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Article abstract

Will the widespread use of cashless payments reduce the frequency of the use of cash payments? This question is important because the major costs of cash use are fixed costs that would only be reduced if the frequency of cash payments substantially decreased, and thus the extent of the reduction of the cost of cash use depends on the frequency of cash use after the widespread use of cashless payment methods. Using the data from the Financial Literacy Survey 2019 in Japan, this paper shows that the frequency of cash use for those who use both cash and noncash payment methods and that of those who exclusively use cash are about once in 2.3 days and about once in 2 days, respectively, and thus there is only a slight difference. The result did not change even if a regression model for cash usage was used that considers the endogenous choice of payment methods or if counterfactual simulations of the decrease in consumers' willingness to use cash were conducted. The results suggest that the benefit of reducing the cost of cash use due to the widespread use of cashless payment methods is overestimated because the frequency of the use of cash payments is unlikely to decrease despite the use of cashless payment methods.

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Will The Widespread Use of Cashless Payments Reduce the Frequency of the Use of Cash Payments?

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Will the widespread use of cashless payments reduce the frequency of the use of cash payments? This question is important because the major costs of cash use are fixed costs that would only be reduced if the frequency of cash payments substantially decreased, and thus the extent of the reduction of the cost of cash use depends on the frequency of cash use after the widespread use of cashless payment methods. Using the data from the Financial Literacy Survey 2019 in Japan, this paper shows that the frequency of cash use for those who use both cash and noncash payment methods and that of those who exclusively use cash are about once in 2.3 days and about once in 2 days, respectively, and thus there is only a slight difference. The result did not change even if a regression model for cash usage was used that considers the endogenous choice of payment methods or if counterfactual simulations of the decrease in consumers' willingness to use cash were conducted. The results suggest that the benefit of reducing the cost of cash use due to the widespread use of cashless payment methods is overestimated because the frequency of the use of cash payments is unlikely to decrease despite the use of cashless payment methods.

Keywords: Cash demand, costs of cash usage, payment methods
JEL Classifications: D12; D14; E41; G51; G53

1 Introduction

Reducing the costs of cash use is often cited as one of the benefits of the widespread use of cashless payment methods in addition to the other important benefit that consumers can enjoy a variety of payment methods, such as contactless payments or payments based on applications on a mobile phone. The private costs spent to use cash are estimated to be 0.12% of the GDP in Germany (Cabinakova *et al.*, 2019), 0.45% of the GDP in Canada (Kosse *et al.*, 2017), 0.60%

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of the GDP in Uruguay (Álvez *et al.*, 2019), and 0.29% of the GDP, or 1.6 Trillion JPY, in Japan (Nomura Research Institute, Ltd., 2018). In the case of Japan, among the 1.6 Trillion JPY, the largest breakdown of costs is 500 billion JPY in personnel costs for cash management at stores, 412 billion JPY in ATM equipment and installation costs, 146 billion JPY in ATM business operating expenses, 140 billion JPY in ATM security company outsourcing costs, and 100 billion JPY in counter personnel costs for cash-related operations.

Policies that promote cashless payments in Japan that would be beneficial in reducing the costs of cash use focus on subsidizing the use of cashless payment methods. For example, the Japanese government's Point Reward Project for Consumers Using Cashless Payment subsidized cashless payments in some registered retail shops from October 1, 2019, to June 30, 2020.[1] Increasing the cost of using cash would also promote cashless payments. For example, Japanese commercial banks are reducing the number of ATMs; however, the total number of ATMs increased from 2009 to 2019 because the increase in the number of ATMs in convenience stores exceeded the decrease in the number of ATMs in Japanese commercial banks. Therefore, the increase in the cost of using ATMs seems to have a limited impact on cash users.

To help implement policies to promote cashless payments and to reap the benefit of reducing the cost of cash use, many researchers have examined the question: Will the spread of cashless payments reduce the frequency of cash payments? Such studies have included data from Canada (Payments Canada, 2018), the Netherlands (Jonker *et al*., 2018), and Switzerland (Brown *et al.*, 2020). Note that the costs of installing ATMs and keeping cash registers in stores, which explain the largest and the second-largest breakdown of the cost of cash use, respectively, are fixed costs that can only be saved if the amount of cash in circulation becomes close to zero. Thus, answering this question is important to determine the extent to which a nation could reap the benefit of reducing the costs of cash use; however, few studies have examined the question in Japan due to the limitation of data. An exception is Wakamori (2020), who used the data from Macro Mill for November 2018 and October 2019 to show a decrease in the frequency of cash use (from 60% to 50%) and an increase in the frequency of Quick Response (QR)-cord payment use (from 0% to 7%) in the choice of household payment methods.

To fill this research gap, this paper explores the question: Will the widespread use of cashless payments, such as credit cards, contactless prepaid cards, and mobile payments via smartphone applications, reduce the frequency of the use of cash payments? To this end, data were collected from the Financial Literacy Survey (the FLS 2019) that was administered from March 1, 2019, to March 20, 2019, to 25,000 individuals aged 18–79 years in Japan, which

[1] Under the Point Reward Project for Consumers Using Cashless Payments, the registered retail shops received a 75% subsidy for the costs of introducing new registers and terminals that accepted cashless payments, and the registered shops enjoyed the upper limit of the merchant fee at 3.25% (with a 1.08% government subsidy until June 30, 2020).

contains a question regarding the frequency of the use of payment methods (almost every day, once a week, once a month, rarely or never, no adoption). The FLS data show that the frequency of cash use for those who use both cash and noncash payment methods is about once in 2.3 days and about once in two days for those who use cash exclusively. Therefore, there is only a slight difference between the frequency of cash use for those who use both cash and noncash payment methods and that of those who exclusively use cash. The result did not change even if a model that considers the endogenous choice of payment methods was used for the analysis. Two counterfactual simulations were also conducted to examine the potential factors that could promote cashless payments, the decrease in the consumers' willingness to use cash and the increase in the cost of ATM usage based on the unique data from the FLS 2019; however, the effect of these changes on the frequency of cash usage is also slight. Overall, the results show that the benefit of reducing the cost of cash use due to the widespread use of cashless payment methods is overestimated because the frequency of cash payments is unlikely to decrease despite the use of cashless payment methods.

This paper relates to the estimation of the social costs of using cash and other payment methods. Recent examples in Germany (Cabinakova *et al*., 2019) and Canada (Kosse *et al*., 2017) and summaries of the methodology and literature are provided by Hayashi and Keeton (2012) and Krüger and Seitz (2014). This paper focuses on the possible changes in consumers' choices of payment methods due to the decrease in the willingness to use cash, including the possible increase in the cost of using ATMs and its effect on the frequency of cash use. This paper also relates to the literature on cash demand and the choice of payment methods in Japan and abroad.[2] This study is unique in that the new data on the frequency of cash use obtained from the FLS 2019 were used.

The limitations of the study are as follows. First, the results are based on the FLS 2019 conducted in March 2019, which does not cover the effects of the spread of COVID-19 on cash usage or the Japanese government's Point Reward Project for Consumers Using Cashless Payments, which subsidized cashless payments from October 1, 2019, to June 30, 2020, and increased the usage of QR-code payments. Second, we could not estimate the cash demand function due to a lack of data on the outstanding amount of cash holdings. Finally, we could not distinguish between cash usage based on transaction values or payment contexts (e.g., day-to-day payments, regular payments, or hoarding) due to a lack of data.

[2] Japanese studies include Fujiki and Tanaka (2018a, 2018b) or Fujiki (2020a), but these studies do not examine cash usage based on the number of cash transactions per day. Studies in foreign economies include Esselink and Hernández (2017) for the Eurozone; Trütsch (2020), Hayashi and Toh (2020), Greene et al. (2017), Koulayev et al. (2016), Schuh and Briglevics (2014), Schuh and Stavins (2010), and Borzekowski et al. (2008) for the US; Henry et al. (2018), Wakamori and Welte (2017), and Chen et al. (2017) for Canada; Jonker et al. (2018) for the Netherlands; and Brown et al. (2020) for Switzerland.

The remainder of the paper is organized as follows. Section 2 discusses the data, and Section 3 explains the methodology. Section 4 reports the results of the estimation. Section 5 concludes.

2 Data

The FLS 2019 is a web survey that was administered from March 1, 2019, to March 20, 2019, to 25,000 individuals aged 18–79 years in Japan. Variables on the use of payment methods, financial literacy, financial behavior, and other demographic variables from the FLS were constructed as follows.

2.1 Use of payment methods

For the variables regarding the use of payment methods, Question 45 on the FLS for 25,000 individuals was used: "How often do you use the following payment methods: credit cards, debit cards, electronic money, mobile payments using smartphones, or cash? Choose only one answer from the following options: 1. Almost every day, 2. About once a week, 3. About once a month, 4. Scarcely or never, 5. Do not adopt it." For this question, mobile payments using smartphones could be prepaid or post-paid, QR-code based, or mobile wallets for credit cards, debit cards, and electronic money. Cash includes checks. Note that electronic money refers to Japanese prepaid cards.

Regarding the willingness to use noncash payment methods, Question 46 on the FLS was used for the 24,516 sub-sample for those who responded "Scarcely or never" or "Do not adopt it" for a credit card, and/or debit card, and/or electronic money, and/or smartphone payments: "Under what conditions will you use those payment methods? Choose up to three answers from the following options: 1. Generous rewards programs, 2. Increase in the cost of using cash (Increase in the ATM charge, Decrease in the number of ATMs), 3. Wide acceptance by merchants, 4. Shorter time for settlement, 5. Flexible reloading of electronic money, 6. Safer information security, 7. Some tools that reduce the possibility of overuse, 8. Universal payment methods among merchants that do not require consumers to select particular payment methods for each merchant, 9. Other, and 10. I am satisfied with cash payments and do not plan to use other payment methods."

