Online Banking Users vs. Branch Visitors: Why Are Their Portfolio Returns Different?

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Abstract

This study investigates why portfolio returns of online banking users are higher than those of non-online users. We first demonstrate that households that are eager to improve their level of financial literacy are more likely to use online banking. Second, a marginal increase in risk appetite increases portfolio returns of online users; however, this is not the case for non-online users. Third, online banking promotes debt repayment, and this further encourages risk tolerant investments. In sum, we conclude that financial literacy efforts moderate a positive relationship between use of online banking, risk appetite, and portfolio returns. The positive relationship between use of online banking and debt repayment further increases risk appetite.

JEL classification: G50, G51, G53, G59
Keywords: Online Banking; Portfolio Investment; Risk Appetite; Debt Repayment; Mortgage Debt

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1 Research Motivation

A series of existing literatures consistently conclude that household portfolio investment returns, household asset allocations, and the degree of risk appetite vary across households (Cambell, 2006; Calvet et. al., 2014). More recent literatures also focus on where these household investment diversifications come from. Some of these literatures such as Lusardi and Mitschell (2011), Von Gaudecker (2015), and Bianchi (2018) point out that household financial literacy influences this diversification. These literatures assert that households that have low degrees of financial literacy are likely to employ risk-averse portfolio investment behaviors. These risk-averse portfolio investments are also likely to result in low investment returns.

Existing literatures have also discussed other determinants of household portfolio investment behaviors. Chetty et al. (2017) conclude that a decrease in household mortgage debt increases household risk appetite. Vestman (2019) also asserts that a household's homeownership increases risk appetite in portfolio investment. Other literatures also empirically demonstrate the relationship between volatility in household income and portfolio risk appetite (Betermier et al., 2012; Bonaparte et al., 2014). These conclude that a decrease in household income through poor business performance or job hopping causes these households to become risk tolerant in terms of portfolio investment. Thus, existing literatures assert that a household's level of financial literacy, the size of household debt outstanding, homeownership, and income volatility are major determinants of household risk-taking behaviors in portfolio investment.

Based on these existing literatures, this study newly investigates the different household portfolio investment patterns between online banking users and non-online users. This study uses individual household questionnaire survey data from the Bank of Japan. This study uses individual survey response data from 43,601 households between 2012–2018. We obtain these data from the "Questionnaire Survey on Household Financing Behaviors" by the Central Committee on Savings and Public Relations, the Bank of Japan. By using these data, we empirically investigate and show the causal relationship between household financial literacy, use of online banking, and portfolio investment risk appetite. We also show how these are different from those of non-online users.

If we are allowed to report our conclusions beforehand, the empirical evidence we present in this paper is as follows. We first demonstrate that household online use is promoted by financial literacy efforts. This relationship, therefore, results in higher portfolio returns among online users than those of other households. Subsequently, we verify and prove that the increase in the degree of risk appetite among online users results in higher portfolio returns. The risk appetite of non-online users does not influence their returns. We further demonstrate that higher debt repayment to income ratio among online users encourages more risk tolerant portfolio investment compared to that of non-online users. The progress in debt repayment among online users further promotes risk tolerant portfolio

investments. Based on this evidence, this paper concludes that household financial literacy efforts promote online banking. This online use also promotes risk tolerant portfolio investments and encourages debt repayments. The progress in debt repayment further increases risk appetite among online users. These risk tolerant portfolio investments result in higher portfolio returns among online users compared to those of non-online users.

The remainder of the paper is organized as follows. In the following section, we review the extant literature on this domain. Subsequently, we demonstrate our theoretical framework and the hypotheses in Section 3. In Section 4, we present our empirical model and the data used to examine our hypotheses. In Sections 5 and 6, we discuss the results produced by our empirical analyses. Finally, in Section 7, we offer discussions and concluding remarks.

2 Existing Literature

There is a great deal of empirical evidence from literature reports concerning household portfolio investment behaviors. The propositions of these reports consistently promote household portfolio investments and demonstrate how asset allocation mutates under the household life cycle. Some literatures especially focus on what determines a household's participation in the equity market. Overall, the existing literatures assert that the major determinants of household portfolio investments and asset allocation are the degree of financial literacy, size of mortgage debt outstanding, homeownership, volatility in earnings or income, and the related taxations (**Table 1**). In these literatures, either household survey response data or individual credit card data from the Netherlands, the United States, France, Finland, and Sweden are respectively used. The following sub-sections present the overview of the related literatures and explain how this study adds on to these literatures.

2.1 Household Financial Literacy and Portfolio Investment

The recent trend of related literature is to focus on the relationship between household financial literacy and portfolio investment. Van Rooij et al. (2011) examine the relationship between the degree of household financial literacy and portfolio investment patterns by using Dutch household data. They employ individual household survey response data from *Household Survey* 2005 by the Central Bank of the Netherlands. This study concludes that the higher the degree of household financial literacy, the higher the ratio of equity investment assets to the total assets. It also concludes that a lower degree of household financial literacy conversely leads households to become risk-averse in terms of portfolio investment.

Anderson et al. (2017) further develop the examination of the relationship between the degree of personal financial literacy and portfolio investment. A major contribution of this study is the focus on the misperception of each individual's financial literacy. This study distinguishes the

difference between the actual objective level of personal financial literacy and the degree of financial literacy recognized by oneself. It employs more than 20,000 response data from LinkedIn members in the United States, and estimates the financial literacy gap between the actual objective level and the self-belief level. The authors conclude that this misperception results in low portfolio investment returns. This is because a personal investor who has this gap in knowledge is often likely to miss the opportunity for improvement in financial literacy. The paper explains that such investors tend to avoid financial advice from experts and are likely to misunderstand the structures of portfolio investment products that financial institutions offer.

Bianchi (2018) analyzes the French household financial investment behaviors by using the 2002–2011 French household financial asset data obtained from a French investment bank. He reports that the degree of household financial literacy influences the degree of risk appetite in portfolio investment. Specifically, his study concludes that, on average, the portfolio investment return of the most financially literate household group exceeds that of the least financially literate group by 0.4 percent. This study also asserts that a household that has a high degree of financial literacy also has a high ratio of high-risk investment assets.

Huang (2019) also supports this conclusion by analyzing data from 78,000 U.S. households between 1991–1996 obtained from securities discount brokers in the United States. Huang (2019) additionally reports that households that have a high degree of financial literacy are unlikely to repeat past successful equity investment patterns. In other words, this paper asserts that households that have a low degree of financial literacy are likely to imitate past successful equity investment patterns, resulting in poor returns.

Under the assumption of a third party's financial literacy as a public good, some literatures investigate how this externality influences a household's portfolio investment. Kaustia and Knüpfer (2012) verify that colleagues and neighbors of the households influence the degree of financial literacy of the household and improve the results of the household's portfolio investment. They examine household portfolio investment data obtained from the Finnish Securities Depository Center and empirically verified the participation of the households' neighbors and colleagues in the equity market in that they influence the households' investment results. They report that a household that has neighbors or colleagues that are equity market participants is more likely to take part in the equity market. This paper concludes that this is because the household improves in terms of financial literacy by learning from the experiences of the equity investment of neighbors and colleagues.

Haliassos et al. (2020) also report empirical evidence on the existence of financial literacy externalities. They use LINDA and STATIV database of household financial activities in Sweden, and examine how a household's exposure to financial knowledge influences the portfolio investment patterns of neighbors. They conclude that this exposure promotes saving in private retirement accounts and stock holdings by neighbors as personal investors, especially if these neighbors have been exposed

to economics or business education in the past.

To contribute the series of literature, our theoretical framework newly considers the high financial literacy of household promotes the use of online banking and therefore results in high portfolio returns. We empirically verify this model by using household survey individual data.

2.2 Household Debt and Portfolio Investment

Becker and Shabani (2010) report empirical results of the relationship between household debt structure and portfolio investment in the United States. They use household individual survey data of the U.S. Federal Reserve Board's official statistics, *Survey of Consumer Finance,* between 1989–2004. They empirically examine how household interest payments of each type of household debt, that is, mortgage, educational loan, and consumer loan, influence the household portfolio investment returns. They conclude that the larger the interest payment of debt that a household pays, the more passive the risk-taking behaviors when it comes to household portfolio investments. In other words, they conversely suggest that a homeowner household experiences an increase in risk appetite for portfolio investment when the remaining mortgage debt becomes small in the late second-half period of the life cycle. This is because the mortgage debt outstanding decreases with the progress in repayment as time goes by, and therefore the decrease in the payment of total interest consequently increases risk appetite for portfolio investment according to Becker and Shabani (2010).

Chetty et al. (2017) show empirical evidence that indicate a positive impact from the decrease in household mortgage debt on portfolio investment, in that it is larger than that from the increase in market value of a residential house on portfolio investment. Both a decrease in mortgage debt outstanding by repayment and an increase in market value of a residential house increase home equity value, as a home equity value is defined as the total market value of a residential house minus the total book value of mortgage debt outstanding. This study points out that a household remains passive in portfolio investment even though there is an increase in the market value of their residential house. Conversely, they assert that as household debt repayment continues and total mortgage debt outstanding decreases, this case of an increase in the home equity value promotes risk tolerance in the household.

Keys et al. (2016) study the different total interest payments among households that aggressively refinance mortgage loans and those that do not. By analyzing each household's residential loan contract data as of February 2002, their study concludes that households that do not refinance mortgage loans lose more household savings than those that aggressively refinance the loan. Although their study does not directly examine the relationship between refinancing mortgage loans and household portfolio investment, it is possible to interpret that their conclusion implies that when a household frequently refinances a mortgage loan, then it is able to save on the interest payments, and this may promote household portfolio investments. This conclusion is consistent with that of Chetty

et al. (2017) in this regard.

In addition to the relationship between the use of online banking and portfolio return, we also investigate the relationship between the relationship among the use of online banking, mortgage debt, and the risk appetite of households. We empirically show the use of online banking increases risk appetite, because the use promotes debt repayments compared to bank branch visitors.

2.3 Homeownership and Portfolio Investment

Another series of existing literatures also report empirical results of the relationship between household homeownership and portfolio investment. Corrading et al. (2014) demonstrate empirical evidence on the relationship between household investment risk appetite and the expected growth rate in housing prices. They use They use the University of Michigan Panel Study of Income Dynamics (PSID) household survey data for 1984–2007 and SIPP 1997–2005 survey data from the United States Census Bureau, and conclude that the share of risky financial assets among households is higher in the expected high growth period of housing prices.

