	2.5	0.0	0.2	2.0	5.0	0.6	3.5	6.0	—	-3.3 ***
Relative Risk Aversion (rates)	22.3	4.0	5.6	17.6	23.5	4.0	9.7	22.9	—	-4.1 ***
Concerns about unemployment (%)	29.4	—	—	—	31.2	—	—	—	-1.8 ***	—
Concerns about later life (%)	45.6	—	—	—	20.1	—	—	—	25.5 ***	—
Financial debts to assets ratio	0.35	0.00	0.00	0.40	0.34	0.00	0.13	0.43	—	-0.13 ***
Past experience of loan rejection (%)	7.3	—	—	—	19.0	—	—	—	-11.7 ***	—
Financial literacy (correct answer rate, %)										
Compound interest	70.5	—	—	—	78.4	—	—	—	-8.0 ***	—
Inflation	58.8	—	—	—	69.7	—	—	—	-11.0 ***	—
Investment diversification	39.4	—	—	—	49.4	—	—	—	-9.9 ***	—
Bond prices	11.0	—	—	—	24.2	—	—	—	-13.2 ***	—

Notes: 1. *** denotes significance at the 1% level.
2. To test for median differences, we use Wilcoxon rank-sum (Mann-Whitney) tests.
3. Figures for financial literacy are as of 2010; those for relative risk aversion are the averages from 2012 to 2013.
4. Figures for concerns about later life are the average of 2005, 2006, 2012, and 2013.
5. Other figures are as from 2005 to 2011.
6. Figures for concerns about unemployment are the proportion of households who selected "Strong possibility" or "Some possibility" to the question regarding the possibility of unemployment.
7. Figures for concerns about later life are the proportion of households who selected "Particulary True" or "True"to the question regarding concerns about life situations in their old age.

Source: Osaka University, “Preferences and Life Satisfaction Survey.”

Table 5. Relationship between proportion of households holding risky assets and risk attitude for insurance, lottery tickets, and monthly salary payments

How much would you spend to purchase insurance for the case of loss with a 50% chance of losing ¥100,000 ($1,000) on a given day.	Japan		the USA	
	proportion of households	deviation from the mean	proportion of households	deviation from the mean
not purchase the insurance	22.7	-6.7 ***	31.7	-13.1 ***
¥1,000 ($10)	25.0	-4.4	39.5	-5.3 ***
¥5,000 ($50)	25.3	-4.1 **	48.2	3.4 **
¥10,000 ($100)	27.5	-2.0	50.2	5.4 ***
¥15,000 ($150)	29.1	-0.3	53.5	8.7 ***
¥20,000 ($200)	31.7	2.3 *	53.5	8.7 ***
¥30,000 ($300)	37.5	8.1 ***	50.5	5.7 *
¥40,000 ($400)	39.3	9.8 **	68.6	23.8 ***
¥45,000 ($450)	43.8	14.3 ***	54.8	10.0 **
¥50,000 ($500)	28.6	-0.8	41.2	-3.6

↓ risk averse

How much would you spend to buy a lottery ticket with a 50% chance of winning ¥100,000 ($1,000).	Japan		the USA	
	proportion of households	deviation from the mean	proportion of households	deviation from the mean
¥50,000 ($500)	31.6	2.1	30.8	-14.0 **
¥30,000 ($300)	48.9	19.5 ***	54.8	9.9 **
¥25,000 ($250)	49.1	19.7 ***	68.0	23.2 ***
¥15,000 ($150)	38.0	8.5 ***	63.2	18.3 ***
¥8,000 ($80)	30.7	1.2	58.5	13.6 ***
¥4,000 ($40)	30.5	1.0	53.5	8.7 ***
¥2,000 ($20)	24.5	-4.9 ***	45.2	0.3
¥10 (10¢)	25.1	-4.3 **	42.5	-2.3 *
not buy the ticket	23.1	-6.3 ***	31.2	-13.6 ***

↓ risk averse

In which of the following ways would you prefer to receive your monthly salary?	Japan		the USA	
	proportion of households	deviation from the mean	proportion of households	deviation from the mean
A 50% chance of the salary doubling, but also decreasing by 60%	21.2	-8.2 **	35.5	-9.3 ***
A 50% chance of the salary doubling, but also decreasing by 50%	36.8	7.4	32.8	-12.0 **
A 50% chance of the salary doubling, but also decreasing by 45%	40.0	10.6 **	38.8	-6.1
A 50% chance of the salary doubling, but also decreasing by 30%	36.5	7.1 ***	55.5	10.7 ***
A 50% chance of the salary doubling, but also decreasing by 10%	33.5	4.1 ***	55.6	10.8 ***
A 50% chance of the salary doubling, but also decreasing by 5%	28.7	-0.7	45.8	1.0
A 50% chance of the salary doubling, but also decreasing by 1%	28.0	-1.5	42.5	-2.4
Guaranteed salary increase of 0.5%	23.4	-6.0 ***	35.8	-9.0 ***

↓ risk averse

Notes: 1. Figures are as of 2013.
2. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Source: Osaka University, “Preferences and Life Satisfaction Survey.”