Based on Question 46, the FLS regards those who responded "Scarcely or never" or "Do not adopt it" in Question 45 as nonusers of noncash payment methods. Hence, it is assumed that the users of each payment method include those who replied, "Almost every day," "About once a week," and "About once a month" to Question 45. Moreover, we are interested in the substitution from cash to noncash payment methods due to changes in the opportunity costs of

using cash, and we focus on cash users. Unfortunately, about 30% of respondents did not reply regarding their financial asset holdings, and about 20% did not reply regarding their annual pretax incomes. Thus, we dropped these households from the analysis. Among the 24,516 respondents, we focused on 14,977 cash users.

2.2.1. Combination of the use of payment methods

In this subsection, we explain the combination of the use of noncash payment methods. The third to fifth columns of Table 1 show the combination of the use of payment methods by 14,977 cash users shown in the first column who replied to Question 46. It was found that these cash users chose 15 combinations of four noncash payment methods, as shown in the first column. The second column shows the payment methods that the users of the payment methods in the first column do not use. Specifically, the third column shows that 36% of respondents are credit card (hereafter *C*) and electronic money (hereafter *E*) users, 23% uses *C*, 12% uses *C*, *E*, and mobile payments using smartphones (hereafter *S*), 10% does not use four noncash payment methods (namely, they use cash only, hereafter *None*), and 7% uses *E*. The remaining 10 combinations of choices consisted of below 7% of total observations (or below 1,000 observations) and did not provide enough degrees of freedom for the later regression analyses that contained about 50 independent variables. The use of debit cards is rare, as only 3% uses *C*, *E*, and debit cards (hereafter *D*), and we do not analyze the choice of *D*. The focus is the 13,218 sample of the top five combinations of users of four noncash payment methods listed in the sixth to eighth columns in Table 1: *CE*, *C*, *CES*, *None* (cash only), and *E*.

Table 1 Use of payment methods by cash users

Using	Not using	Proportion (%)	Cumlative proportion (%)	Observations	Proportion (%)	Cumlative proportion (%)	Observations
CE	DS	36.3	36.3	5,430	41.1	41.1	5,430
C	EDS	23.4	59.7	3,512	26.6	67.7	3,512
CES	D	11.6	71.3	1,737	13.1	80.8	1,737
None(cash only)	CEDS	10.1	81.4	1,510	11.4	92.2	1,510
E	CDS	6.9	88.3	1,029	7.8	100.0	1,029
CED	S	3.0	91.3	450			
CS	ED	3.0	94.2	444			
ES	CD	1.5	95.7	224			
CD	ES	1.1	96.9	170			
DE	CS	1.0	97.8	148			
S	CED	0.7	98.5	105			
D	CES	0.7	99.2	102			
EDS	C	0.4	99.7	67			
CDS	E	0.3	99.9	38			
DS	CE	0.1	100.0	11			
Total		100.0		14,977	100.0		13,218

2.1.2. Number of transactions made using a specific payment method per day

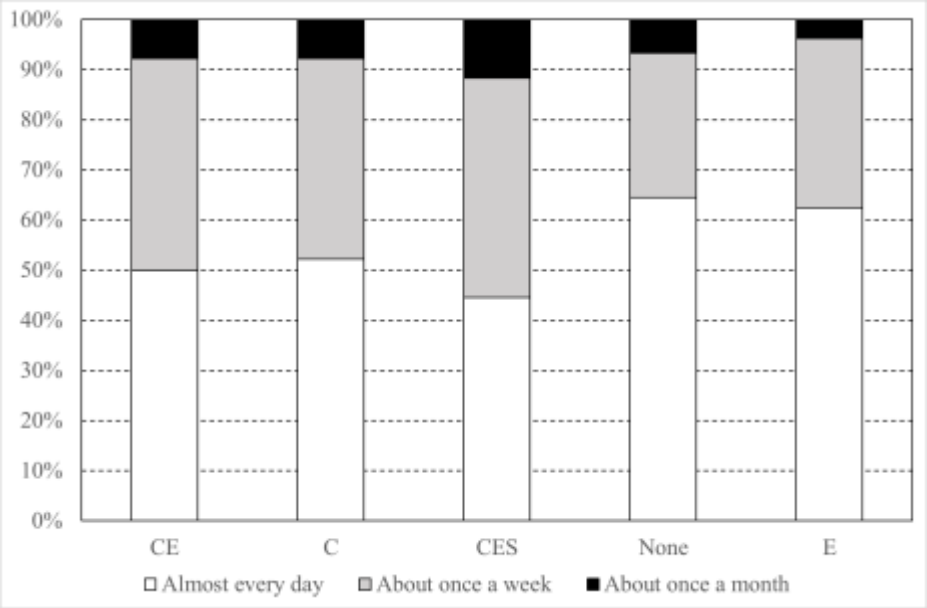
Second, the number of transactions made by a specific payment method per day was measured using Question 45 as follows. We assigned the value of (1/2) to 1 time, (1/14) to (1/7) times, (1/60) to (1/30) times, 0 to (1/60) times, and 0 times for those who replied, "Almost every day," "About once a week," "About once a month," "Scarcely or never," and "Do not adopt it," respectively. We assigned these values because if a respondent stated that s/he uses a payment instrument almost every day (or every week or every month) and does not use the payment instrument on a given day (week or month), it was assumed that s/he is likely to use it on the following day (week or month), and thus the expected number of transactions made by this payment instrument within a day (week or month) is from 1/2 time to 1 time (1/14 to 1/7 times a day or 1/60 to 1/30 times a day). We constructed the variables representing the number of transactions per day made by the payment instrument y, where y = *Cash*, *Credit*, *Emoney*, *Debit*, and *Smartphone*. We assumed that the values of y take 3/4 times, 3/28 times, 1/40 times, 1/120 times, and 0 times for those who replied, "Almost every day," "About once a week," "About once a month," "Scarcely or never," and "Do not adopt it," respectively. Note that in the analysis of cash users, we focus on the respondents who replied "Almost every day," "About once a week," and "About once a month" for the use of cash. The mean values of y are reported in the third to seventh rows of Table 2. The first row shows the choice of the top five preferred payment methods, and the second row shows the payment methods not used for each choice of payment method for the sake of reference. The second column reports the average number of transactions per day of the overall sample, and it shows that *Cash* = 0.44, *Credit* = 0.13, *Debit* = 0.00, *Emoney* = 0.11, and *Smartphone* = 0.02.

Depending on the use of payment methods, the average number of cash transactions per day differs. *Cash* for *None* and *E* take values of 0.52 and 0.51, respectively, which are higher than the overall average value of 0.44; however, based on the ratio of cash users who chose "Almost every day," "About once a week," and "About once a month" for the choice of the top five preferred payment methods in Figure 1, even for those who chose *CE*, *C*, or *CES*, about 90% chose either "Almost every day" or "About once a week," which is similar to those who chose *None* and *E*. Thus, the data show that regardless of the use of noncash payment methods, the majority of cash users uses cash at least once a week. This means that the use of noncash payment methods does not necessarily indicate a less frequent use of cash by cash users. Sections 3 and 4 will examine whether the same tendency would be observed even if we adjusted the demographic background of respondents and possible self-selection bias arising from the endogenous choice of payment methods.

Table 2 Means of control variables

Using Not using	Oveall	*CE* *DS*	*C* *EDS*	*CES* *D*	*None* *CEDS*	*E* *CDS*
Cash	0.438	0.421	0.437	0.384	0.517	0.505
Credit	0.134	0.164	0.149	0.205	0.004	0.004
Debit	0.002	0.002	0.002	0.003	0.001	0.002
Emoney	0.124	0.181	0.003	0.253	0.003	0.199
Smartphone	0.023	0.004	0.003	0.150	0.002	0.003
Satisfied with cash	0.204	0.142	0.224	0.146	0.432	0.229
ATM	0.127	0.138	0.131	0.108	0.104	0.123
Reward	0.453	0.467	0.435	0.590	0.307	0.423
Acceptance	0.250	0.278	0.248	0.268	0.155	0.217
Speed	0.089	0.088	0.091	0.080	0.075	0.121
Reload	0.152	0.175	0.136	0.163	0.084	0.162
Security	0.192	0.233	0.212	0.056	0.143	0.214
Restraint	0.105	0.099	0.111	0.077	0.109	0.155
Standard	0.183	0.223	0.169	0.177	0.093	0.164
Other_factor_only	0.040	0.047	0.032	0.043	0.039	0.034
Objective_financial_literacy	7.255	7.952	7.072	7.805	5.269	6.192
Fraud1	0.062	0.050	0.055	0.077	0.081	0.090
Debt	0.335	0.337	0.321	0.463	0.261	0.267
News	2.396	2.590	2.287	2.714	1.825	2.041
S_dont_know	0.046	0.043	0.046	0.040	0.052	0.067
S_fin_inst	0.419	0.471	0.403	0.440	0.281	0.366
S_exclude_fin_inst	0.224	0.245	0.215	0.299	0.136	0.152
Over_confidence	-5.684	-6.283	-5.523	-6.006	-4.070	-4.897
Impatience	2.130	2.014	2.237	2.033	2.362	2.206
Reputation	1.580	1.528	1.609	1.651	1.621	1.571
Self_control	2.970	2.943	3.000	2.912	3.017	3.035
Risk_aversion1	0.746	0.732	0.772	0.632	0.830	0.800
Risk_aversion2	0.904	0.897	0.909	0.906	0.911	0.914
Income	5.171	5.708	4.899	6.199	3.575	3.876
Asset	7.596	8.955	7.815	7.242	4.261	5.169
Age	50.633	52.329	53.474	43.973	48.392	46.520
Edu	14.207	14.486	14.024	14.689	13.407	13.719
Male	0.524	0.501	0.514	0.632	0.523	0.494
Private	0.357	0.373	0.314	0.538	0.274	0.242
Public	0.036	0.043	0.029	0.053	0.019	0.018
Teacher	0.015	0.017	0.015	0.016	0.008	0.009
Selfemployed	0.066	0.059	0.083	0.064	0.063	0.054
Parttime	0.142	0.143	0.136	0.122	0.152	0.175
House	0.184	0.195	0.208	0.104	0.185	0.182
Student	0.045	0.024	0.017	0.037	0.107	0.169
Hokkaido	0.046	0.047	0.048	0.029	0.055	0.052
Tohoku	0.068	0.067	0.066	0.062	0.070	0.087
Hokuriku	0.039	0.028	0.055	0.041	0.046	0.031
Chubu	0.140	0.134	0.164	0.124	0.140	0.120
Kinki	0.161	0.145	0.199	0.143	0.172	0.124
Chugoku	0.057	0.056	0.053	0.060	0.058	0.063
Shikoku	0.031	0.028	0.030	0.028	0.045	0.035
Kyushu	0.111	0.099	0.118	0.112	0.145	0.101

Figure 1 Frequency of cash usage based on the choice of the top five preferred payment methods



Sources: Author's calculation.