Vestman (2019) also reports that homeownership positively influences household portfolio investment. He employs individual survey data from Swedish households between 2000–2007, and shows empirical results that equity asset ratio to total financial assets of homeowner households is twice as high as that of home renters. He emphasizes that this is because the size of total homeowner household savings is larger than that of home renters. Therefore, this study concludes that homeownership promotes household saving activities and encourages portfolio investment which may result in a loss of principal.

In addition, some literatures assert that the degree of liquidity of a house as a collateral tangible fixed asset influences a household's portfolio investment. Specifically, Defusco (2018) asserts that the degree of liquidity of a house as an asset influences a household's portfolio risk appetite. He shows empirical evidence of whether a household can quickly convert the house asset to cash or whether it can quickly sell even a part of the house asset influences the total household debt size and portfolio investment.

We verify both relationship between the use of online banking and the mortgage debt repayment, and the use of online banking and homeownership. We will demonstrate empirical evidence that the homeownership also influences the household risk appetite and this impacts are different between online banking users and bank branch visitors.

<Table 1>

3 Model and Hypotheses

3.1 Model Setup

We apply a simple two-period model of portfolio choice considering the model by Chetty et al. (2017). The major difference between our model and that of Chetty et al. (2017) is that we consider the cost of household asset reallocation under the assumption that each household does not move house. A household is endowed with mortgage debt M_0 and financial assets L_0, and makes a portfolio choice in period 0. The household incurs a cost when the household reallocates the composition of the financial asset L_0. We assume that the cost is expressed as a fraction $\delta \in (0,1)$ of household labor income Y_1. This cost includes both direct and indirect costs, that is, a portfolio reallocation commission fee, and so forth, and opportunity costs of bank visits. The household must pay a commission fee to financial institutions, and transportation costs when one of the household members visits a branch to complete the asset reallocation. Further, the household incurs indirect costs which would have earned additional income when the household inputted man-hours not for bank branch visits, but for other income opportunities. δY_1 represents the various direct and indirect costs.

A household obtains labor income Y_1 and the post-reallocation market value of the portfolio $\big(1 + R_p\big)L_0$, where R_p is the portfolio return. The household also repays mortgage debt $(1 + R_m)M_0$, where R_m is the mortgage rate, and consumes C_1 in period 1. We assume that labor income Y_1 and the mortgage rate R_m are deterministic. Our assumption is that the household has two types of financial assets: risk-free and risky assets. The household obtains a fixed return $1 + R_f = \exp\big(r_f\big)$ from the risk-free assets. The household obtains a return $1 + R = \exp(r)$ from the risky assets, where r is a normally distributed random variable with mean μ_r and variance σ_r^2. In this paper, equities, investment and trusts funds, and foreign currency denominated assets are assumed to be risk assets of households. Let $\alpha \in [0, 1]$ denote the share of the risky assets out of the total financial assets. Subsequently, the portfolio return is given by $R_p = \alpha(1 + R) + (1 - \alpha)\big(1 + R_f\big)$.

The preference of the household is specified as

$$E_0\left[\frac{(C_1)^{1-\gamma}}{1-\gamma}\right], \tag{1}$$

where E_0 denotes the expectation operator conditional for period 0, and γ is the coefficient of relative risk aversion. The household's optimization problem is to choose α to maximize (1) subject to the budget constraint

$$C_1 = \big(1 + R_p\big)L_0 + (1 - \delta)Y_1 - (1 + R_m)M_0.$$

By solving this problem, we obtain the Euler equation

$$E_0[(1+R)(C_1)^{-\gamma}] = \left(1+R_f\right)E_0[(C_1)^{-\gamma}]. \quad (2)$$

Using log linearization in the same way as in Chetty et al. (2017), we obtain an approximation for the optimal share of a risky asset α as follows (see Appendix A for the derivation):

$$\alpha = \frac{\mu_r - r_f + \frac{\sigma_r^2}{2}}{\gamma \frac{\left(1+R_f\right)L_0}{\left(1+R_f\right)L_0 + (1-\delta)Y_1 - (1+R_m)M_0}\sigma_r^2}. \quad (3)$$

Equation (3) implies that a lower (higher) cost of household asset reallocation through online banking (bank branch visit) leads to a higher (lower) share of risky assets out of total financial assets: $\partial\alpha/\partial\delta < 0$. The intuitive understanding of this result is that a decrease in the cost of household asset reallocation through online banking increases the total value of financial assets in the next period, $\left(1+R_f\right)L_0 + (1-\delta)Y_1 - (1+R_m)M_0$. Therefore, the household makes efforts in increasing α to keep the high share of risky assets to total financial assets constant.

3.2 Hypotheses Development

The main purpose of this study is to investigate whether portfolio returns of online banking users are higher than those of non-online users because of the higher share of risky assets. Our first hypothesis is derived from our theoretical framework and various existing literatures. As explained in the previous section, Van Rooij et al. (2011), Anderson et al. (2017), and Bianchi (2018) consistently report that a high degree of financial literacy results in high household portfolio returns in the Netherlands, the United States, and France, respectively. These literatures do not directly analyze the households' use of online banking. However, we implicitly interpret these literatures that suggest a high degree of financial literacy activates household asset allocations and improves portfolio returns. Therefore, as online banking enables household agile active asset reallocation as shown in 3.1, we hypothesize that financial literacy improvement efforts promote the use of online banking among households, and online banking therefore brings higher portfolio returns than those of non-online users.

H1: Financial literacy efforts promote the use of online banking among households.
H2: The portfolio returns of online users are therefore higher than those of non-online users.

The third hypothesis in this study is on the origins of higher portfolio returns among online users. Existing literatures assert that households that have high (low) degrees of financial literacy are likely to employ risk-tolerant (risk-averse) portfolio investment behaviors. These risk-tolerant portfolio investments are also likely to result in high portfolio returns, according to Lusardi and Mitschell (2011), and Von Gaudecker (2015). Our third hypothesis is developed from these literatures

newly focusing on the relationship between the use of online banking and the degree of household risk appetite in portfolio investments. We suppose that online users are more likely to experience an increase in risk appetite as shown in our theoretical model, and a marginal increase in risk appetite creates higher portfolio returns; this is not the case for non-online users. This is because, first, a household's financial literacy effort promotes online use and the risk-taking behavior as noted above. Second, online use enables the household's active and agile asset reallocations, and this increases risk appetite.

H3: An increase in risk appetite among online users increases their portfolio returns, while this is not the case for non-online users.

Our fourth hypothesis is on the relationship between debt repayments and risk appetite among online users. Becker and Shabani (2010) suggest that frequent household debt refinancing encourages household equity investments. Existing literature by Chetty et al. (2017) also concludes that a decrease in household mortgage debt increases the degree of household risk appetite, and debt refinancing therefore increases the household risk appetite as well. Our fourth hypothesis is that online users are more likely to have a higher debt repayment ratio, and the impact of an increase in debt repayment on the risk appetite is also larger than that of non-online users. We suppose that this is because the progress in debt repayment among online users decreases the debt outstanding. The decrease in debt consequently saves interest payment costs among online users, and this encourages households' further risk tolerant investments, consistent with the conclusions of Becker and Reza (2010), and Lian et al. (2018).

H4: Online banking promotes progress in debt repayment, and this encourages the users to be more risk tolerant in portfolio investments than non-online users.

Defusco (2018) and Vestman (2019) also focus on the relationship between household homeownership and risk-taking behaviors in portfolio investments. Our fifth hypothesis is that household online banking users experience an increase in risk appetite more than non-online banking users when both are homeowners. Vestman (2019) concludes that homeownership positively influences household risk appetite as homeowners generally have more savings than home renters. We hypothesize that homeowners who use online banking have higher degrees of risk appetite than non-online banking user homeowners. This is because homeowners have more household savings than home renters, and this increases the risk appetite of homeowners as Vestman (2019) noted. In addition, some household housing assets might even have a high degree of liquidity, and this further promotes risk-taking behaviors among such households as Defusco (2018) suggests.

H5: Online banking users who are homeowners have a higher risk appetite than non-online users who are homeowners.

4 Empirical Strategy

To investigate the first (**H1**) and second (**H2**) hypotheses indicated in the previous section, we estimate the following empirical model (A)–(B) by endogenous treatment effect models. The empirical model (A) employs either *Online vs. Branch*, or *Online vs. Non-online* as a dependent variable. We define *Online vs. Branch* as one when household *i* is an online banking user, and zero when household *i* is a frequent bank branch visitor. Meanwhile, *Online vs. Non-online* equals one when household *i* is an online banking user, or zero otherwise. Households of "*Online vs. Non-online* equals zero" include both frequent bank branch visitors and households that are neither online banking users nor frequent bank branch visitors.

The empirical model (A) also employs the following independent variables. *Financial Literacy* employs five dummy variables, that is, *Literacy_Bank*, *Literacy_Professional*, *Literacy_Seminar, Literacy_Friend*, and *Literacy_School.* Each dummy variable respectively equals one when household *i* chooses that the household obtains information for portfolio investment from either financial institutions (*Literacy_Bank* =1) or professional experts (*Literacy_Professional* =1) or seminars held by third neutral organizations (*Literacy_Seminar* =1) or friends (*Literacy_Friend* =1) or university/other school class (*Literacy_School* =1), or zero otherwise, respectively. Van Rooij et al. (2011), Kaustia and Knüpfer (2012), and Bianchi (2018) consistently support the positive relationship between the degree of household financial literacy and their portfolio returns. Based on these literature conclusions, we first verify our hypothesis (**H1**) by examining the relationship between *Literacy_Professional* and *Online vs. Branch* (*Online vs. Non-online*). Here, we expect that **H1** is supported when the parameter of *Literacy_Professional* is significantly positive.