Table 6. Difference in the mechanisms determining CS and PR

	CS: Share of risky assets (Stockholders, %)				PR: Proportion of households holding risky assets (All households, %)			
	Mean	Difference	t-value	p-value	Mean	Difference	Z-value	p-value
Households with excess assets	26.4	—	—	—	35.3	—	—	—
Households with excess debts	22.2	—	—	—	14.2	—	—	—
Difference	—	4.2	1.26	0.10	—	21.0 ***	7.93	0.00
Households with no concerns about later life	27.1	—	—	—	34.6	—	—	—
Households with concerns about later life	24.8	—	—	—	23.0	—	—	—
Difference	—	2.2 *	1.58	0.06	—	11.7 ***	8.34	0.00
Households employed in financial sector activities	25.8	—	—	—	48.9	—	—	—
Households employed in non-financial sector activities	24.7	—	—	—	27.0	—	—	—
Difference	—	1.1	0.31	0.62	—	21.9 ***	4.62	0.00

Notes: 1. Figures are as of 2013.
2. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Source: Osaka University, “Preferences and Life Satisfaction Survey.”

Table 7. Results of testing risky asset holders' portfolio selection

Analysis target, Estimation period		Households holding risky assets, From 2005 to 2011				
Sample Size		444	430	438	427	345
Model		Model 1	Model 2	Model 3	Model 4	Model 5
The factor of excess return, volatility, and relative risk aversion ($\alpha\beta_1$)		0.15 ***	0.15 ***	0.14 ***	0.14 ***	0.17 ***
Liquidity Constraints ($\alpha\beta_2$)	Excess debts (0, 1)	—	-0.44 ***	—	-0.42 **	-0.46 **
	Loan rejection (0, 1)	—	—	-0.05	-0.10	0.06
Precautionary Saving ($\alpha\beta_3$)	Concerns about unemployment (0, 1)	—	—	—	—	-0.06
α (1 - coefficient of lagged dependent variable)		0.28 ***	0.29 ***	0.28 ***	0.29 ***	0.29 ***
Sargan Test (p-value)		11.67 (0.90)	11.80 (0.89)	12.78 (0.85)	13.03 (0.84)	12.00 (0.89)
Arellano-Bond Test (p-value)	AR(1)	-2.22 (0.03)	-2.14 (0.03)	-2.19 (0.03)	-2.14 (0.03)	-2.23 (0.03)
Arellano-Bond Test (p-value)	AR(2)	-0.02 (0.99)	-0.12 (0.91)	-0.00 (1.00)	-0.10 (0.92)	1.35 (0.18)

Notes: 1. Robust standard errors are used in all cases. The results are based on two-step estimation.
2. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.
3. The Sargan test shows statistics for the null hypothesis that the over-identifying restrictions are valid.
4. The Arellano-Bond test shows statistics for the null hypothesis of no autocorrelation in error terms.

Table 8. Results of testing households' participation rate in the risky asset market

Analysis target, Estimation periods		All households, From 2005 to 2011				
Model		Model 1	Model 2	Model 3	Model 4	Model 5
Sample Size		933	934	1,351	944	1,186
The factor of excess return, volatility, and relative risk aversion (α_1)		0.03 *** [0.008]	0.03 *** [0.008]	0.03 *** [0.009]	0.04 *** [0.010]	0.04 *** [0.010]
Liquidity Constraints (α_2)	Excess debts (0, 1)	-0.92 ** [-0.214]	-0.96 ** [-0.228]	—	-0.93 ** [-0.253]	-0.94 *** [-0.227]
	Loan rejection (0, 1)	-1.26 ** [-0.294]	-1.30 *** [-0.311]	—	-1.32 *** [-0.360]	-0.98 ** [-0.238]
Precautionary Saving (α_3)	Concerns about unemployment (0, 1)	-0.16 [-0.037]	—	-0.25 * [-0.081]	—	-0.23 [-0.056]
	Concerns about later life (0 - 2)	-0.58 *** [-0.135]	—	-0.53 *** [-0.170]	-0.63 *** [-0.170]	-0.64 *** [-0.156]
Entry Costs (α_4)	Financial literacy					
	Interest (0, 1)	-0.09 [-0.020]	-0.01 [-0.003]	—	—	-0.25 [-0.062]
	Compound inflation (0, 1)	0.48 [0.112]	0.47 [0.111]	—	—	0.57 * [0.138]
	Investment diversification (0, 1)	0.92 *** [0.214]	0.98 *** [0.234]	—	—	0.88 *** [0.214]
	Bond prices (0, 1)	1.07 *** [0.250]	1.04 *** [0.247]	—	—	1.36 *** [0.330]
	Financial business (0 ,1)	1.82 *** [0.423]	1.76 *** [0.419]	—	2.58 *** [0.700]	—
Constant		-1.18 ***	-1.60 ***	-0.20 *	-0.18	-0.97 ***
Pseudo R^2		0.125	0.116	0.049	0.094	0.112
LR test		146.4 ***	148.6 ***	195.3 ***	157.7 ***	204.1 ***