Regarding the average number of transactions per day for noncash payment methods, *Credit* for those who use *CES*, *CE*, and *CE* takes the values of 0.21, 0.16, and 0.15, respectively, which are higher than the overall average value of 0.13. *Emoney* for those who use *CES*, *E*, and *CE* takes the values of 0.25, 0.20, and 0.18, respectively, which are higher than the overall average value of 0.12. *Smartphone* for those who use *CES* takes the value of 0.15, which is higher than the overall average value of 0.02.

One might be interested in the respondents who replied "Scarcely or never" or "Do not adopt it" for cash, although they are not included in the analysis thus far. If these respondents use noncash payment methods very frequently, it would be expected that the prevalence of noncash payment methods would indicate very little cash usage. An examination of the data showed that 607 respondents chose "Do not adopt it" for cash. Among them, 381 (or 63%) responded "Do not adopt it" for all other payment instruments, and only 82 (or 14%) responded "Almost every day" or "About once a week" for a credit card. These 82 respondents tended to have lower incomes, lower financial asset holdings, a lower age, and a lower level of financial literacy and tended to be male compared with the overall average reported in Table 2. A total of 416 respondents chose "Scarcely or never" for cash, and among them, 199 (or 48%) responded "Almost every day" or "About once a week" for a credit card. These 199 respondents might serve as a good approximation of cash usage under the frequent use of

noncash payment methods. These respondents tended to have higher incomes, higher financial asset holdings, and a lower age and were more likely to be male; however, due to the small number of respondents in this group, we could not include them in the later regression analyses that contained about 50 independent variables. Thus, we approximated the impact of the widespread use of noncash payment methods on the frequency of cash usage by comparing the exclusive cash users and cash users who also use noncash payment methods in the analysis.

2.1.3. Willingness to use cash and conditions for using noncash payment methods

Third, we measured the willingness to use cash based on Question 46. First, among the 13,218 samples, 2,701 (or 20% of the sample) respondents exclusively chose 10 ("I am satisfied with cash payments and do not plan to use the other payment methods"). We created a dummy variable, *Satisfied with cash*, that takes a value of 1 for these respondents and otherwise zero. If no one replied to this question affirmatively, the satisfaction regarding cash usage is so low that everyone would adopt noncash payment methods. Second, we grouped 1,679 (13%) respondents who chose 2 (Increase in the cost of using cash [Increase in the ATM charge, decrease in the number of ATMs]) because these respondents are willing to use cash if the costs of using ATMs are sufficiently low compared with the cost of using other noncash payment methods. We created a dummy variable, *ATM*, which takes a value of one for these respondents and otherwise zero to determine the willingness to use cash given the current costs of using ATMs. If no one replied to this question affirmatively, the costs of using ATMs are too high, and everyone would use noncash payment methods.

We developed eight dummy variables to determine the conditions under which a household would be willing to use other noncash payment methods that had not been adopted. Note that these questions ask about the future use of noncash payment methods conditional on the current use of noncash payment methods and are not directly related to the current frequency of cash usage. The following eight dummy variables take a value of 1 for the respondents who chose the eight options in Question 46 and otherwise zero: *Reward* for those who selected "Generous rewards programs," *Acceptance* for those who selected "Wide acceptance by merchants," *Speed* for those who selected "Shorter time for settlement," *Reload* for those who selected "Flexible reloading to electronic money," *Security* for those who selected "Safer information security," *Restraint* for those who selected "Some tools that reduce the possibility of overuse," *Standard* for those who selected "Universal payment methods among merchants that do not require consumers to select particular payment methods for each merchant," and *Other_factors_only* for those who selected "Other." Note that the variable names *Acceptance*, *Security*, and *Restraint* follow the names of the dummy variables that represent the underlying needs that are satisfied by the consumers' chosen payment methods, as demonstrated by Borzekowski *et al.* (2008). Note also that *Satisfied with cash* and *Other factors only* are exclusively chosen; however, the respondents who selected *ATM* could choose other variables—*Reward*,

Acceptance, *Speed*, *Reload*, *Security*, *Restraint,* and *Standard*—because the respondents could choose up to three answers.

The average values of *Satisfied with cash*, *ATM*, *Reward*, *Acceptance*, *Speed*, *Reload, Security*, *Restraint*, *Standard*, and *Other factors only* according to the use of payment methods are reported in the eighth to seventeenth rows in Table 2. Observe that as many as 45% of respondents chose *Reward*, which reflects tough competition between payment methods through a discount program or a reward program. Twenty-five percent of respondents choose *Acceptance*, which suggests that the wide acceptance by merchants would also increase the use of noncash payment methods. The average values differ substantially across the use of payment methods. For example, the average value of *Satisfied with cash* for *None* takes a value of 0.43, which is substantially higher than the average value of 0.20. The average value of *Satisfied with cash* for *C* and *E* takes values of 0.22 and 0.23, respectively. This means that 22% of *C* do not plan to use electronic money, debit card, or mobile payments via smartphone applications and that 23% of *E* do not plan to use credit cards, electronic money, debit card, or mobile payments via smartphone applications because they are satisfied with cash payments. The average value of *Satisfied with cash* for the users of *CE* and *CES* takes values of 0.14 and 0.15, respectively, which are lower than the values for *None*, *C*, and *E*. The results suggest that satisfaction with cash payments tends to be one of the reasons for the non-adoption of noncash payment methods when the person adopts fewer kinds of payment methods. Note also that the values of *None* (exclusively cash users) for *Reward*, *Acceptance*, *Speed*, *Reload*, *Security*, and *Standard* are also smaller than the average values, which suggests that it is difficult to encourage the use of cashless payments for the users of *None*.

2.2. Financial literacy[3]

We followed Sekita et al. (2018) in using a proxy for objective financial literacy. *Objective financial literacy* is defined as the number of correct answers to 12 questions on five categories of financial literacy: two questions on the compound interest rate, two questions on the diversification of risk in stock investments, two questions on life insurance products, four questions on mortgage payments and the relationship between interest rates and bond prices, and two questions on inflation. We discuss the details of the 12 questions in the Appendix. We followed Kadoya and Khan (2020) in using the experience of financial troubles, such as bank transfer fraud or multiple debts (*Fraud1*). We add to the work of Sekita *et al.* (2018) and Kadoya and Kahn (2020) via the dummy variables of debt holdings (*Debt*). The means of *Objective financial literacy*, *Fraud1*, and *Debt* based on the use of payment methods are reported in the eighteenth to twentieth rows in Table 2. The means of *Objective financial literacy* for the users

[3] Sections 2.2 and 2.3 are heavily based on Fujiki (2020b) and Fujiki (2020c).

of *CE* and *CES* take higher values compared with the overall means, and the means of those for the users of *None* take lower values compared with overall means.

As a proxy of information sources, the frequency of obtaining information on financial and economic conditions from mass media (*News*) was examined.4 The means of *News* in the twenty-first row for the users of *CE* and *CES* take higher values compared with the overall means, and the means of those for the users of *None* take lower values compared with the overall means.

We also used dummy variables indicating the source for obtaining knowledge and information when selecting financial products from Question 35 of the FLS (See details on Question 35 in the Appendix). We first created a dummy variable that takes a value of 1 for respondents who do not invest in financial products (*S_do_not_choose*) and a dummy variable that takes a value of 1 for respondents who were not sure what opportunities would allow them to acquire such knowledge or information (*S_do_not_know*). Second, we created dummy variable *S_fin_inst* for respondents who chose at least one of the following information sources that are related to financial institutions: sales staff at financial institutions, pamphlets provided at financial institutions, lecture meetings or seminars, financial professionals/professional financial advisors, and schools. Finally, we created a dummy variable *S_exclude_fin_inst* that takes a value of 1 for respondents who chose at least one information source—mass media, websites, and conversations with family members or friends—but did not choose the information sources included in *S_fin_inst*. Respondents take a value of 1 for *S_exclude_fin_inst* who use family and friends, mass media, and websites as their information sources but do not use formal information sources, such as financial institutions or financial experts. In the remaining regression analysis, we use *S_do_not_choose* as the base case. The mean values of *S_fin_inst* and *S_exclude_fin_inst* in the twenty-third and twenty-fourth rows for the users of *CES* and *CE* take higher values than the average value. Overall, the users of *None* and *E* are less financially literate compared with users of noncash payment methods.

2.3. Financial behavior

We followed Sekita *et al.* (2018) and used six variables that capture financial behavior from the perspective of behavioral economics (see Beshears *et al*., 2018, for literature on behavioral household finance). *Over-confidence* captures one's over-confidence regarding financial literacy through the difference between one's subjective financial literacy (self-evaluation of one's level of financial literacy in comparison to other people) and *Objective financial literacy*.

[4] News is based on Question 53 of the FLS: "How often do you get financial and economic information through newspapers, magazines, TV, and the Internet?" Choose one answer from the following options: 1. Almost every day; 2. About once a week; 3. About once a month; 4. Less than once a month; and 5. Never. News takes values of 4, 3, 2, 1, and 0 for a respondent who chooses options 1 through 5, respectively.