Income is defined as natural logarithm values of household *i* annual income (10 thousand JPY). *Assets* is defined as a natural logarithm value of household *i* financial asset outstanding (10 thousand JPY) as of household *i* head's response to the survey. Either *Age20s*, *Age30s*, *Age40s*, and *Age50s* equals one when the age of household *i* head is either 20s/under 20, or 30s, or 40s, or 50s, and zero otherwise, respectively. *Payment* equals one when household *i* responds that any of the family members uses an IC card for micro payment or a credit card for general payment on a daily basis, and equals zero when any of the family members uses neither. The details of the definition of this variable are specifically explained in the next section. In addition, the respective questionnaire survey questions regarding the employed variables are specifically explained in the Appendix. The empirical model (A) also employs regional dummy variables that may influence the choice of financial delivery channels

of household *i*. This is because the size of regional population, the size of regional GDP, the size of regional area, and the number of bank branches deployed in the area vary across regions and they may influence the choice of use of online banking among households. *Hokkaido-Tohoku*, *Kanto*, *Chubu*, *Hokuriku*, *Kinki*, *Chugoku-Shikoku,* respectively, equal one when the residential address of household *i* corresponds to either of them, or zero otherwise. The empirical equation (A) also employs six-year dummy variables.

$$Online\ or\ Branch_i = \gamma_0 + \Sigma\ \gamma_m\ Financial\ Literacy^m{}_i + \gamma_1\ Income_i + \gamma_2\ Assets_i + \Sigma\ \gamma_n\ Age^n{}_i + \gamma_3 Payment_i + \Sigma\ \gamma_p Controls^p{}_i + \varepsilon^1{}_i \quad (A)$$

$$Portfolio\ Return_i = \phi_0 + \phi_1\ Market\ Risk_i \times Online\ vs.\ Branch_i + \phi_2\ Mortgage\ to\ Income_i + \Sigma\ \phi_l Controls^l{}_i + \xi^1{}_i \quad (B)$$

The empirical model (B) employs *Portfolio Return* as a dependent variable which is defined as a percentage of portfolio investment returns of household *i*. The model (B) employs the following independent variables. *Market Risk* is defined as outstanding values of equities plus investment and trusts, and financial assets denominated in foreign currencies divided by the total financial assets of household *i*. *Mortgage to Income* is defined as residential mortgage loan outstanding divided by annual income of household *i*. The case of households that have zero outstanding mortgage loan is included in the sample. In this case, *Mortgage to Income* equals zero.

The empirical equation (B) also employs the following control independent variables other than *Income* and *Assets*. *Married* equals one when the household *i* head is married, or zero otherwise. *Education* equals one when any of the household members has graduated from undergraduate university or graduate school, or zero otherwise. The survey also asks each household a question on which industry the household head works, and five single response alternatives are prepared, that is, agriculture, manufacturing, retail/wholesale, public offices, and others. We employ each dummy variable of *Agriculture*, *Manufacturing*, *Retail_Wholesale*, and *Public Service*, which respectively equals one when household *i* chooses either of them, or zero otherwise, respectively. The equation (B) also employs six-year dummy variables.

We expect that the second hypothesis (**H2**) is empirically supported when *Online vs. Branch* and *Portfolio Return* are positively related. Thus, by concurrently verifying **H1** and **H2**, we aim to derive a conclusion that the degree of household financial literacy, use of online banking, and portfolio returns are positively related.

$$Online\ or\ Branch_i = \gamma_0 + \Sigma\ \gamma_m\ Financial\ Literacy^m{}_i + \gamma_1 Income_i + \gamma_2 Assets_i + \Sigma\ \gamma_n Age^n{}_i + \gamma_3 Payment_i + \Sigma\ \gamma_l Controls^l{}_i + \varepsilon^2{}_i \quad (C)$$

$$Market\ Risk_i = \omega_0 + \omega_1\ Repayment\ to\ Income_i \times Online\ or\ Branch_i + \omega_2\ Income_i + \omega_3 Assets_i + \Sigma\ \omega_l Controls^l{}_i + \xi^2{}_i \quad (D)$$

We then examine the third (**H3**), fourth (**H4**), and fifth (**H5**) hypotheses concerning the relationship between risk-taking behaviors and mortgage debt management among online and non-online users. The empirical model (C) applied is the same as the first empirical model (A). The other empirical model (D) employs *Market Risk* as the dependent variable. We expect that our third hypothesis (**H3**) is supported when the average treatment effect of *Online or Branch* on *Market Risk* is significantly positive in this model (D).

Becker and Shabani (2010) conclude that household portfolio risk appetite increases when mortgage debt interest payment to annual income decreases. Chetty et al. (2017) assert that household risk appetite and mortgage debt outstanding are negatively related. We improve on these studies by examining the effect of use of online banking on the relationship between debt repayment and risk appetite, and on the relationship between debt outstanding and risk appetite. The independent variable of *Repayment to Income* is defined as household annual debt repayment divided by annual income of household *i.* Instead of *Repayment to Income*, we also employ and examine the independent variable of *Mortgage* which is defined as a natural logarithm value of residential mortgage loan outstanding of household *i*.[1] We expect that the fourth hypothesis (**H4**) is supported when the parameter of the intersected variable between *Online vs. Branch* (*Online vs. Non-online*) and *Repayment to Income* is positive, and the parameter of that between *Online vs. Branch* (*Online vs. Non-online*) and *Mortgage* is negative.

In our empirical analyses, we assume that the net worth of household *i* increases when household *i* is a homeowner, and the debt outstanding decreases with the progress in debt repayment. Vestman (2018) concludes that homeowners are more risk tolerant than home renters. Subsequently, to test the fifth hypothesis (**H5**), we finally estimate one more empirical equation model which employs *Housing* as an independent variable, instead of *Repayment to Income*. *Housing* equals one when household *i* is a homeowner, and equals zero when household *i* is a home renter. We expect that the fifth hypothesis (**H5**) is supported when the parameter of the intersected variable between *Online vs. Branch* (*Online vs. Non-online*) and *Housing* is positive in the model (D).

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[1] When calculating *Mortgage to Income,* we include households that do not have any mortgage loan outstanding. Meanwhile, when calculating *Mortgage,* households that have no mortgage loan outstanding are excluded. Therefore, the number of observations of *Mortgage to Income* is 40,653, and that of *Mortgage* is 20,513.

5 Data

The Central Committee on Savings and Public Relations, the Bank of Japan, has been conducting an annual questionnaire survey referred to as the "Questionnaire Survey on Household Financing Behaviors" since 1961. A question concerning the household's use of online banking and bank branch visits has been added since 2007. To eliminate sample biases which may come from stock market turmoil right after the 2008 Lehman Crisis and the 2011 Great East Japan Earthquake, we employ 2012–2018 data for this study. The Central Committee on Savings and Public Relations made this survey by visiting each individual household or postal mail-in in the case of households that have more than one family member, and by Internet response for single-person households. This study uses data from 43,601 households between 2012–2018 which includes 26,101 single-person households. The distribution of this household sample is shown in Table 2.

5.1 Definition of Online Users and Branch Visitors

From the survey sample data, we define *Online vs. Branch* and *Online vs. Non-online* as follows. In each year between 2012–2018, one of the survey questions to each household was, "Why did you open the current bank account as a main transactional account?" Further, each household was requested to choose a maximum of three answers from thirteen response alternatives as indicated in the Appendix. The thirteen response alternatives include the following two choices.

(1) It is because the current transactional bank has prepared the most effective Internet or other online banking services among banks.
(2) It is because the current transactional bank branch or ATM is geographically convenient as it is located close to my/our house or office.

We define household i as an online banking user, but not a frequent bank branch visitor (*Online vs. Branch* =1, *Online vs. Non-online* =1) when the household chooses (1) and does not choose (2), simultaneously.

The definitions of *Online vs. Branch* =1 and *Online vs. Non-online* =1 are the same, but the definitions of *Online vs. Branch* =0 and *Online vs. Non-online* =0 are not. We define *Online vs. Branch* =0 when household i does not choose (1), but chooses (2). We define *Online vs. Non-online* =0 when household i does not choose (1), but chooses (2), or chooses neither (1) nor (2). In other words, household samples of *Online vs. Non-online* =0 contain all the following households. (a) Households that opened the current transactional bank account because the geographical location of the bank branch/ATM is close. (b) Households that opened the current transactional bank account because of neither online banking service nor branch location reasons. (c) Households that did not open a bank

account at any banks. *Online vs. Branch* =0 contains only households that opened the current transactional bank account because of the convenient geographical location of the bank branch/ATM. We eliminate all household samples that chose both (1) and (2).

As a result, the number of *Online vs. Branch* =1 and *Online vs. Non-online* =1 in the sample is 2,229 households, while those of *Online vs. Branch* =0 and *Online vs. Non-online* =0 are 26,391 and 41,372 households, respectively.

5.2 Portfolio Returns and Risk Appetite

The Central Committee on Savings and Public Relations requests each household to fill out the figure of net increase/decrease of household financial assets in the recent one year in percentages as of when the questionnaire form was sent. However, our concern is that these responses may include households that experienced an increase in their portfolio assets through a net increase in savings or other reasons apart from portfolio investment results. Fortunately, following this question, the survey also asks a multiple answer sub-question where the households can choose from eight response alternatives regarding the reasons of the net increase/decrease of financial assets. Therefore, we only extract households that choose either or both (1) and (2) in this sub-question, but exclude all the households that choose any response alternatives apart from (1) and (2)[2].

(1) The reason for the recent increase/decrease in the one-year financial assets is because the market values of my/our equities and debt securities increased/decreased.
(2) The reason for the recent increase/decrease in the one-year financial assets is because of the dividend revenue of my/our equities or interest revenues of my/our debt securities.

We define this net increase/decrease of these households' portfolio investment returns as *Portfolio Return* of household *i*. We, on the other hand, add household samples that have at least more than zero JPY worth of portfolio financial assets, and fill out that the net increase/decrease of such household financial assets in the recent one year is zero percent.

The Central Committee on Savings and Public Relations also directly asks a question regarding the values and breakdown of each household's total financial asset outstanding. The question asks outstanding values of deposits, money trust and loan trust, life insurance, private pension, bonds, equities, investment and trust, foreign currency denominated financial assets, and others, and the total as of when the questionnaire survey was sent. *Market Risk* is defined as outstanding values of equities

[2] Appendix B. 2 "Survey Question and Response Alternatives on Portfolio Return" specifically explains each response alternative of sub-question (a) Why did your total financial asset values increase? and (b) Why did your total financial asset values decrease? Here, we extract households that only chose response alternatives (iii) and (vi) for sub-question (a), or only (vi) for sub-question (b). We exclude all the households that chose any other response alternatives from the sample, except for or in addition to (iii) and (vi) for sub-question (a), and (vi) for sub-question (b). This is because these sub-questions allow households to choose an unlimited number of response alternatives.

plus investment, and trusts plus financial assets denominated in foreign currencies divided by the total financial assets of household *i*.

5.3 Financial Literacy Efforts

The Central Committee on Savings and Public Relations questionnaire survey asks a multiple answer question in each year between 2012–2018, "Where do you mainly obtain information that you utilize in your portfolio investment?" with six response alternatives. The prepared six response alternatives are "I/We receive portfolio investment information from (1) financial institutions, (2) finance professionals, (3) seminars held by third neutral parties that have no interests with banks and markets, (4) friends and family members, (5) university or school class, and (6) others."

The first dummy variable *Literacy_Bank* equals one when household *i* chooses (1), and zero otherwise. The second dummy variable *Literacy_Professional* equals one when household *i* chooses (2), and zero otherwise. The third dummy variable *Literacy_Seminar* equals one when household *i* chooses (3), and zero otherwise. The fourth dummy variable *Literacy_Friend* equals one when household *i* chooses (4), and zero otherwise. The fifth dummy variable *Literacy_School* equals one when household *i* chooses (5), and zero otherwise.