Notes: 1. Robust standard errors are used in all cases.
2. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.
3. Averages of marginal effects are shown in parentheses [ ].
4. Figures for financial literacy are dummy variables that take the value of unity for households who correctly answered and zero otherwise.
5. For concerns about later life, we apply two to households who selected "Particularly True" to the question regarding concerns about life situations in their old age, one to households who selected "True," and zero otherwise.
6. The likelihood ratio test shows statistics for the null hypothesis that a pooling model is appropriate.

Table 9. Results of testing households' portfolio choice for Japanese and US risky asset holders

Analysis target	Japanese and US households holding risky assets		Japan		the USA	
Estimation periods	From 2005 to 2011		From 2005 to 2011		From 2005 to 2011	
Sample Size	1,051	1,027	444	430	607	597
Model	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
The factor of excess return, volatility, and relative risk aversion ($\alpha\beta_1$)	0.13 ***	0.13 ***	0.15 ***	0.15 ***	0.09 *	0.09 *
Liquidity Constraints ($\alpha\beta_2$) Excess debts (0, 1)	—	-0.35 ***	—	-0.44 **	—	-0.30
α (1 - coefficient of lagged dependent variables)	0.37 ***	0.36 ***	0.28 ***	0.29 ***	0.33 ***	0.30 ***
Sargan Test (p-value)	18.95 (0.46)	16.18 (0.65)	11.67 (0.90)	11.80 (0.89)	18.08 (0.52)	14.05 (0.78)
Arellano-Bond Test AR(1) (p-value)	-2.98 (0.00)	-2.88 (0.00)	-2.22 (0.03)	-2.14 (0.03)	-2.26 (0.02)	-2.20 (0.03)
Arellano-Bond Test AR(2) (p-value)	-0.58 (0.56)	-0.70 (0.48)	-0.02 (0.99)	-0.12 (0.91)	-1.26 (0.21)	-1.28 (0.20)

Notes: 1. Robust standard errors are used in all cases. The results are based on two-step estimation.
2. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.
3. The Sargan test shows statistics for the null hypothesis that the over-identifying restrictions are valid.
4. The Arellano-Bond test shows statistics for the null hypothesis of no autocorrelation in error terms.

Table 10. Results of testing households' participation rate in Japan and the USA

Analysis target		Japanese & US households	Japanese households	US households
Estimation periods		From 2005 to 2011	From 2005 to 2011	From 2005 to 2011
Sample Size		2,369	933	954
Model		Model 1	Model 2	Model 3
The factor of excess return, volatility, and relative risk aversion (α_1)		0.02 *** [0.004]	0.03 *** [0.008]	0.01 *** [0.002]
Liquidity Constraints	Excess debts (0, 1)	-0.38 ** [-0.095]	-0.92 ** [-0.214]	-0.29 [-0.069]
	Loan rejection (0, 1)	-1.07 *** [-0.271]	-1.26 ** [-0.294]	-0.96 *** [-0.224]
Precautionary Savings	Concerns about unemployment (0, 1)	-0.12 [-0.031]	-0.16 [-0.037]	-0.17 [-0.039]
	Concerns about later life (0 - 2)	-0.48 *** [-0.123]	-0.58 *** [-0.135]	-0.38 * [-0.089]
Entry costs	Compound interest (0, 1)	-0.08 [-0.021]	-0.09 [-0.020]	0.22 [0.052]
	Inflation (0, 1)	0.53 *** [0.136]	0.48 [0.112]	0.25 [0.060]
	Investment diversification (0, 1)	0.72 *** [0.182]	0.92 *** [0.214]	0.50 *** [0.118]
	Bond prices (0, 1)	0.83 *** [0.212]	1.07 *** [0.250]	0.33 * [0.078]
	Financial sector activities (0, 1)	—	1.82 *** [0.423]	-0.11 [-0.026]
Constant	Japan dummy	-0.54 *** [-0.138]	—	—
	Constant term	-0.31	-1.18 ***	0.09
Pseudo R^2		0.105	0.125	0.060
LR test		292.1 ***	204.1 ***	79.7 ***

Notes: 1. Robust standard errors are used in all cases.
2. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.
3. Averages of marginal effects are shown in parentheses [ ].
4. Figures for financial literacy are dummy variables that take the value of unity for households who correctly answered and zero otherwise.
5. For concerns about later life, we apply two to households who selected "Particularly True" to the question regarding concerns about life situations in their old age, one to households who selected "True," and zero otherwise.
6. The likelihood ratio test shows statistics for the null hypothesis that a pooling model is appropriate.