Impatience captures the present-biased preferences in which one places extra value on more immediate awards. It is based on the following question: "If I had the choice of (1) receiving 100,000 yen now or (2) receiving 110,000 yen in 1 year, I would choose (1), provided that I can definitely receive the money. Choose from a scale of 1 to 5 where 1 means 'agree', and 5 means 'disagree.'" *Impatience* is defined as the difference between 5 and the answer to this question, so that a higher value corresponds to a respondent with a higher time preference and thus impatience, assuming that the safe interest rate remains about zero in the Japanese economy. *Reputation* is a proxy variable that shows whether a person considers reputation in making financial decisions. It is based on the following question: "When there are several similar products, I tend to buy what is recommended as the best-selling product rather than what I actually think is a good product." *Self-control* is a proxy of the degree to which a person makes deliberate and thoughtful decisions. It is based on the following question: "Before I buy something, I carefully consider whether I can afford it."

We created two proxy variables for risk aversion. *Risk aversion 1* is a dummy variable that takes a value of 1 for a person who says "no" to the question "If you invested 100,000 yen, you would either get a capital gain of 20,000 yen or a capital loss of 10,000 yen at 50% probability." *Risk aversion 2* is a proxy value for the extent to which a person is reluctant to take a risk on an investment. It is based on the following question: "I am prepared to take a risk when saving or making an investment."

The means of these variables based on the use of payment methods are reported in the twenty-fifth to thirtieth rows in Table 2. The users of *None* seem to be less overconfident compared with users of noncash payment methods.

2.4. Demographic variables

We constructed the following demographic variables. We first constructed a variable indicating household annual pretax income (*Income*). Because the FLS asks about household annual pretax income (in units of million yen) by ranges (zero, below 2.5, 2.5–5, 5–7.5, 7.5–10, 10–15, 15 over, no response, or do not know), we assigned the values of 0, 1.25, 3.75, 6.25, 8.75, 12.5, and 15 for those who chose zero, below 2.5, 2.5–5, 5–7.5, 7.5–10, 10–15, and 15 and over, respectively. We constructed a variable indicating the household total financial asset holdings (*Asset*). Because the FLS asks about household total financial asset holdings (in units of million yen) by ranges (zero, below 2.5, 2.5–5, 5–7.5, 7.5–10, 10–20, 20 over, no response, or do not know), we assigned the values of 0, 1.25, 3.75, 6.25, 8.75, 15, and 20 for those who chose zero, below 2.5, 2.5–5, 5–7.5, 7.5–10, 10–20, and 20 and over, respectively. We constructed a variable indicating the ages of respondents (*Age*). Because the FLS asks for the ages of respondents by ranges (below 20, 20–24, 25–29, 30–34, 35–39, 40–44, 45–49, 50–54, 55–59, 60–64, 65–69, 70–74, and 74–79), we assigned the values of 19, 22, 27, 32, 37, 42, 47, 52, 57, 62, 67, 72, and 77 for those who chose below 20, 20–24, 25–29, 30–34, 35–39, 40–44, 45–49,

50–54, 55–59, 60–64, 65–69, 70–74, and 75–79, respectively. We constructed a variable indicating years of education (*Edu*). Because the FLS asks about educational attainment via the choice of below senior high, senior high, vocational college, junior college, university, graduate school, and others, we assigned the values 9, 12, 13, 14, 16, and 18 for those who chose below senior high, senior high, vocational college, junior college, university, and graduate school, respectively. We dropped the observations of those who chose "others."

We also constructed the following dummy variables. They include dummy variables indicating the gender of respondents (*Male* = 1 for men), the employment status of respondents (*Private* company, *Public* company, *Teacher*, *Self-employed*, *Part-time*, *House* [stay-at-home mum/dad], *Student, No Job and Other Job,* where the base case is the sum of *No Job* and *Other Job*), and nine areas of residence (*Hokkaido*, *Tohoku*, *Hokuriku*, *Kanto*, *Chubu*, *Kinki*, *Chugoku*, *Shikoku*, and *Kyushu*, and the base case is *Kanto* region). The means of these variables based on the use of payment methods are reported in the thirty-first to fiftieth rows in Table 2. Regarding the differences in the average values among the use of payment methods, users of *None* and *E* tended to have a lower *income*, a lower *Asset*, and shorter years of education. The users of *None* and *E* included many students. The users of *CES* tended to have a higher income and longer years of education, to be young, and to be male. This suggests that one should consider possible differences in demographic characteristics among users of a particular combination of payment methods.

3 Methodology

In Section 4, we approximate the impact of the widespread use of noncash payment methods on the frequency of cash usage by comparing exclusive cash users and cash users who also use noncash payment methods. In doing so, we note that the choice of payment methods is an endogenous decision made by the respondents. Thus, we began by examining whether the choice of payment methods is affected by the respondents' demographic characteristics. We then examined cash transactions per day conditional on the use of noncash payment methods using the ordinary least square (OLS) regression. We also used Heckman's (1979) model when the endogenous choice of payment methods should be considered in estimating cash transactions per day conditional on the use of noncash payment methods. We used the predicted value of cash transactions per day conditional on the use of noncash payment methods to examine whether the frequency of cash use was similar for those who use both cash and noncash payment methods and those who exclusively use cash. Finally, we conducted counterfactual simulations to examine whether the decrease in consumers' willingness to use cash and the resulting changes in the choice of payment methods would reduce cash usage.

First, to examine whether the choice of payment methods is affected by the respondents' demographic characteristics, we estimated a multinomial logit model to explain the respondents' use of the top five preferred payment methods conditional on the vector of

conditioning variables *X* explained in the previous section: financial literacy, financial behavior, demographic variables, two dummy variables for the willingness to use cash—*Satisfied with cash* and *ATM*—and a vector *Z* that contains the variable asking under which conditions the household would be willing to use the other noncash payment methods that they have not adopted: *Reward*, A*cceptance*, *Speed*, *Reload*, *Security*, *Restraint*, *Standard*, and *Other_factor_only*. We assumed that the multinomial logit model would approximate a household's choice of noncash payment methods. Assume that an indirect utility function V_{ijt} of a respondent *i* conditional on the choice of noncash payment methods *j* = *CE*, *C*, *CES*, *None*, and *E* at time *t* is approximated by the following linear function:

$$V_{ijt} = X_{ijt}\delta 1_j + Z_{ijt}\delta 2_j + \nu_{ijt}, j = CE, C, CES, None, and\ E \quad (1)$$

where $\delta 1_j$ and $\delta 2_j$ are the vector of parameters, and ν_{ijt} are unobservable preferences for payment method *j* of respondent *i*. If the respondent i at a time t (in our case, 2019) chooses the noncash payment method *k* instead of *l*, it means that $V_{ikt} > V_{ilt}, k \neq l$. Let ν_{ijt} follow an independent extreme value distribution whose cumulative distribution function is exp(–exp(–v_j)) for each noncash payment choice *j*. Under these assumptions, the choice of a noncash payment method follows a multinomial logit model, where the probability of the choice of a noncash payment method *j* for respondent *i* at time *t*, P_{ijt}, depends on X_{ijt} and Z_{ijt} in equation (1) after normalizing the parameter value for choice *None* to zero. Therefore, the estimation of a multinomial logit model of equation (2) is as follows:

$$D_{ijt} = X_{ijt}\delta 1_j + Z_{ijt}\delta 2_j + \nu_{ijt}, j = CE, C, CES, None, \text{and } E \quad (2)$$

where D_{ikt} is an indicator variable that takes a value of 1, 2, …, 5 if the choice of a noncash payment method *k* for respondent *i* is *CE*, *C*, *CES*, *None*, or *E*, respectively. The mlogit command of Stata 16 was used to estimate the model. Standard errors in the following analysis were adjusted to an intragroup correlation within the clusters formed by gender, age group, and prefectures because the respondents of the FLS were selected from the people registered with an internet survey company by the weight of gender, six age groups, and 47 prefectures (2*6*47 = 564 clusters) based on the Japanese census.

Second, we estimated the conditional mean value of *Cash* using two methods. First, we used the ordinary least square (OLS) regression. Because the variables in *Z* ask about the future use of noncash payment methods and are not directly related to the frequency of current cash usage, we regressed *Cash* on *X* but not on *Z*. We estimated the following equation (3) for each choice of noncash payment method *j*:

$$Cash_{ijt} = X_{ijt}\beta_j + \epsilon_{ijt}, j = CE, C, CES, None\ and\ E \quad (3)$$

where β_j is a vector of parameters, and ε_{ijt} are error terms of respondent *i* who selects payment method *j*. The reg command of Stata 16 was used to estimate the model.

We also estimated a model by Heckman (1979) to correct possible self-selection bias from the choice of payment method following Schuh and Stavins (2010):

$$Cash_{ijt} = X_{ijt}\beta_j + \epsilon_{1ijt}, j = CE, C, CES, , None\ and\ E \quad (4)$$

$Cash_{ijt}$ is observed for j-th choice if $Z_{ijt}\gamma 1_j + X_{ijt}\gamma 2_j + \epsilon_{2ijt} > 0$,

$$\epsilon_{1ijt} \sim N(0, \sigma^2), \epsilon_{2ijt} \sim N(0,1), \text{and } corr(\epsilon_{1ijt}, \epsilon_{2ijt}) = \rho$$

Because the variables in *Z* ask about the future use of noncash payment methods conditional on the current use of noncash payment methods and are not directly related to the frequency of current cash usage, we use *Z* only for the second equation; a probit equation was used for self-selection only. The Heckman command of Stata 16 was used to estimate the model using the maximum likelihood method.

Finally, using the estimates of the multinomial logit model, equation (2), we first simulated the effects of the decrease in the values of *Satisfied with cash* and *ATM* on the use of noncash payment methods measured by the changes in P_{ijt}. We then used the estimates of OLS regression, equation (3), to simulate the effects of the decrease in the values of *Satisfied with cash* and *ATM* on the conditional mean value of *Cash*. To cope with the possible self-selection problem, we also used the conditional cash demand function, equation (4), to simulate the changes in the conditional mean value of *Cash*. This methodology could be criticized because the choice of the values of *Satisfied with cash* and *ATM* is endogenous; however, we assumed that these two variables reflect the preference for the willingness to use cash and that the exogenous changes in these two variables would approximate preference shocks for the willingness to use cash.