5.4 Mortgage Loan and Homeownership

The Central Committee on Savings and Public Relations questionnaire survey requests each household to fill out the amount of residential mortgage loan outstanding and the annual repayment of that in 10 thousand JPY. *Mortgage to Income*, *Mortgage* (10 thousand JPY), and *Repayment to Income* are also obtained from the survey response data. The survey also asks a single answer question in each year between 2012–2018 of whether the household is a homeowner. An independent dummy variable of *Housing* is obtained based on these survey response data.

5.5 Payment Methodology

The questionnaire survey also asks each household which type of payment method, that is, (1) cash, (2) credit card, (3) IC card (including debit card), (4) others, is used on a daily basis in each year between 2012–2018 as a multiple answer question. A household is potentially expected to choose from a minimum of zero to a maximum of twenty answers as the above four payment methods are multiplied by the below five categorical payment values per price of purchased item, that is, "(a) Below 1,000 JPY," "(b) 1,000–5,000 JPY," "(c) 5,000–10,000 JPY," "(d) 10,000–50,000 JPY," "(e) over 50,000 JPY." We define *Payment* equals one when household *i* chooses "(2) credit card" for at least one of the above (a)–(e) categorized payment values, and when household *i* simultaneously chooses "(3) IC card" for at least one of the above five (a)–(e) categorized payment values.

<Table 2>

6 Empirical Results

6.1 Online Users vs. Branch Visitors: Portfolio Returns

Table 3 presents equations (1a)–(1b) as empirical results of model (A) and (B) when the dependent variable is *Online vs. Branch* for model (A), and *Portfolio Return* for model (B). Equation (1a) indicates that the parameters of *Literacy_Bank* and *Literacy_Friend* are negatively significant. Meanwhile, it also indicates that the parameters of *Literacy_Professional* and *Literacy_Seminar* are positively significant. These imply that households that obtain portfolio investment information from financial institutions (*Literacy_Bank* =1) and friends (*Literacy_Friend* =1) are unlikely to use online banking. However, the results also imply that households that are eager to improve their level of financial literacy by contacting financial professionals (*Literacy_Professional* =1) and by participating in seminars held by third neutral parties (*Literacy_Seminar* =1) are likely to use online banking. Equation (1b) indicates that the parameter of *Online vs. Branch* is positively significant, and this parameter represents the average treatment effect of use of online banking (*Online vs. Branch* =1) on portfolio returns (*Portfolio Return*). This result implies that portfolio returns of online users significantly exceed those of frequent bank branch visitors.

Empirical results of equations (2a)–(2b) are also consistent with those of equations (1a)–(1b). Equation (2a) indicates that the parameters of *Literacy_Professional* and *Literacy_Seminar* are positively significant when the dependent variable is also *Online vs. Non-online*. Equation (2b) indicates that the parameter of *Online vs. Non-online* is positively significant, and this implies that the use of online banking (*Online vs. Non-online* =1) increases portfolio returns (*Portfolio Return*). Equations (3a)–(3b), and (4a)–(4b) represent the results when we employ a data set where both the upper- and lower-1 percent of *Portfolio Return* in the household sample have been eliminated. The purpose of this data set is to exclude excessively over and underperforming households in terms of portfolio investment returns. The results of these equations, (3a)–(3b) and (4a)–(4b), are also consistent with the empirical results of (1a)–(1b) and (2a)–(2b).

<Table 3>

6.2 Online Users vs. Branch Visitors: Portfolio Risk Appetite

Table 4 (1)–(2) also indicate the empirical results of another version of model (B). Table 4 (3)–(4) demonstrate the empirical results of model (D) in which *Market Risk* has been employed as a dependent variable. The dependent variable of equations (1)–(2) is *Portfolio Return,* and independent

variables include intersected variables between *Online vs. Branch* and *Market Risk* and those between *Online vs. Non-online* and *Market Risk*. In Table 4, empirical results of model (A) are consistent with the results of equations (1a)–(2a) in Table 3. We, therefore, omit the reports of empirical results of model (A) in Table 4.

Equation (1) indicates that the parameter of *Market Risk* is significantly positive when *Online vs. Branch* = 1. Meanwhile, equation (1) also indicates that the parameter of *Market Risk* is insignificant when *Online vs. Branch* =0. These results imply that online users (*Online vs. Branch* =1) increase their portfolio returns when they experience a marginal increase in risk appetite (*Market Risk*), while branch visitors (*Online vs. Branch* =0) do not increase their returns when they experience an increase in risk appetite (*Market Risk*). Equation (2) also indicates that the parameter of *Market Risk* is significantly positive when *Online vs. Non-online* =1. Meanwhile, equation (2) indicates that the parameter of *Market Risk* is insignificant when *Online vs. Non-online* =0, as well. These results also imply that online users (*Online vs. Non-online* =1) increase their portfolio returns when they experience a marginal increase in risk appetite (*Market Risk*), while non-online users (*Online vs. Non-online* =0) do not increase their returns when they experience an increase in risk appetite (*Market Risk*).

Table 4 also indicates the empirical results of the relationship between the use of online banking (*Online vs. Branch*, *Online vs. Non-online*) and household risk appetite (*Market Risk*). In equation (3), the parameter of *Online vs. Branch* is significantly positive. The parameter of *Online vs. Non-online* is also significantly positive in equation (4). These two results consistently imply that the use of online banking (*Online vs. Branch* =1, *Online vs. Non-online* =1) increases risk appetite (*Market Risk*).

<Table 4>

6.3 Online Users vs. Branch Visitors: Mortgage Debt Repayment

Table 5 also indicates empirical results of equation model (D). Equations (1)–(4) employ *Market Risk* as the dependent variable. Independent variables include intersected variables between *Online vs. Branch* and *Repayment to Income,* and those between *Online vs. Non-online* and *Repayment to Income*. In Table 5, empirical results of model (C) are also approximated using the results of equation (1a)–(4a) in Table 3. We, therefore, omit the reports of empirical results of model (C) in Table 5.

Equation (1) indicates that the parameter of *Repayment to Income* is significantly positive when *Online vs. Branch* =1. Meanwhile, equation (1) also indicates that the parameter of *Repayment to Income* is insignificant when *Online vs. Branch* = 0. These results imply that online users (*Online vs. Branch* =1) experience an increase in portfolio risk appetite (*Market Risk*) when their mortgage debt repayment to income ratio (*Repayment to Income*) is high. Branch visitors (*Online vs. Branch*

=0) do not experience an increase in portfolio risk appetite (*Market Risk*) when there is an increase in the mortgage debt repayment to income ratio (*Repayment to Income*). Equation (2) also indicates that the parameter of *Repayment to Income* is significantly positive when *Online vs. Non-online* = 1. Meanwhile, equation (2) indicates that the parameter of *Repayment to Income* is insignificant when *Online vs. Non-online* = 0, as well. We also reconfirm the results of these analyses by using a data set that eliminates the upper- and lower- 1 percent of *Market Risk* samples. Empirical results of equations (3) and (4) of these estimations are also consistent with those of equations (1) and (2) in Table 5, respectively.

Table 6 indicates supplemental empirical results regarding the relationship between a household's use of online banking and debt repayment. Equations (1)–(4) employ *Repayment to Income* as the dependent variable. Independent variables include *Online vs. Branch* or *Online vs. Non-online*. Equation (1) and (2) are estimated by using samples that we exclude household that do not have any mortgage loan outstanding. Equation (3) and (4) are estimated by using samples that have have mortgage loan outstanding and household chiefs are active salaried workers of age 20s or 30s or 40s or 50s. In Table 6, empirical results of model (A) are also approximated using the results of equation (1a)–(2a) in Table 3. Equation (1) indicates that the parameter of *Online vs. Branch* is significantly positive. Equation (2) also indicates that the parameter of *Online vs. Non-online* is significantly positive. Empirical results of equation (3) and (4) also indicate that the parameters of *Online vs. Branch* and *Online vs. Non-online* are significantly positive. These results imply that online banking users (*Online vs. Branch* =1, *Online vs. Non-online* =1) are more likely to increase mortgage debt repayment to income ratio (*Repayment to Income*).

<Table 5>

<Table 6>

6.4 Online Users vs. Branch Visitors: Mortgage Debt and Homeownership

Table 7 indicates the empirical results of another version of model (D). Equations (1)–(4) employ *Mortgage,* which is defined as natural logarithm values of remaining mortgage debt (10 thousand JPY), instead of *Repayment to Income*. The dependent variable in equations (1)–(4) is *Market Risk,* and the independent variables include intersected variables between *Online vs. Branch* and *Mortgage,* and those between *Online vs. Non-online* and *Mortgage*. In Table 7, empirical results of model (A) are also consistent with the results of equations (1a)–(2a) in Table 3. Equation (1) and (2) are estimated by using household samples that have at least non-zero mortgage loan outstanding. Equation (3) and (4) are estimated by using household samples that have at least non-zero mortgage loan outstanding and household chiefs are active salaried workers of age 20s or 30s or 40s or 50s.

Equation (1) indicates that the parameter of *Mortgage* is significantly negative when *Online vs. Branch* =1 and *Online vs. Branch* = 0. Meanwhile, the absolute 90 percent confidence interval value of the parameter of *Mortgage* when *Online vs. Branch* = 1 is significantly larger than that of the same parameter when *Online vs. Branch* =0. The confidence intervals of these two parameters are not overwrapped at all. Equation (2) also indicates that the parameter of *Mortgage* is significantly negative when *Online vs. Non-online* =1 and *Online vs. Non-online* = 0. Meanwhile, the absolute 90 percent confidence interval value of the parameter of *Mortgage* when *Online vs. Non-online* = 1 is significantly larger than that of the same parameter when *Online vs. Non-online* =0. The confidence intervals of these two parameters are not overwrapped, either. These results imply that online users (*Online vs. Branch* =1, *Online vs. Non-online* =1) are more likely to experience an increase in risk appetite (*Market Risk*) when the remaining mortgage debt (*Mortgage*) decreases with the progress in their debt repayment (*Repayment to Income*). Equation (3) indicates that the parameter of *Mortgage* is significantly negative when *Online vs. Branch* =1 and the parameter is insignificant when *Online vs. Branch* = 0. Equation (4) also indicates that the parameter of *Mortgage* is significantly negative when *Online vs. Non-online* =1 and the parameter is insignificant when *Online vs. Non-online* = 0. These results are consistent with empirical results of equation (1) and (2).