4 Results

4.1 Results of the multinomial regression on the use of noncash payment methods

Table 3 reports the results of the marginal effects computed from the parameter estimates of a multinomial logit model equation (2). *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The baseline case corresponding to the constant term is a respondent who does not select financial products by themselves, who has no experience with financial trouble, who does not have debt, whose value of *Risk aversion*1 is zero, whose gender is female, whose occupation is other occupation, and who is living in the Kanto area. In Table 3, the first row shows the top five preferred payment methods, and the second row shows the

payment options that were not chosen by the users of the top five preferred payment methods. We focused on the statistically significant estimates of the marginal effects reported in Table 3.

Regarding the variables related to the willingness to use cash, the third row shows that *Satisfied with cash* is positively associated with the use of *None* and *E* and negatively associated with the use of *CE* and *CES*, as expected. The fourth row shows that *ATM* is positively associated with the use of *None. ATM* is negatively associated with *CES* because these people would use ATMs rarely and would be insensitive to the increase in the cost of using ATMs. Taken together, we anticipated that the decrease in the willingness to use cash as expressed by the decrease in the value of *Satisfied with cash* and *ATM* would reduce the use of *None* and *E* (except for *ATM*) and would increase the number of users of *CES* and *CE* (except for *ATM*).

Regarding the eight variables contained in vector *Z* reported in the fifth to twelfth rows, the users of *None* are negatively associated with *Reload* and *Standard* and positively associated with *Security* and *Restraint.* The users of *E* are positively associated with *Speed, Reload*, *Security,* and *Restraint.* The users of *E* are concerned about the *Speed* and convenience of reloading, while the users of *None* are not. The users of *C* are negatively associated with *Reload*, *Standard*, and *Other factors only* and positively associated with *Security.* These users seem to value the benefit of security but do not value the speed of electronic money or are not interested in widely accepted mobile payments. The users of *CE* are negatively associated with *Restraint* and positively associated with *Acceptance*, *Reload*, *Security*, *Standard*, and *Other factors only.* These users seem to be prepared to use mobile payments if safe and widely accepted applications are available. The users of *CES* are negatively associated with *Acceptance*, *Speed*, *Security*, and *Restraint.* These users seem to be unprepared to use debit cards in the future.

Regarding the variables related to financial literacy, *Objective financial literacy* is negatively associated with the use of *None* and *E* and positively associated with the use of *CE* and *CES*. This is a reasonable result because the use of electronic money is easy enough for a less financially literate person or students because it does not involve credit from the providers of the electronic money and has the upper limit of the daily usage; however, the use of credit cards in Japan is restricted to above age 18 with a certain level of annual income. *Fraud1* is negatively associated with the use of *CE* and *C* and positively associated with the use of *None*, *E*, and *CES*. *News* is negatively associated with the use of *C* and *None* and positively associated with the use of *CES* and *CE*. It also shows that users of *None* tend to be negatively associated with *S_fin_inst* and *S_exclude_fin_inst* and that the users of *CES* tend to be positively associated with these variables. Overall, the users of *None* and *E* are less financially literate compared with users of noncash payment methods.

Table 3 Use of payment methods (Marginal effects, Equation [2])

Using Not using	*CE* *DS*	*C* *EDS*	*CES* *D*	*None* *CEDS*	*E* *CDS*
Satisfied with cash	-0.072***	0.02	-0.042***	0.078***	0.016*
ATM	-0.004	0.009	-0.042***	0.028***	0.008
Reward	-0.01	0.007	0.009	-0.008	0.002
Acceptance	0.021**	0.009	-0.012*	-0.011	-0.007
Speed	-0.007	0.004	-0.035***	0.009	0.03***
Reload	0.038***	-0.028**	-0.003	-0.024**	0.017**
Security	0.06***	0.041***	-0.151***	0.024***	0.025***
Restraint	-0.037**	0.019	-0.038***	0.031***	0.024***
Standard	0.043***	-0.028***	0.007	-0.027***	0.005
Other_factor_only	0.063***	-0.064***	-0.004	0.012	-0.006
Objective_financial_literacy	0.011**	-0.002	0.02***	-0.019***	-0.009***
Fraud1	-0.052***	-0.033**	0.024**	0.026***	0.035***
Debt	0.009	0.011	0.027***	-0.029***	-0.018***
News	0.009**	-0.015***	0.011***	-0.004**	-0.001
S_dont_know	0.016	-0.011	0.006	-0.019*	0.008
S_fin_inst	0.013	-0.026***	0.032***	-0.015**	-0.004
S_exclude_fin_inst	0.016	0.001	0.022**	-0.021**	-0.018**
Over_confidence	-0.002	0.003	0.016***	-0.01***	-0.007***
Impatience	-0.008***	0.005**	0.001	0.002	0
Reputation	-0.01**	0.007*	0.003	0.002	-0.002
Self_control	-0.012***	0.01***	-0.008***	0.006**	0.003
Risk_aversion1	0.006	0.002	-0.019***	0.005	0.005
Risk_aversion2	-0.016	0.004	0.029***	-0.018**	0.002
Income	0.005***	-0.004***	0.006***	-0.005***	-0.001
Asset	0.003***	0.002***	-0.001	-0.003***	-0.001**
Age	0.002***	0.002***	-0.004***	0	0
Edu	0.018***	-0.003*	0.003*	-0.011***	-0.007***
Male	-0.088***	0.018*	0.011	0.042***	0.017***
Private	0.07***	-0.053***	0.033***	-0.029***	-0.021**
Public	0.11***	-0.059**	0.013	-0.037*	-0.028
Teacher	0.056	-0.021	-0.003	-0.022	-0.009
Selfemployed	-0.001	0.008	0.038**	-0.031**	-0.014
Parttime	0.041**	-0.061***	0.024	-0.016	0.012
House	0.018	-0.022	-0.003	0.001	0.005
Student	0.048*	-0.186***	-0.014	0.057***	0.095***
Hokkaido	-0.022	0.054***	-0.059***	0.03*	-0.003
Tohoku	-0.045**	0.039**	-0.015	0.016	0.005
Hokuriku	-0.158***	0.144***	0.004	0.036***	-0.027**
Chubu	-0.072***	0.098***	-0.032***	0.026***	-0.021***
Kinki	-0.088***	0.113***	-0.022**	0.028***	-0.032***
Chugoku	-0.059***	0.029*	0.005	0.026*	-0.001
Shikoku	-0.088***	0.043	-0.016	0.059***	0.003
Kyushu	-0.085***	0.064***	-0.001	0.043***	-0.021***
N	13,218				
Pseudo-R2	0.109				
Wald chi2(172)	6758.99***				
Actual proportion	0.411	0.266	0.131	0.114	0.078
Predicted proportion	0.411	0.266	0.131	0.114	0.078
Proportion at Satisfied with cash = 0	0.427	0.265	0.141	0.091	0.076
Proportion at ATM = 0	0.411	0.264	0.137	0.111	0.077

Note for tables 3-4: *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

The variables related to financial behavior show that the users of *CES* are positively associated with *Overconfidence* and *Risk aversion2* and negatively associated with *Risk aversion1* and *Self-control*. In contrast, users of *None* are negatively associated with *Overconfidence* and *Risk aversion2* and positively associated with *Self-control*. Negative association with *Overconfidence* suggests that while the users of *None* are less financially literate, they understand their low level of financial literacy and behave in financially conservative ways. For example, their positive association with *Self-control* could mean that they avoid using noncash payment methods so they do not overspend The users of *C* are positively correlated with *Impatience*, *Self-control*, and *Reputation.* In contrast, the users of *CE* are negatively associated with *Impatience*, *Self-control*, and *Reputation.* Finally, the users of *E* are negatively associated with *Overconfidence.*

Regarding the demographic variables *Income*, *Assets, Age*, and *Edu*, the users of *CE* tend to have a higher income, a higher amount of financial assets, a higher age, and long years of schooling, while the users of *C* tend to have a lower income, a higher amount of financial assets, a higher age, and shorter years of schooling. The users of *CES* tend to have a higher income, a lower age, and longer years of schooling, while the users of *None* tend to have a lower income, a lower amount of financial assets, and shorter years of schooling. The users of *E* tend to be associated with a lower amount of financial assets and shorter years of schooling.

Regarding the results for gender, the users of *C*, *None*, and *E* are positively associated with *Male*, and the users of *CE* are negatively associated with *Male*.

Regarding the results for the dummy variables for occupations, the users of *CE* are positively associated with *Private*, *Public*, *Part-time*, and *Students*, and in contrast, the users of *C* are negatively associated with *Private*, *Public*, *Part-time*, and *Students*. The users of *CES* are positively associated with *Private* and *Self-employed*. The users of *None* are negatively associated with *Private*, *Pubic,* and *Self-employed* and positively associated with *Students.* The users of *E* are negatively associated with *Private* and positively associated with *Students.*

Finally, the results for regional dummies show that the users of *C* and *None* tend to live in the non-Kanto area (the base case, most high-density populated area in Japan), and the users of *CE*, *CES*, and *E* tend to be negatively associated with the non-Kanto area because shops that accept electronic money and mobile payments are located more often in highly populated areas.

The actual and forecasted proportion of the payment method chosen by equation (2) is reported in the forty-ninth and fiftieth rows. Equation (2) was effective in forecasting the proportion of the payment methods chosen by the respondent.

The results of forecasting the proportion of the payment methods chosen by setting the value of *Satisfied with cash* and *ATM* to zero to examine the effect of a declining willingness to use cash by respondents are reported in the fifty-first and fifty-second rows. The reduction in the

value of *Satisfied with cash* reduces the proportion of users of *C*, *None,* and *E* and increases the proportion of users of *CE* and *CES*, as expected. The reduction in the value of *ATM* reduces the proportion of the users of *C*, *None,* and *E* and increases the proportion of the users of *CES* slightly, as expected. Regarding the potential effects on the adoption of noncash payment methods by people exclusively using cash, the proportion of respondents using *None* (11.4% of the sample) would decrease by 2.3% point and 0.3% point if all households replied negatively to *Satisfied with cash* and *ATM*, respectively. These results suggest that the decrease in the willingness to use cash does not lead to a substantial decrease in the proportion of respondents exclusively using cash.

4.2 Results of the regressions on the frequency of cash usage conditional on the use of noncash payment methods

Table 4 reports the parameter estimates of equation (3) by the OLS for the top five combinations of the use of payment methods.

First, the third and fourth rows show that *Satisfied with cash* is positively correlated with *Cash* for the users of *CE*, *C*, *CES*, and *None*, and *ATM* is positively correlated with *Cash* for the users of *CE* and *CES.* These users would reduce the frequency of cash use if the willingness of using cash decreased as expressed by the decrease in the values of *Satisfied with cash* and *ATM*.

Second, *Objective financial literacy* is negatively correlated with *Cash* for the users of *CE. News* is positively associated with *Cash* for the users of *CE* and *C*. Third, for the users of *CE*, *Cash* is negatively associated with *Overconfidence. Impatience* is positively correlated with *Cash* for most cases except for the use of *CES*, which suggests that impatient people tend to use cash more frequently regardless of the choice of noncash payment methods except for the use of *CES*. *Reputation* is positively correlated with *Cash* for the users of *None* and *E*. *Risk aversion2* is negatively associated with *Cash* for the users of *C* and *None*.

Fourth, regarding the demographic variables, *Cash* is negatively correlated with *Asset* for the users of *CE*. *Cash* is positively correlated with *Income* and *Age* and negatively correlated with *Asset* for the users of *C*. *Cash* is positively correlated with *Age* and *Edu* for the users of *None*. *Cash* is negatively correlated with *Age* for the users of *E*.

Fifth, regarding occupations, *Cash* is positively correlated with *Private* for all users, positively correlated with *Public* for the users of *C* and *CES*, positively correlated with *Self-employed* for the users of *CES* and *None*, positively correlated with *Part-time* and *Students* for the users of *CE, C, CES,* and *None*, and positively correlated with *House* for the users of *CES* and *None.*

Table 4 Estimates of the conditional frequency of cash usage (Equation [3])

Using Not using	*CE* *DS*	*C* *EDS*	*CES* *D*	*None* *CEDS*	*E* *CDS*
Satisfied with cash	0.071***	0.046***	0.074***	0.050***	0.016
ATM	0.055***	0.021	0.088***	0.010	-0.018
Objective_financial_literacy	-0.016***	-0.011	-0.015	-0.003	0.005
Fraud1	0.019	0.037	0.025	0.021	0.052
Debt	0.008	0.006	0.006	0.017	0.015
News	0.012***	0.010**	0.006	0.003	0.010
S_dont_know	-0.014	0.031	-0.059	0.053	-0.034
S_fin_inst	0.006	0.039***	0.038	0.026	-0.002
S_exclude_fin_inst	-0.042***	-0.009	-0.010	-0.018	-0.041
Over_confidence	-0.019***	-0.008	-0.014	-0.011	-0.003
Impatience	0.008***	0.011***	0.008	0.015***	0.012**
Reputation	0.003	-0.004	-0.002	0.018**	0.016*
Self_control	-0.005	0.000	-0.009	0.002	0.005
Risk_aversion1	-0.001	0.005	0.024	0.016	-0.019
Risk_aversion2	-0.017	-0.036*	-0.021	-0.061**	0.006
Income	0.002	0.005**	0.003	0.002	0.003
Asset	-0.002***	-0.003***	-0.002	-0.003	-0.002
Age	0.000	0.002***	0.001	0.002***	-0.002***
Edu	0.000	0.003	-0.006	0.010**	-0.002
Male	-0.003	-0.012	-0.043*	-0.020	-0.011
Private	0.041**	0.067***	0.109***	0.130***	0.079**
Public	0.037	0.098**	0.085*	-0.039	0.074
Teacher	0.018	0.020	-0.010	-0.123	0.077
Selfemployed	0.031	0.019	0.088*	0.111***	0.055
Parttime	0.060***	0.038*	0.099**	0.108***	0.063
House	0.014	0.013	0.084**	0.062**	0.006
Student	0.156***	0.101**	0.136***	0.124***	0.059
Hokkaido	-0.058**	-0.040	-0.011	-0.087**	-0.117**
Tohoku	-0.066***	-0.047*	-0.053	-0.021	-0.015
Hokuriku	-0.005	-0.017	-0.006	-0.011	0.071
Chubu	-0.076***	-0.055***	-0.025	-0.028	-0.026
Kinki	0.025*	0.021	0.045*	0.021	0.080***
Chugoku	-0.006	0.001	-0.001	-0.002	-0.018
Shikoku	-0.006	0.034	-0.047	0.020	-0.041
Kyushu	0.031*	0.047**	0.059**	0.010	0.011
Constant	0.359***	0.263***	0.342***	0.130	0.475***
N	5,430	3,512	1,737	1,510	1,029
F test statistics	8.38***	4.58***	3.12***	4.27***	2.69***
Actual cash	0.421	0.437	0.384	0.517	0.505
Predicted cash	0.421	0.437	0.384	0.517	0.505
Standard errors of prediction	0.005	0.006	0.008	0.008	0.009
Cash at Satisfied with cash = 0	0.411	0.426	0.373	0.495	0.501
Cash at ATM = 0	0.414	0.434	0.375	0.516	0.507

Finally, regarding regions, people living in the *Kinki* and *Kyusyu* areas tend to use *Cash* more frequently compared with the *Kanto* area (the base case, most high-density populated area in Japan).

Using the parameter estimates reported in Table 4, we forecasted the average number of cash transactions per day conditional on the choice of the combinations of the use of noncash payment methods, which is reported in the fortieth row labeled *Predicted cash*. Compared with the actual value of average *Cash* reported in the forty-fourth row labeled *Actual cash*, the models predicted the cash transaction per day accurately. This means that even after controlling for the heterogeneity of respondents by regression, the average frequency of the cash use of exclusively cash users (0.517) is close to those of both cash and noncash payment method users (a range from 0.384 to 0.505).

We also calibrated the model to estimate the average number of cash transactions per day under a decrease in the willingness to use cash by setting the values of *Satisfied with cash* and *ATM* to 0 for all respondents, which is reported in the forty-second and forty-third rows labeled *Cash at satisfied with cash* = 0 and *Cash at ATM* = 0, respectively. The reduction in the value of *Satisfied with cash* and *ATM* reduced the average predicted value of *Cash* only slightly, at most by 0.01 times a day, except for the users of *E* for *Cash at ATM* = 0, as anticipated.

4.3 Results of Heckman's (1979) model on the frequency of cash usage conditional on the use of noncash payment methods

The parameter estimates of equation (4) are reported in Tables 5 and 6. Specifically, Table 5 reports the parameter estimates of the conditional cash demand equation shown in the first line of equation (4), and Table 6 reports the marginal effects computed from the parameter estimates of the probit selection equation shown in the second line of equation (4). The results of the conditional cash demand equation in Table 5 are similar to the results reported in Table 4, except for the users of *CES*, which makes the parameter estimates of *News*, *Debt*, *S_fin_inst*, *Impatience, Self-control, Income*, *Asset*, and *Age* statistically significant and the parameter estimates of *Male* not statistically significant.

The forty-first row labeled as Predicted cash shows that the average predicted values of *Cash* for the users of *CE* and *CES* are 0.511 and 0.619, respectively, which are higher than the corresponding average predicted values made by OLS, 0.421 and 0.437, respectively. Moreover, the average predicted value of *Cash* for the users of *CES* in the forty-first row takes a small value of 0.091 and is not statistically different from zero based on its standard error (0.063), reported in the forty-second row. It was found that 262 of the 1,737 (or 15%) predicted *Cash* values for the users of *CES* took negative values, which is inconsistent with the assumption that *Cash* must be greater than or equal to zero. Thus, we did not use the results from the Heckman model for the use of *CES.*

Table 5 Estimates of the conditional frequency of cash usage (Equation [4])

Using Not using	*CE* *DS*	*C* *EDS*	*CES* *D*	*None* *CEDS*	*E* *CDS*
Satisfied with cash	0.091***	0.045***	0.041*	0.074***	0.016
ATM	0.057***	0.015	0.055*	0.019	-0.017
Objective_financial_literacy	-0.018***	-0.010	0.005	-0.009	0.004
Fraud1	0.030	0.051**	0.041	0.029	0.054
Debt	0.006	0.001	0.032*	0.009	0.014
News	0.011***	0.015***	0.016**	0.002	0.009
S_dont_know	-0.019	0.032	-0.054	0.047	-0.034
S_fin_inst	0.001	0.046***	0.059**	0.022	-0.003
S_exclude_fin_inst	-0.045***	-0.010	0.009	-0.025	-0.041
Over_confidence	-0.018***	-0.009	0.002	-0.015*	-0.003
Impatience	0.010***	0.009***	0.009*	0.016***	0.012**
Reputation	0.005	-0.006	0.002	0.018**	0.016*
Self_control	-0.003	-0.005	-0.017**	0.004	0.005
Risk_aversion1	-0.004	0.001	0.009	0.018	-0.019
Risk_aversion2	-0.015	-0.038**	0.002	-0.067**	0.006
Income	0.001	0.007***	0.007**	0.001	0.003
Asset	-0.003***	-0.003***	-0.003**	-0.003**	-0.002
Age	0.000	0.001*	-0.002**	0.002***	-0.002***
Edu	-0.003	0.004	-0.003	0.006	-0.002
Male	0.014	-0.016	-0.031	-0.008	-0.011
Private	0.028	0.085***	0.141***	0.122***	0.078**
Public	0.018	0.120***	0.103**	-0.050	0.073
Teacher	0.006	0.024	-0.003	-0.129	0.077
Selfemployed	0.030	0.014	0.124***	0.103***	0.054
Parttime	0.050***	0.057***	0.122***	0.104***	0.063
House	0.010	0.019	0.088**	0.063**	0.006
Student	0.164***	0.185***	0.088	0.135***	0.063
Hokkaido	-0.055**	-0.060*	-0.062	-0.078**	-0.117**
Tohoku	-0.060***	-0.063**	-0.065*	-0.016	-0.015
Hokuriku	0.024	-0.069**	-0.006	-0.002	0.070
Chubu	-0.064***	-0.092***	-0.052**	-0.019	-0.027
Kinki	0.041**	-0.022	0.026	0.030	0.079**
Chugoku	0.004	-0.012	0.002	0.006	-0.018
Shikoku	0.011	0.019	-0.059	0.036	-0.041
Kyushu	0.045***	0.023	0.056*	0.023	0.010
Constant	0.529***	0.482***	0.020	0.086	0.468***
Wald chi2(35)	290.9***	167.61***	104.29***	154.83***	95.4***
Actual cash	0.421	0.437	0.384	0.517	0.505
Predicted cash	0.511	0.619	0.091	0.427	0.494
Standard errors of prediction	0.034	0.045	0.063	0.053	0.181
Cash at Satisfied with cash = 0	0.492	0.609	0.085	0.395	0.490
Cash at ATM = 0	0.497	0.617	0.085	0.425	0.496