Table 8 also indicates the empirical results of the revised version of model (D). Equations (1)–(4) employ *Homeownership,* which equals one when the respondent household is a homeowner, or zero otherwise, instead of *Repayment to Income* of model (D). The dependent variable in equations (1)–(4) is *Market Risk,* and the independent variables include intersected variables between *Online vs. Branch* and *Homeownership,* and those between *Online vs. Non-online* and *Homeownership*. In Table 8, the empirical results of model (A) are also consistent with the results of equations (1a)–(2a) in Table 3. Equation (1) and (2) are estimated by using full samples that include all the generation of household chiefs. Equation (3) and (4) are estimated by using household samples that household chiefs are active salaried workers of age 20s or 30s or 40s or 50s.

Equation (1) indicates that the parameter of *Homeownership* is significantly positive when *Online vs. Branch* = 1 and *Online vs. Branch* = 0. Meanwhile, the 90 percent confidence interval of the parameter of *Homeownership* when *Online vs. Branch* = 1 is significantly larger than when *Online vs. Branch* =0. The confidence intervals of these parameters are not overwrapped. Equation (2) also indicates that the parameter of *Homeownership* is significantly positive when *Online vs. Non-online* = 1, and when *Online vs. Non-online* = 0. Meanwhile, 90 percent confidence interval value of the parameter of *Homeownership* when *Online vs. Non-online* = 1 is significantly larger than that of the same parameter when *Online vs. Non-online* =0. The confidence intervals of these parameters are not overwrapped, either. These results imply that in terms of risk- taking behaviors, households are far more risk tolerant (*Market Risk*) when they are online banking users (*Online vs. Branch* =1, *Online vs. Non-online* =1) and homeowners (*Homeownership* =1) than when they are homeowners and branch

visitors (*Online vs. Branch* =0, *Homeownership* =1), and home renters and online users (*Online vs. Branch* =1, *Online vs. Non-online* =1, *Homeownership* =0). Equation (3) indicates that the parameter of *Homeownership* is significantly positive when *Online vs. Branch* = 1 and *Online vs. Branch* = 0. Meanwhile, the 90 percent confidence interval of the parameter of *Homeownership* when *Online vs. Branch* = 1 is significantly larger than when *Online vs. Branch* =0. The confidence intervals of these parameters are not overwrapped. Equation (4) also indicates that the parameter of *Homeownership* is significantly positive when *Online vs. Non-online* =1 and the parameter is insignificant when *Online vs. Non-online* = 0. These results are consistent with empirical results of equation (1) and (2).

<Table 7>

<Table 8>

7 Discussion

How can we interpret our empirical results corresponding to our hypotheses, **H1**–**H5**, respectively? First, the empirical results in Table 3 indicate that households that are eager to make financial literacy efforts by contacting finance professionals or by participating in seminars held by third neutral organizations are likely to use online banking. These two are the expertized information sources compared to other two response alternatives of financial literacy improvement methodologies, that is, friends, and university/school class[3]. The response alternative of "financial institutions" is a party of interest among the related portfolio brokers. Anderson et al. (2017) and Bianch (2018) consistently assert that a high level of financial literacy among households positively influences the portfolio returns. Our results also share their views. Our empirical results point out that households that are eager to improve their level of financial literacy are more likely to use online banking because it increases their portfolio returns as also shown in Table 3. Therefore, these results support our hypotheses **H1** and **H2**.

Kaustia and Knüpfer (2012) empirically assert that a high level of financial literacy invites households to participate in the equity market. Huang (2019) also concludes that such a financial literacy level enables households to employ various portfolio investment patterns other than past successful portfolio investment patterns employed. Following these literature conclusions, we interpret our empirical results in Table 3 that online banking facilitates the mobilization of household portfolio assets reallocation and improves portfolio returns. This is because, as we have repeatedly

[3]Our empirical results imply that households that obtain investment information from friends are less likely to participate in equity markets. This is inconsistent with the empirical results of Huang (2019), and Kaustia and Knüpfer (2012). We understand that this inconsistency comes from the survey question that we have applied in this study. These existing literatures assume that these friends and family members are financial experts, but the survey question does not.

discussed, households that are eager to improve their level of financial literacy use online banking. Therefore, our first conclusion based on the results indicated in Table 3 is that financial literacy improvement efforts promote online banking among households, and these efforts also increase the portfolio returns compared to those of frequent bank branch visitors and other non-online users.

Our empirical results in Table 4 show that the reason online users record higher portfolio returns than those of branch visitors and other non-online users is because an increase in risk appetite causes an increase in the returns only for online users. These results support our third hypothesis (**H3**). Specifically, online banking users enjoy higher portfolio returns because they have a higher risk appetite endorsed by their financial literacy as facilitated by professional experts, and so forth. Our second conclusion is, therefore, that financial literacy efforts moderate the positive relationship between the use of online banking, risk appetite, and portfolio returns.

The empirical results in Tables 5–7 demonstrate and support the relationship between the use of online banking, debt repayment, and risk appetite. The empirical results in Table 5 indicate that the impact of repayment to income ratio among online users on the risk appetite is larger than that of branch visitors and other non-online users. These results support our fourth hypothesis (**H4**). Becker and Shabani (2010) assert that household interest payments negatively influence risk appetite in portfolio investments. Lian et al. (2018) also point out that as the total debt decreases followed by progress in debt repayment, the households experience an increase in risk appetite. The results in Table 6 consistently imply that online use promotes repayment of mortgage debt. In addition, empirical results in Table 7 indicate that a decrease in debt among online users increases risk appetite compared to those of branch visitors and non-online users. Combining the results in Tables 5–7, we therefore conclude that online banking promotes debt repayment, decreasing the remaining debt, and consequently increasing risk appetite.

Why do online users experience an increase in risk appetite compared to branch visitors and other non-online users through a marginal decrease in debt? Keys et al. (2016) and Lian et al. (2018) consistently assert that debt refinancing enables households to save on interest payments, and this increases their risk appetite for portfolio investments. Our interpretation of these literatures also relates to our conclusions. The progress in debt repayment and a decrease in mortgage debt result in an increase in household net worth. Therefore, our results suggest that this also promotes risk-taking behaviors and increases portfolio returns among online users compared to those of branch visitors and non-online users.

Further, generally speaking, for many households, the largest tangible asset is their houses in their life cycles, as pointed out by Vestman (2019). The results in Table 8 indicate that not only a decrease in household debt, but also homeownership encourages online user households to be more risk tolerant when it comes to portfolio investment compared to non-online users. The positive relationship between the households' risk appetite and homeownership was originally reported by

Vestman (2019) and Chetty et al.（2017）. To add on to these literature conclusions, our new finding is that the positive impact of homeownership on the online users' risk appetite is larger than that of non-online users when both are homeowners. These results support our fifth hypothesis (**H5**). Vestman (2019) and Chetty et al.（2017） have already shown that home renters experience less risk appetite than homeowners in Sweden and the United States, respectively. Consistent with these literatures, our empirical results also derive another interpretation that online users who are homeowners experience more increase in risk appetite compared to home renters who are online users and those who are non-online users.

8. Concluding Remarks

By using household survey data of 2,999 online banking users, 26,391 frequent bank branch visitors, and 15,041 other non-online banking users between 2012–2018, this study derived the following conclusions. Our empirical evidence shows that portfolio returns of online users exceeds those of bank branch visitors by 4.2–12.9 percent. Based on other empirical evidence, this study concludes that this is because households that are eager to improve their level of financial literacy are more likely to use online banking.

We also demonstrate that the household ratio of equities, investment and trust, and foreign currency denominated assets to total assets of online users exceed those of bank branch visitors by 14.0–24.1 percent. Our second conclusion is that this is because a marginal increase in the ratio of equities, investment and trust, and foreign currency denominated assets to total assets creates an increase in the portfolio returns only for online users; however, this is not the case for bank branch visitors and other non-online users.

This study finally demonstrates the empirical evidence that an increase in the ratio of equities, investment and trust, and foreign currency denominated assets to total assets among online users exceeds that of bank branch visitors by at least 11.6 percent when both types of households experience a marginal increase in debt repayment to income ratio. We have also shown that the decrease in outstanding mortgage debt, and homeownership also increase the ratio of equities, investment and trust, and foreign currency denominated assets of online banking users more than those of bank branch visitors and other non-online uses. Accordingly, our conclusion is that online users who are homeowners further experience an increase in their risk appetite and portfolio returns as these homeowners promote debt repayment within the household life cycles.

Appendix A: Derivation of Optimal Share of Household Risky Financial Assets

This section explains how we derive theoretical results of equation (3) in section 3.1. Taking the log of both sides of (2), we obtain

$$\log E_0[(1+R)(W_1)^{-\gamma}] = r_f + \log E_0[(W_1)^{-\gamma}], \tag{A.1}$$

where $W_1 \equiv \big(1+R_p\big)L_0 + (1-\delta)Y_1 - (1+R_m)M_0$. Using the approximation $\log E[\exp(x)] \approx E(x) + \mathrm{Var}(x)/2$, we obtain

$$\log E_0[(1+R)(W_1)^{-\gamma}] \approx E(w) + \mu_r + \frac{\mathrm{Var}(w) + 2\mathrm{Cov}(w,r) + \sigma_r^2}{2}, \tag{A.2}$$

$$\log E_0[(W_1)^{-\gamma}] \approx E(w) + \frac{\mathrm{Var}(w)}{2}, \tag{A.3}$$

where $w \equiv \log(W_1)^{-\gamma}$. We substitute (A.2) and (A.3) into (A.1) and rearrange the terms to obtain

$$\begin{aligned} &\mu_r - r_f + \mathrm{Cov}(w,r) + \frac{\sigma_r^2}{2} = 0 \\ \leftrightarrow\ &\mu_r - r_f + \mathrm{Cov}(-\gamma\log(W_1), r) + \frac{\sigma_r^2}{2} = 0. \end{aligned} \tag{A.4}$$

Let $l \equiv \log\big(1+R_p\big)L_0$. W_1 can be log linearized around the point where the risky asset return equals $1+R_f$ as follows:

$$\log(W_1) \approx k + \frac{\big(1+R_f\big)L_0}{\big(1+R_f\big)L_0 + (1-\delta)Y_1 - (1+R_m)M_0} l, \tag{A.5}$$

where k is a constant. Substituting (A.5) into (A.4), we obtain

$$\begin{aligned} &\mu_r - r_f + \mathrm{Cov}\left(-\gamma\left(k + \frac{\big(1+R_f\big)L_0}{\big(1+R_f\big)L_0 + (1-\delta)Y_1 - (1+R_m)M_0} l\right), r\right) + \frac{\sigma_r^2}{2} = 0 \\ \leftrightarrow\ &\mu_r - r_f - \gamma\frac{\big(1+R_f\big)L_0}{\big(1+R_f\big)L_0 + (1-\delta)Y_1 - (1+R_m)M_0}\mathrm{Cov}(l,r) + \frac{\sigma_r^2}{2} = 0 \\ \leftrightarrow\ &\mu_r - r_f - \gamma\frac{\big(1+R_f\big)L_0}{\big(1+R_f\big)L_0 + (1-\delta)Y_1 - (1+R_m)M_0}\mathrm{Cov}\big(r_p,r\big) + \frac{\sigma_r^2}{2} = 0 \\ \leftrightarrow\ &\mu_r - r_f - \alpha\gamma\frac{\big(1+R_f\big)L_0}{\big(1+R_f\big)L_0 + (1-\delta)Y_1 - (1+R_m)M_0}\sigma_r^2 + \frac{\sigma_r^2}{2} = 0 \\ \leftrightarrow\ &\alpha = \frac{\mu_r - r_f + \frac{\sigma_r^2}{2}}{\gamma\frac{\big(1+R_f\big)L_0}{\big(1+R_f\big)L_0 + (1-\delta)Y_1 - (1+R_m)M_0}\sigma_r^2}, \end{aligned}$$

where the third line uses $l = \log(1 + R_p)L_0$ and the fourth line uses $r_p \approx (1 - \alpha)r_f + \alpha r$ (see Campbell and Viceira (2002)).

Appendix B: Definition of Main Variables

1. Survey Question and Response Alternatives on Households' Use of Online Banking

Between 2012–2018, in the Questionnaire Survey on Household Financing Behaviors by the Central Committee on Savings and Public Relations, the households were asked the following question every year.

Question: Why did you open the current bank account as a main transactional account?

Thirteen response alternatives were also prepared for this question, and households were requested to choose a maximum of three.

(a) It is because the current transactional bank branch or ATM is geographically convenient as it is located close to my/our house or office.
(b) It is because the bank branch network is nationally deployed.
(c) It is because the current transactional bank has prepared the most effective Internet or other online banking services among banks.
(d) It is because the bank offers more variety in terms of banking services compared to any other banks.
(e) It is because the bank offers more profitable portfolio investment products compared to those of any other banks.
(f) It is because the bank's service commission fee is lower than that of any other banks.
(g) It is because the bank prepares financial advisory staff for personal clients.
(h) It is because the bank's financial performance is stable and sound.
(i) It is because the bank's staff are eager and aggressively attend to customers.
(j) It is because the bank's impression is good because of TV commercials, posters, and so forth.
(k) It is because the bank's branch opens early in the morning or late at night during weekdays, or opens on either/both Saturday or/and Sunday.
(l) It is because the bank offers more variety in terms of personal loan products compared to any other banks.
(m) Others

2. Survey Question and Response Alternatives on Portfolio Return

In the survey, each household was asked to choose one answer from the following response alternatives and requested to fill out the figures in percentage numbers with an increase/decrease rounded to the nearest whole number.

Question: Did your latest financial asset values increase or decrease, and by how much percentage is the increase or decrease compared to the values as of one year ago?

(a) Increased (b) Decreased (c) Flat

(___.__ percentage in 10s; "Wari" in Japanese) (___.___ percentage in 10s; "Wari" in Japanese)

Following the above question, in the sub-question below, each household was also asked to choose among the following response alternatives. The number of answers that households can choose is unlimited.

Sub-question: for respondents who chose "(a) Increased" in the previous question

(a) Why did your total financial asset values increase?

(i) It is because my/our annual or monthly earnings increased.

(ii) It is because I/we increased the ratio of savings from income.

(iii) It is because I/we obtained dividends or interest revenues.

(iv) It is because I/we obtained extra revenues by selling real estate or house.

(v) It is because I/we obtained extra revenues from succession of property.

(vi) It is because market values of my/our stocks or bonds increased.

(vii) It is because the number of dependent family members decreased.

(viii) Others

Sub-question: for respondents who chose "(b) Decreased" in the previous question

(b) Why did your total financial asset values decrease?

(i) It is because I/we spent down savings.

(ii) It is because of extra household expenditures for real estate or house purchase.

(ii) It is because of extra household expenditures for durable goods purchase.

(iv) It is because of extra household educational expenditures for children.

(v) It is because I/we spent on our travels or other leisure expenditure.

(vi) It is because market values of my/our stocks or bonds decreased.

(vii) It is because the number of dependent family members increased.

(viii) Others

3. Survey Question and Response Alternatives on Financial Literacy

In the Questionnaire Survey on Household Financing Behaviors, households were also asked the following question between 2012–2018.

Question: How do you mainly obtain information which you can utilize for your portfolio investment?

Six response alternatives were also prepared for the question, and households were requested to choose a maximum of three.

(a) Financial Institutions (Branch Tellers, Booklet, Bank HP, etc.)

(b) Finance Professionals (Books, Seminars, TV, etc.)

(c) Seminars held by third neutral parties that have no interests with banks and markets

(d) Conversations with Friends and Family Members

(e) Lectures at University or School Class

(f) Others

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Table 1. Related Literature and the Major Conclusions

Literature	Country/Sample Period/Data Source	Major Conclusions
I. Household Financial Literacy and Portfolio Investment		
Van Rooij et al. (2011)	Netherlands 2005 De Nederlandsche Bank Household Survey	The more (less) financially literate households are more risk-tolerant (risk-averse) in portfolio investments.
Kaustia and Knüpfer (2012)	Finland 1995 January–2002 November Finnish Security Depository Center's Investment Data	When close friends of households are equity market participants, it improves the degree of financial literacy of the households and increases the probability of equity market participation among the households.
Anderson et al. (2017)	United States 2014 January–July LinkedIn 220,000–240,000 Members	Personal misperceptions of own financial literacy are more likely to result in poor investment performances. This is because the misperceptions prevent those households from getting financial advice and this induces misunderstandings of the investment product structures.
Bianchi (2018)	France 2002—2011 Individual personal client data from a major bank	Portfolio returns of the most financially literate household group are higher than those of the least financially literate household group by 0.4 percent. The more financially literate a household is, the higher the degree of risk appetite.
Huang (2019)	United States 1991–1996 Discount brokers' client data	Households that have experienced successful investments in the past are likely to invest in the same industry. However, a high degree of financial literacy prevents such households from investing in the same industry.
Haliassos et al. (2020)	Sweden 1987–2007 LINDA and STATIV	Exposure to financial knowledge promotes savings in private retirement accounts and stockholding when neighbors have been exposed to economics or business education.
II. Mortgage Debt and Portfolio Investment		
Becker and Shabani (2010)	United States, 1989—2004 FRB, Survey of Consumer Finance	Households that pay larger interest payments are passive when participating in the equity market. Household debts and participation in the bond market are also negatively related.
Keys et al. (2016)	United States 2010 December Individual Mortgage Contract Data	A household that does not refinance their mortgage debt under the low interest rate phase loses a significant size of personal savings.
Chetty et al. (2017)	United States 1975—2011 FRB, Survey of Consumer Finance	The increase in home equity values by the decrease in mortgage debt encourages households to participate in the equity market. The increase in home equity values by the increase in home market values does not encourage households to participate in the equity market.
III. Homeownership and Portfolio Investment		
Corradin et al. (2014)	United States, PSID: 1984–2007 SIPP: 1997–2005	The share of household risky assets is lower during periods of expected high growth of house prices.

Vestman (2019)	Sweden 2000—2007 LINDA	Homeowners' equity asset ratios are twice as high as those of home renters. Homeowners' household savings are more than those of home renters.
Ⅳ. Household Income Volatility and Portfolio Investment		
Betermier et al. (2012)	Sweden 1999—2002 Annual Report on Family Income and Expenditure	When a household head experiences job hopping and it causes a decrease in annual income, there is passivity in household portfolio investment.
Roche et al. (2013)	Theoretical Model	When a household head is young, there is poor performance in portfolio investment. This is because the size of financial assets is relatively small compared to those of older generations, and therefore the investment is more likely to be concentrated in one single industry.
Bonaparte et al. (2014)	Netherland 1993—2011 De Nederlandsche Bank Household Survey	A household is more likely to participate in the equity market when the coefficient correlation between the annual earned income growth rate and stock market investment returns decreases.
Donaldson et al. (2019)	Theoretical Model	A household whose debt is guaranteed will face a high probability of future unemployment. This is because the household's guaranteed debt is more likely to increase afterwards, and the household head then has to search for a high-income job in the labor market.
V. Other Determinants of Household Portfolio Investment		
Rydquist et al. (2014)	Canada, Finland, France, Germany, Japan, Sweden, United Kingdom, United States 1945—2010	In countries where tax preferential treatments for public pension benefits are small, households are less likely to invest in the equity market.
Lian et al. (2018)	United States 2016 MTurk: Amazon's Mechanical Turk	Households under a low interest rate economy are more risk tolerant than those under a high interest rate economy.
Mtsurana and Nickerson (2019)	United States Texas Education Agency 2002-2009 DataQuick 2002-2009	Refinancing activity among teachers' peers increases their likelihood of refinancing by 20.7 percent. Peers also affect teachers' choice of lender.
Gianpaolo and Peijnenburg (2019)	Netherlands 2008-2017 Household Survey conducted by CentERdata at Tilburg University	People in the low quintile of noncognitive abilities are 10 times more likely to experience financial distress than those in the top quintile.

Table 2. Summary of Statistics

The table reports a summary of statistics for all variables used in the regression analyses. The definitions of variables can be found in Section 4, Section 5, and the Appendix. The data are the author's calculations based on the "Questionnaire Survey on Household Financing Behaviors 2012–2018" by the Central Committee on Savings and Public Relations, the Bank of Japan.