Table 6 Use of payment methods (Marginal effects, Equation [4])

Using Not using	*CE* *DS*	*C* *EDS*	*CES* *D*	*None* *CEDS*	*E* *CDS*
Satisfied with cash	-0.082 ***	0.006	-0.050 ***	0.082 ***	0.012
ATM	-0.001	0.012	-0.041 ***	0.029 ***	0.009
Reward	-0.011	0.006	0.011	-0.006	0.002
Acceptance	0.019 *	0.007	-0.012 *	-0.010	-0.008
Speed	-0.004	0.007	-0.035 ***	0.008	0.031 ***
Reload	0.040 ***	-0.030 ***	-0.005	-0.022 **	0.016 **
Security	0.041 ***	0.030 ***	-0.139 ***	0.020 ***	0.022 ***
Restraint	-0.040 ***	0.022	-0.037 ***	0.031 ***	0.027 ***
Standard	0.042 ***	-0.032 ***	0.003	-0.025 ***	0.003
Other_factor_only	0.068 ***	-0.062 ***	-0.006	0.010	-0.008
Objective_financial_literacy	0.009 *	-0.003	0.020 ***	-0.019 ***	-0.010 ***
Fraud1	-0.056 ***	-0.038 **	0.022 **	0.024 **	0.034 ***
Debt	0.010	0.012	0.028 ***	-0.029 ***	-0.017 ***
News	0.010 ***	-0.015 ***	0.012 ***	-0.004 **	-0.001
S_dont_know	0.025	-0.003	0.007	-0.020 *	0.012
S_fin_inst	0.020 *	-0.021 **	0.033 ***	-0.016 **	-0.003
S_exclude_fin_inst	0.020	0.003	0.023 ***	-0.022 ***	-0.017 **
Over_confidence	-0.003	0.003	0.016 ***	-0.011 ***	-0.008 ***
Impatience	-0.008 ***	0.005 **	0.001	0.002	0.000
Reputation	-0.009 **	0.007 **	0.004	0.002	-0.002
Self_control	-0.013 ***	0.011 ***	-0.009 ***	0.006 **	0.004
Risk_aversion1	0.015	0.009	-0.018 ***	0.007	0.007
Risk_aversion2	-0.013	0.004	0.029 ***	-0.018 **	0.003
Income	0.004 ***	-0.005 ***	0.005 ***	-0.004 ***	-0.001
Asset	0.003 ***	0.002 **	-0.001 *	-0.003 ***	-0.001 **
Age	0.002 ***	0.002 ***	-0.004 ***	0.000	0.000
Edu	0.019 ***	-0.003	0.003 **	-0.011 ***	-0.006 ***
Male	-0.089 ***	0.014	0.010	0.043 ***	0.018 ***
Private	0.077 ***	-0.050 ***	0.033 ***	-0.029 ***	-0.019 **
Public	0.114 ***	-0.059 **	0.011	-0.040 **	-0.026 *
Teacher	0.072 **	-0.018	-0.007	-0.021	-0.009
Selfemployed	0.014	0.014	0.035 **	-0.029 **	-0.012
Parttime	0.055 ***	-0.055 ***	0.021	-0.014	0.014
House	0.024	-0.018	-0.002	0.002	0.008
Student	-0.028	-0.222 ***	-0.054 ***	0.039 ***	0.099 ***
Hokkaido	-0.021	0.053 ***	-0.055 ***	0.031 **	-0.001
Tohoku	-0.039 **	0.044 **	-0.014	0.018 *	0.007
Hokuriku	-0.158 ***	0.146 ***	0.001	0.033 ***	-0.030 **
Chubu	-0.069 ***	0.101 ***	-0.032 ***	0.028 ***	-0.020 **
Kinki	-0.087 ***	0.117 ***	-0.023 **	0.029 ***	-0.029 ***
Chugoku	-0.051 ***	0.033 *	0.005	0.029 **	0.001
Shikoku	-0.089 ***	0.040	-0.015	0.062 ***	0.004
Kyushu	-0.079 ***	0.065 ***	-0.002	0.046 ***	-0.020 ***
rho	-0.303	-0.442	0.566	0.202	0.022
Wald test for rho = 0; chi2(1)	7.740	18.720	23.890	2.930	0.000
P-value of Wald test	0.005	0.000	0.000	0.087	0.949
N	13,218	13,218	13,218	13,218	13,218
Log pseudolikelihood	-9943.6	-8360.7	-4944.2	-4324.9	-3562.3
Actual proportion	0.411	0.266	0.131	0.114	0.078
Predicted proportion	0.411	0.265	0.132	0.113	0.078
Proportion at Satisfied with cash = 0	0.443	0.259	0.142	0.081	0.075
Proportion at ATM = 0	0.406	0.264	0.135	0.116	0.078

The results of the selection equation reported in Table 6 are similar to the results in Table 3, and the predicted proportions of the use of payment methods reported in the fifty-second row labeled as Predicted proportion are fairly precise; however, note that the parameter estimates of ρ, the correlation of error terms in the conditional cash demand equation and probit selection equation, reported in the forty-sixth row labeled as rho, are not statistically significantly different from zero at 5% points for the users of *None* and *E*, as the forty-seventh row labeled Wald test for rho=0 and chi2(1) and the forty-eighth row labeled P-values of the Wald test show. The results mean that we have no justification to use the Heckman model for the users of *None* and *E*. Taken together, we should not use the results from the Heckman model for the uses of *CES*, *None*, and *E*.

4.4 Results of counterfactual simulations for average cash use

Based on the results in Sections 4.2 and 4.3, we used the parameter estimates of the Heckman model for the uses of *CE* and *C* and the results from the OLS for the users of *CES*, *None*, and *E* to conduct counterfactual simulations on the changes in the willingness to use cash.

The third and fourth rows of Table 7 show the average predicted probabilities of the use of each payment method obtained from the multinomial logit model or probit model (the estimates of average P_{ijt} obtained from equation [2] for the users of *CES*, *None*, and *E* or the Heckman model of equation [4] for the uses of *CE* and *C*) and the estimates of *Cash* conditional on the use of each noncash payment method (the forecast values of the number of cash transactions per day conditional on the use of each noncash payment method obtained from equation [3] for the users of *CES*, *None*, and *E* or equation [4] for the uses of *CE* and *C*). The average *Cash* weighted by the proportion of the choice of payment method is 0.523.

The fifth and sixth rows of Table 7 show the average predicted probabilities of the use of each payment method and the estimates of *Cash* conditional on the use of each noncash payment method when we set the value of *Satisfied with cash* to 0. Because the parameter estimates of *Satisfied with cash* in the conditional cash demand for the users of *E* are not

Table 7 Results of the counterfactual simulations

Using / Not using		CE DS	C EDS	CES D	None CEDS	E CDS	Weighted Average
Baseline	Proportion	0.411	0.265	0.131	0.114	0.078	
	Cash	0.511	0.619	0.384	0.517	0.505	0.523
Satisfied with cash=0	Proportion	0.443	0.259	0.141	0.091	0.076	
	Cash	0.492	0.609	0.373	0.495		0.507
ATM=0	Proportion	0.406	0.264	0.137	0.111	0.077	
	Cash	0.497		0.375			0.516
Cash forecast model		Heckman	Heckman	OLS	OLS	OLS	

statistically significantly different from zero in Table 4, we did not use the simulated value of *Cash* when we set the value of *Satisfied with cash* to 0 for the users of *E*. Thus, it was assumed that there is no change in conditional cash demand for the users of *E*. The average *Cash* weighted by the proportion of the choice of payment method is 0.507: a decrease of 0.016 from the baseline estimates. The impact on the frequency of cash transactions is small because the changes in the average cash transactions per day when we set the value of *Satisfied with cash* to 0 is at most -0.02. Note that if we change the proportion of the choice of payment methods alone, average *Cash* weighted by the proportion of the choice of payment method is 0.521, a decrease by 0.002 from the baseline estimates, which accounts for 13% (i.e., 0.002 out of 0.016) of the decrease from the baseline estimate.

The seventh and eighth rows of Table 7 show the average predicted probabilities of the use of each payment method and the estimates of *Cash* conditional on the use of each noncash payment method when we set the value of *ATM* to 0. Because the parameter estimates of *ATM* in the conditional cash demand for the users of *C* is not statistically significantly different from zero in Table 5 and those for *None* and *E* are not statistically significantly different from zero in Table 4, we did not use the simulated value of *Cash* when we set the value of *ATM* to 0 for the users of *C*, *None*, and *E*. Thus, it was assumed that there is no change in conditional cash demand for these three cases. The average *Cash* weighted by the proportion of the choice of payment method is 0.516—a decrease of 0.007 from the baseline estimate. The impact on the frequency of cash transactions is small because the changes in the average cash transactions per day when we set the value of *ATM* to 0 is at most -0.01. Note that if we change the proportion of the choice of payment methods alone, average *Cash* weighted by the proportion of the choice of payment method is 0.520—a decrease of 0.003 from the baseline estimate—which accounts for a 43% (i.e., 0.003 of 0.007) decrease from the baseline estimate. The results suggest that the number of cash transactions per day would decrease only slightly even if the consumer's willingness to use cash decreased.