	Observations		Total	mean	s.d.	max	min
	=1	=0					
Online vs. Branch	2,229	26,391	28,620	0.078	0.268	1	0
Online vs. Non-online	2,229	41,372	43,601	0.051	0.220	1	0
Portfolio Return			12,126	0.005	0.334	30.000	-9.000
Market_Risk			24,612	0.095	0.200	1.000	0.000
Income			38,312	5.753	0.846	11.513	0.000
Assets			24,669	6.423	1.638	11.695	0.000
Payment	28,715	14,886	43,601	0.659	0.474	1	0
Age20s	5,532	38,069	43,601	0.127	0.333	1	0
Age30s	6,592	37,009	43,601	0.151	0.358	1	0
Age40s	7,632	35,969	43,601	0.175	0.380	1	0
Age50s	7,923	35,678	43,601	0.182	0.386	1	0
Age_over60	15,713	27,888	43,601	0.360	0.480	1	0
Literacy_Bank	26,108	17,493	43,601	0.599	0.490	1	0
Literacy_Professional	9,348	34,253	43,601	0.214	0.410	1	0
Literacy_Seminar	3,843	39,758	43,601	0.088	0.284	1	0
Literacy_Friend	12,437	31,164	43,601	0.285	0.452	1	0
Literacy_School	520	43,081	43,601	0.012	0.109	1	0
Agriculture	560	43,041	43,601	0.013	0.113	1	0
Manufacturing	5,630	37,971	43,601	0.129	0.335	1	0
Retail and Wholesale	3,229	40,372	43,601	0.074	0.262	1	0
Public Service	2,930	40,671	43,601	0.067	0.250	1	0
Hokkaido_Totohoku	5,398	38,203	43,601	0.124	0.329	1	0
Kanto	14,465	29,136	43,601	0.332	0.471	1	0
Hokuriku	1,919	41,682	43,601	0.044	0.205	1	0
Chubu	6,052	37,549	43,601	0.139	0.346	1	0
Kinki	6,622	36,979	43,601	0.152	0.359	1	0
Chugoku	2,625	40,976	43,601	0.060	0.238	1	0
Shikoku	1,334	42,267	43,601	0.031	0.172	1	0
Kyushu	5,186	38,415	43,601	0.119	0.324	1	0
Housing	20,458	23,143	43,601	0.469	0.499	1	0
Repayment to Income			19,106	0.111	0.670	60.000	0.000
Mortgage to Income			40,653	0.586	2.658	200.000	0.000
Mortgage			20,513	2.523	3.415	10.463	0.000
Married	17,500	26,101	43,601	0.401	0.490	1	0
Education	17,098	26,503	43,601	0.392	0.488	1	0
Female	34,034	9,567	43,601	0.781	0.414	1	0

Table 3. Determinants of Use of Online Banking and Portfolio Returns

This table reports the results of empirical model (A) which is simultaneously estimated using empirical model (B) by endogenous treatment effects models. Equations (1a)–(4a) correspond to equations (1b)–(4b), respectively. The dependent variable of equations (1a) and (3a) is *Online vs Branch*, while that of equations (2a) and (4a) is *Online vs Non-online.* The dependent variable of equations (1b)–(4b) is *Portfolio Return* which is the annual returns of the portfolio investment. Equations (1a), (1b), (2a), and (2b) are the results of a full sample data set, while equations (3a), (3b), (4a), and (4b) are those of a data set that eliminates upper- and lower-one percent samples of *Portfolio Return.* We estimate separate variance and correlation parameters for each of the control and treatment groups. Each Wald test result of the null hypothesis of no correlation between the treatment-assignment errors and the outcome errors is respectively indicated. The definitions of variables are indicated in Section 4, Section 5, and the Appendix. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Dep. Variable	*Online vs. Branch*	*Portfolio Return*	*Online vs. Non-online*	*Portfolio Return*	*Online vs. Branch*	*Portfolio Return*	*Online vs. Non-online*	*Portfolio Return*
	Full Sample		Full Sample		99 percent Sample		99 percent Sample	
	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)	(4a)	(4b)
Online vs. Branch		0.129 **				0.042 ***		
		(2.010)				(2.970)		
Online vs. Non-online				0.199 **				0.065 ***
				(2.050)				(3.250)
Market Risk		-0.004		-0.012		-0.007		-0.011 **
		(-0.012)		(-0.500)		(-1.190)		(-2.140)
Income	-0.118 ***	0.008 **	-0.070 **	0.009 ***	-0.121 ***	0.006 ***	-0.073 **	0.005 ***
	(-3.410)	(2.140)	(-2.480)	(3.420)	(-3.410)	(4.910)	(-2.530)	(4.800)
Assets	0.142 ***	0.007	0.116 ***	0.005	0.140 ***	-9.6E-05	0.113 ***	-0.001
	(6.970)	(1.370)	(6.630)	(1.330)	(6.630)	(-0.210)	(6.240)	(-1.190)
Mortgage to Income		0.001		0.001 *		3.1E-04		2.1E-04
		(1.230)		(1.700)		(1.370)		(1.350)
Married		0.032		0.025 *		0.004		0.004 **
		(1.370)		(1.830)		(1.550)		(2.330)
Education		0.002		0.007		0.006 ***		0.006 ***
		(0.140)		(0.760)		(4.440)		(4.840)
Payment	0.564 ***		0.486 ***		0.560 ***		0.481 ***	
	(8.900)		(8.300)		(8.620)		(8.010)	
Literacy_Bank	-0.314 ***		-0.184 ***		-0.316 ***		-0.179 ***	
	(-6.690)		(-4.380)		(-6.540)		(-4.140)	
Literacy_Professional	0.112 **		0.111 **		0.117 **		0.117 **	
	(2.210)		(2.440)		(2.240)		(2.500)	

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Literacy_Seminar	0.344 ***		0.252 ***		0.365 ***		0.262 ***	
	(5.280)		(4.390)		(5.440)		(4.430)	
Literacy_Friend	-0.363 ***		-0.244 ***		-0.344 ***		-0.230 ***	
	(-6.690)		(-4.960)		(-6.240)		(-4.600)	
Literacy_School	-0.031		-0.110		-0.119		-0.199	
	(-0.110)		(-0.460)		(-0.390)		(-0.770)	
constant	-2.355 ***	-0.110 **	-2.606 ***	-0.102 ***	-2.311 ***	-0.040 ***	-2.565 ***	-0.035 ***
	(-9.900)	(-2.070)	(-13.030)	(-3.220)	(-9.490)	(-5.430)	(-12.530)	(-5.580)
Age Dummies	Yes		Yes		Yes		Yes	
Regional Dummies	Yes		Yes		Yes		Yes	
Occupation Dummies		Yes		Yes		Yes		Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations		7,662		11,274		7,471		10,945
Wald test of Indep. (rho0=rho1=0): chi2		7.750 **		8.590 **		8.800 **		13.750 ***

Table 4. Online Users vs. Branch Visitors: Portfolio Returns and Risk Appetite

This table reports the results of empirical model (B) which is simultaneously estimated using empirical model (A) by endogenous treatment effects models. The dependent variable *Portfolio Return* is the annual returns of the portfolio investment. In these estimations, we employ the intersected independent variables of *treatment dummy* and *Market Risk* and allow the parameters of *Market Risk* to vary over treatment level in each estimation. Empirical results of model (C) for equations (1)–(2) in Table 4 respectively correspond to equations (1a)–(2a) in Table 3. Equations (1) and (2) are the results of a full sample data set of *Portfolio Return.* Equations (3) and (4) employ *Market Risk,* which is defined as equities plus investment, and trust assets plus foreign currency denominated assets divided by total assets of households, as a dependent variable. Empirical results of model (C) for equations (3)–(4) also correspond to equations (1a)–(2a) in Table 3. For equations (1)–(4), we estimate separate variance and correlation parameters for each of the control and treatment groups. Each Wald test result of the null hypothesis of no correlation between the treatment-assignment errors and the outcome errors is respectively indicated. The definitions of variables are indicated in Section 4, Section 5, and the Appendix. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Dep. Variable	*Portfolio Return*	*Portfolio Return*	*Market Risk*	*Market Risk*
	(1)	(2)	(3)	(4)
	Full Sample	Full Sample	Full Sample	Full Sample
Online vs. Branch	0.055		0.140 ***	
	(0.730)		(9.630)	
Market Risk				
Online vs. Branch=0	-0.035			
	(-0.930)			
Online vs. Branch=1	0.148 **			
	(2.150)			
Online vs. Non-online		0.100		0.333 ***
		(0.850)		(30.680)
Market Risk				
Online vs. Non-online=0		-0.031		
		(-1.180)		
Online vs. Non-online=1		0.148 **		
		(2.090)		
Income	0.003	0.009 ***	0.007 ***	0.008 ***
	(0.200)	(3.510)	(2.880)	(3.770)
Assets	0.007	0.005	0.022 ***	0.022 ***
	(1.350)	(1.310)	(18.550)	(21.510)
Mortgage to Income	0.001	0.001	5.0E-04	4.3E-04
	(1.100)	(1.620)	(1.310)	(1.600)
Married	0.033	0.026 *	0.044 ***	0.052 ***
	(1.410)	(1.880)	(9.740)	(14.710)
Education	0.003	0.007	0.022 ***	0.023 ***
	(0.200)	(0.800)	(6.980)	(8.500)
constant	-0.109 **	-0.101 ***	-0.149 ***	-0.156 ***
	(-2.040)	(-3.210)	(-9.870)	(-12.640)
Occupation Dummies	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes
Observations	7,662	11,274	15,779	23,100
Wald test of Indep. (rho0=rho1=0): chi2	7.640 **	8.680 ***	7.890 ***	213.590 ***
ATE (*Treatment Dummy*=1 vs. 0)	0.075 **	0.122 **		
	(2.030)	(2.091)		
ATET (*Treatment Dummy*=1 vs. 0)	0.104 ***	0.212 **		
	(2.644)	(2.321)		

Table 5. Online Users vs. Branch Visitors: Debt Repayment and Risk Appetite

This table reports the results of empirical model (D) which is simultaneously estimated using empirical model (C) by endogenous treatment effects models. We employ the intersected independent variables of *treatment dummy* and *Repayment to Income* and allow the parameters of *Repayment to Income* to vary over treatment level in these estimations. Empirical results of model (C) for equations (1)–(4) in Table 5 respectively correspond to equations (1a)–(4a) in Table 3. For equations (1)–(4), we estimate separate variance and correlation parameters for each of the control and treatment groups. Each Wald test result of the null hypothesis of no correlation between the treatment-assignment errors and the outcome errors is respectively indicated. The definitions of variables are indicated in Section 4, Section 5, and the Appendix. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Dep. Variable	*Market Risk* (1) Full Sample	*Market Risk* (2) Full Sample	*Market Risk* (3) 99 percent Sample	*Market Risk* (4) 99 percent Sample
Online vs. Branch	0.226 ***		0.215 ***	
	(5.000)		(5.300)	
Online vs. Non-online		0.337 ***		0.275 ***
		(27.600)		(17.790)
Repayment to Income				
Repayment to Income				
Online vs. Branch =0	0.004		0.004	
	(0.930)		(1.040)	
Online vs. Branch =1	0.116 ***		0.093 ***	
	(3.520)		(3.070)	
Repayment to Income				
Online vs. Non-online =0		0.002		0.002
		(1.540)		(1.590)
Online vs. Non-online =1		0.133 ***		0.105 ***
		(3.710)		(3.590)
Income	0.015 ***	0.018 ***	0.020 ***	0.023 ***
	(7.890)	(11.650)	(12.630)	(19.770)
Assets	0.015 ***	0.018 ***	0.020 ***	0.023 ***
	(7.890)	(11.650)	(12.630)	(19.770)
Married	0.039 ***	0.055 ***	0.041 ***	0.054 ***
	(6.310)	(10.920)	(7.440)	(12.530)
Education	0.018 ***	0.025 ***	0.016 ***	0.024 ***
	(3.520)	(5.890)	(3.530)	(6.360)
constant	-0.102 ***	-0.119	-0.130 ***	-0.146 ***
	(-8.150)	(-11.710)	(-12.820)	(-18.080)
Occupation Dummies	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes
Observations	6,086	9,722	6,025	9,612
Wald test of Indep. (rho0=rho1=0): chi2	19.840 ***	220.470 ***	19.440 ***	86.190 ***
ATE (*Treatment Dummy* =1 vs. 0)	0.241 ***	0.354 ***	0.227 ***	0.283 ***
	(5.250)	(2.975)	(5.349)	(18.066)
ATET (*Treatment Dummy* =1 vs. 0)	0.235 ***	0.347 ***	0.222 ***	0.283 ***
	(5.150)	(2.992)	(5.423)	(18.214)

Table 6. Online Users vs. Branch Visitors: Debt Repayment

This table reports the results of empirical tests of the relationship between household debt repayment and use of online banking. Two empirical models are simultaneously estimated by endogenous treatment effects models. The first equation is the same as model (C) in which the dependent variable is *Online vs. Branch,* and the second dependent variable is *Repayment to Income*. Equation (1) and (2) are estimated by using household samples that have at least non-zero mortgage loan outstanding. Equation (3) and (4) are estimated by using household samples that have at least non-zero mortgage loan outstanding and household chiefs are active salaried workers of age 20s or 30s or 40s or 50s. Covariance and variance matrix corresponding to the parameter estimates are estimated by Huber/White/sandwich estimator for equation (1) and (3). Equation (2) and (4) are estimated by two-step estimation. Empirical results of model (C) for equations (1) and (2) in Table 6 respectively correspond to equations (1a) and (2a) in Table 3. The definitions of variables are indicated in Section 4, Section 5, and the Appendix. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Dep. Variable	*Repayment to Income* (1)	*Repayment to Income* (2)	*Repayment to Income* (3)	*Repayment to Income* (4)
	Household Samples that have Mortgage Loans	Household Samples that have Mortgage Loans	Samples of Active Workers that have Mortgage Loans	Samples of Active Workers that have Mortgage Loans
Online vs. Branch	0.457 ***		0.427 ***	
	(7.150)		(6.360)	
Online vs. Non-online		0.703 ***		0.505 **
		(3.000)		(2.090)
Mortgage	0.043 ***	0.038 ***	0.028 ***	0.030 ***
	(8.790)	(4.200)	(10.450)	(5.720)
Married	0.065 **	0.148 ***	0.008	0.095 ***
	(2.100)	(4.600)	(0.290)	(2.860)
Education	-0.020 **	-0.044 **	-0.022 **	-0.044 **
	(-2.060)	(-2.420)	(-2.340)	(-2.240)
constant	-0.111 ***	-0.067	-0.015	-0.014
	(-3.020)	(-1.000)	(-0.620)	(-0.320)
Occupation Dummies	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes
Observations	2,740	3,883	2,362	3,464
Wald test of Indep. (rho0=0): chi2	35.430 ***		33.550 ***	
Hazard (lambda)		-0.345 ***		-0.255 **
		(-3.180)		(-2.240)

Table 7. Online Users vs. Branch Visitors: Debt Outstanding and Risk Appetite

This table reports the results of empirical model (D) which is simultaneously estimated using empirical model (C) by endogenous treatment effects models. We employ the intersected independent variables of *treatment dummy* and *Mortgage* and allow the parameter of *Mortgage* to vary over treatment level in these estimations. Empirical results of model (C) for equations (1)–(4) in Table 7 respectively correspond to equations (1a) and (2a) in Table 3. Equation (1) and (2) are estimated by using household samples that have at least non-zero mortgage loan outstanding. Equation (3) and (4) are estimated by using household samples that have at least non-zero mortgage loan outstanding and household chiefs are active salaried workers of age 20s or 30s or 40s or 50s. We indicate 90% confidence interval for each parameter of *Online vs. Branch* =0 and *Online vs. Branch* =1, and *Online vs. Non-online*=0 and *Online vs. Non-online*=1 to show that each pair of the two parameters varying over treatment level are significantly different. Covariance and variance matrix corresponding to the parameter estimates are estimated by Huber/White/sandwich estimator for equations (1)–(4). The definitions of variables are indicated in Section 4, Section 5, and the Appendix. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Dep. Variable	*Market Risk*		*Market Risk*		*Market Risk*		*Market Risk*	
	(1)	90% Conf. Interval	(2)	90% Conf. Interval	(3)	90% Conf. Interval	(4)	90% Conf. Interval
	Household Samples that have Mortgage Loans		Household Samples that have Mortgage Loans		Samples of Active Workers that have Mortgage Loans		Samples of Active Workers that have Mortgage Loans	
Online vs. Branch	0.346 ***				0.361 ***			
	(11.370)				(4.060)			
Online vs. Non-online			0.403 ***				0.373 ***	
			(18.950)				(11.350)	
Mortgage								
Online vs. Branch =0	-0.002 ***	-0.003 ~			0.001	-0.001 ~		
	(-3.010)	-0.001			(0.840)	0.002		
Online vs. Branch =1	-0.010 **	-0.016 ~			-0.008 *	-0.016 ~		
	(-2.580)	-0.004			(-1.770)	-0.006		
Mortgage								
Online vs. Non-online =0			-0.002 ***	-0.002 ~			0.001	-4.7E-04 ~
			(-3.130)	-0.001			(0.900)	0.002
Online vs. Non-online =1			-0.009 ***	-0.016 ~			-0.008 *	-0.015 ~
			(-6.750)	-0.003			(-1.640)	-1.2E-04

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Income	0.007 *	0.009 ***	0.024 ***	0.020 ***
	(1.770)	(2.760)	(3.780)	(3.920)
Assets	0.018 ***	0.020 ***	0.004	0.012 ***
	(8.990)	(11.750)	(1.230)	(4.510)
Married	0.049 ***	0.056 ***	0.082 ***	0.077 ***
	(4.520)	(6.840)	(5.040)	(6.710)
Education	0.024 ***	0.028 ***	0.022 ***	0.024 ***
	(5.710)	(7.630)	(4.110)	(5.080)
constant	-0.105 ***	-0.127 ***	-0.170 ***	-0.177 ***
	(-4.780)	(-6.750)	(-4.650)	(-6.000)
Occupation Dummies	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes
Observations	9,401	12,701	4,209	5,901
Wald test of Indep. (rho0=0): chi2	29.770 ***	135.110 ***	5.780 *	41.210 ***
ATE (*Treatment Dummy* =1 vs. 0)	0.326 ***	0.383 ***	0.321 ***	0.335 ***
	(12.535)	(25.594)	(3.689)	(15.911)
ATET (*Treatment Dummy* =1 vs. 0)	0.320 ***	0.378 ***	0.322 ***	0.336 ***
	(12.664)	(25.278)	(3.688)	(15.795)

Table 8. Online Users vs. Branch Visitors: Homeownership and Risk Appetite

This table reports the results of empirical model (D) which is simultaneously estimated using empirical model (C) by endogenous treatment effects models. We employ the intersected independent variables of *treatment dummy* and *Housing* and allow the parameter of *Housing* to vary over treatment level in these estimations. Empirical results of model (C) for equations (1)–(4) in Table 8 respectively correspond to equations (1a) and (2a) in Table 3. Equation (1) and (2) are estimated by using full sample data. Equation (3) and (4) are estimated by using household samples that household chiefs are active salaried workers of age 20s or 30s or 40s or 50s. We indicate 90% confidence interval for each pair of parameters of *Online vs. Branch* =0 and *Online vs. Branch* =1, and *Online vs. Non-online*=0 and *Online vs. Non-online*=1 to show that each pair of the two parameters varying over treatment level are significantly different. Covariance and variance matrix corresponding to the parameter estimates are estimated by Huber/White/sandwich estimator for equations (1) and (2). The definitions of variables are indicated in Section 4, Section 5, and the Appendix. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Dep. Variable	*Market Risk* (1)		*Market Risk* (2)		*Market Risk* (3)		*Market Risk* (4)	
	Full Sample	90% Conf. Interval	Full Sample	90% Conf. Interval	Samples of Active Workers that have Mortgage Loans	90% Conf. Interval	Samples of Active Workers that have Mortgage Loans	90% Conf. Interval
Online vs. Branch	0.140 ***				0.155 ***			
	(8.140)				(7.430)			
Online vs. Non-online			0.323 ***				0.302 ***	
			(27.560)				(16.270)	
Housing								
Online vs. Branch =0	0.019 ***	0.014 ~			0.007 *	1.1E-04 ~		
	(5.630)	0.025			(1.670)	0.014		
Online vs. Branch =1	0.049 ***	0.028 ~			0.036 *	0.002 ~		
	(2.950)	0.077			(1.720)	0.070		
Housing								
Online vs. Non-online =0			0.016 ***	0.011 ~			0.005	-0.001 ~
			(5.230)	0.021			(1.450)	0.012
Online vs. Non-online =1			0.057 ***	0.028 ~			0.040 *	0.006 ~
			(3.290)	0.085			(1.910)	0.075
Income	0.007 ***		0.008 ***		0.011 **		0.013 ***	
	(2.840)		(3.770)		(2.330)		(3.450)	
Assets	0.020 ***		0.021 ***		0.014 ***		0.014 ***	
	(16.930)		(20.370)		(6.940)		(8.880)	

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Married	0.057 ***	0.063 ***	0.060 ***	0.066 ***
	(11.850)	(16.270)	(8.940)	(12.580)
Education	0.022 ***	0.023 ***	0.026 ***	0.028 ***
	(6.990)	(8.580)	(6.320)	(7.820)
constant	-0.156 ***	-0.164 ***	-0.149 ***	-0.164 ***
	(-10.490)	(-13.380)	(-5.680)	(-8.090)
Occupation Dummies	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes
Observations	15,779	23,100	7,743	11,789
Wald test of Indep. (rho0=0): chi2	7.910 ***	219.950 ***	7.350 ***	77.110 ***
ATE (*Treatment Dummy*=1 vs. 0)	0.158 ***	0.345 ***	0.170 ***	0.319 ***
	(9.230)	(29.700)	(8.621)	(18.277)
ATET (*Treatment Dummy*=1 vs. 0)	0.148 ***	0.333 ***	0.163 ***	0.312 ***
	(8.990)	(31.174)	(8.320)	(18.053)