4.5 Robustness checks

This subsection reports the results of three robustness checks on the analysis presented in the previous sections.

First, regarding the choice of estimation methods, the value of the average *Cash* weighted by the proportion of the choice of payment method, 0.523, in Table 7 is higher than the sample average, 0.438. This is because we used the predicted value from the Heckman model rather than the OLS for the users of *CE* and *CES*. If we used the OLS estimates for the simulation for the users of *CE* and *CES*, the value of the baseline average of *Cash* weighted by the proportion of the choice of payment method would be 0.440, which is close to the sample average; however, if we use the forecast value of *Cash* by OLS for the users of *CE* and *CES*

and set the value of *Satisfied with cash* or *ATM* to 0, the average *Cash* weighted by the proportion of the choice of payment method is 0.431 and 0.438, respectively, a decrease of 0.01 and 0.003 from the baseline estimate, respectively. Therefore, the choice of estimation methods affects the baseline average of *Cash* weighted by the proportion of the choice of payment method; however, the results of the counterfactual simulation measured by the changes in the average of *Cash* remain unchanged.

Second, we used interval regressions instead of OLS regressions for the conditional cash demand, but the overall results were unchanged. Again, the Wald test for the parameter of ρ justified the use of the interval regression with a sample selection for the users of *CE* and *C*. The average of *Cash* weighted by the proportion of the choice of payment method when we set *Satisfied with cash* and *ATM* to 0 fell from the benchmark by 0.014 and 0.006, respectively, which is similar to the results shown in Table 7.

Third, regarding the effects of the benefit of using noncash payment methods, the variable *Security* is statistically significant for all five top choices of payment methods shown in Table 3. Thus, we set the value of *Security* to 0 for all respondents to approximate a situation in which there is no concern regarding the security of noncash payment methods and thus a higher willingness to use noncash payment methods. As anticipated based on the marginal effects reported in Table 3, this change would increase the proportion of *CES* users from 0.131 to 0.151 and would decrease the proportion of other users; however, the average *Cash* weighted by the proportion of the choice of payment method would be 0.520, a decrease of 0.003 from the baseline average of *Cash*. We could perform the same exercise for the other variables contained in *Z*; however, the decreases from the baseline average of *Cash* are at most 0.001. Therefore, in our model, the effects on the use of *Cash* through the increase in the benefit of using noncash payment methods are smaller than the effects of the decrease in the consumer's willingness to use cash.

5 Conclusions

Will the widespread use of cashless payments reduce the frequency of cash payments? Using Japanese microdata, this paper examines how much the frequency of cash use for those who use both cash and noncash payment methods differs from those who exclusively use cash. The data show that the frequency of cash use for those who use noncash payment methods is about once in 2.3 days and that of exclusively cash users is about once in two days, and thus they are only slightly different. The result did not change even if we used a regression model that considers the endogenous choice of payment methods. Two counterfactual simulations were also conducted to examine potential factors that could promote cashless payments, the decrease in the consumers' satisfaction with cash, and the increase in the costs of ATM usage; however, the effect of these changes on the frequency of cash usage is also small. The results show that the often stated benefit of the spread of cashless payments to reduce the cost of cash use is

likely to be overestimated because the frequency of cash payments is unlikely to decrease despite the use of cashless payment methods. Note that our results are based on data from March 2019, and thus recent data, if available, might suggest that the frequency of cash usage by exclusive cash users and both cash and noncash payment method users differ more than our results suggest. This limitation will be resolved as new data on cash usage become available in the future.

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Appendix:

The FLS 2019's questions on objective financial literacy and the source for obtaining knowledge and information when selecting financial products

1. *Objective financial literacy* is defined as the number of correct answers to 12 questions on five categories of financial literacy.

First, *deposits literacy* is defined as the number of correct answers to two relevant questions (Questions 18 and 19).

- Question 18: "Suppose you put 1 million yen into a savings account with a guaranteed interest rate of 2% per year. If no further deposits or withdrawals are made, how much would be in the account after 1 year once the interest payment is made?" Disregard tax deductions. Answer with a whole number.
- Question 19: "Then, how much would be in the account after 5 years?" Disregard tax deductions. Choose only one answer from the following options: 1. More than 1.1 million yen; 2. Exactly 1.1 million yen; 3. Less than 1.1 million yen; 4. Impossible to tell from the information given; 5. Do not know.

Second, *risk literacy* is defined as the number of correct answers to two risk literacy questions (Questions 21_3 and 21_4).

- Question 21_3: “Please indicate whether you think the following statement is true or false: An investment with a high return is likely to be high-risk.”
- Question 21_4: “Please indicate whether you think the following statement is true or false: Buying a single company’s stock usually provides a safer return than a stock mutual fund.”

Third, *insurance literacy* is defined as the number of correct answers to two insurance literacy questions (Questions 25 and 26).

- Question 25: “Which of the following statements on the basic function of insurance is appropriate?” Choose only one answer from the following options: 1. Insurance is effective when a risk occurs with high frequency, causing a large loss; 2. Insurance is effective when a risk occurs with low frequency, causing a large loss; 3. Insurance is effective when a risk occurs with high frequency, causing a small loss; 4. Insurance is effective when a risk occurs with low frequency, causing a small loss; 5. Don’t know.
- Question 26: “When a 50-year-old man reviews his life insurance policy (whole life insurance) after his children have become financially independent, which of the following statements is appropriate?” Suppose that other circumstances have not changed. Choose only one answer from the following options: 1. He should consider increasing the death benefit; 2. He should consider decreasing the death benefit; 3. There is no need to review the policy in particular; 4. Don’t know.

Fourth, *debt literacy* is defined as the number of correct answers to four debt literacy questions (Questions 21_2, 30, 31, and 22).

- Question 21_2: “Please indicate whether you think the following statement is true or false: When compared, a 15-year mortgage typically requires higher monthly payments than a 30-year loan, but the total interest paid over the life of the loan will be less.”
- Question 30: “Which of the following statements on mortgages is appropriate?” Choose only one answer from the following options: 1. It is far less costly to continue living in a rented house for your entire life than to buy a house with a loan; 2. Mortgages can be repaid by either the equal payment method or the equal principal payment method, but the total repayment is the same for both methods; 3. Mortgages are offered with either a floating interest rate or a fixed interest rate, and those with a fixed interest rate are always more advantageous than those with a floating interest rate; 4. In order to decrease the total mortgage repayment, it is effective to prepare as much of a down payment as possible and make advanced repayments to the extent possible; 5. Don’t know.
- Question 31: “Suppose you owe 100,000 yen on a loan, and the interest rate you are charged is 20% per year, compounded annually. If you didn’t pay anything off, at this

interest rate, how many years would it take for the amount you owe to double?" Choose only one answer from the following options: 1. Less than 2 years; 2. At least 2 years but less than 5 years; 3. At least 5 years but less than 10 years; 4. At least 10 years; 5. Don't know.

- Question 22: "If interest rates rise, what will typically happen to bond prices?" Choose only one answer from the following options: 1. They will rise; 2. They will fall; 3. They will stay the same; 4. There is no relationship between bond prices and the interest rate; 5. Don't know.

Fifth, *inflation literacy* is defined as the number of correct answers to two inflation literacy questions (Questions 20 and 21_1).

- Question 20: "Imagine that the interest rate on your savings account was 1% per year, and inflation was 2% per year. After 1 year, how much would you be able to buy with the money in this account?" Choose only one answer from the following options: 1. More than today; 2. Exactly the same; 3. Less than today; 4. Do not know.
- Question 21_1: "Please indicate whether you think the following statement is true or false: High inflation means that the cost of living is increasing rapidly."

2. We also used dummy variables indicating the source for obtaining knowledge and information when selecting financial products. We used Question 35 of the FLS: "Where do you get your knowledge and information to help you choose financial products?" Choose up to three answers from the following options: 1. Consultation at financial institutions (asking the sales staff to explain); 2. From pamphlets provided at financial institutions; 3. At a lecture meeting or a seminar; 4. Consultation with financial professionals/professional financial advisors; 5. Through media reports (TV and radio programs, newspapers, magazines, etc.); 6. From websites; 7. Conversations with family members/friends; 8. By taking classes and/or attending lectures at schools (including those for adults); 9. Other information sources; 10. I'm not sure what opportunities would allow me to acquire such knowledge or information; 11. I don't invest in financial products.

We first created a dummy variable that takes a value of 1 for respondents who chose options 11 (*S_do_not_choose*) and 10 (*S_do_not_know*). Note that respondents who chose option 11 or option 10 did not choose any other options. Second, we created the dummy variable *S_fin_inst* for respondents who chose at least one option from options 1, 2, 3, 4, 8, and 9. Options 1 through 4 are grouped because Fujiki (2020b) found that 81% of the respondents chose financial institutions and/or financial experts as their sources of financial knowledge, and these respondents tended to have a higher amount of financial asset holdings compared with other respondents based on the Survey of Household Finances data from 2010 to 2017. The aggregation of options 1 and 2 makes sense because financial institutions, such as banks, security firms, and insurance companies, have traditionally provided financial knowledge in

Japan. Finally, we created the dummy variable *S_exclude_fin_inst* that takes a value of 1 for respondents who chose at least one option from options 5, 6, and 7 but did not choose any options from 1 through 4, 8, or 9. Note that the FLS is a web survey, and given the importance of the Internet, we combined options 5 and 6. The respondents who take a value of 1 for *S_exclude_fin_inst* use family and friends, mass media, and websites as their information sources but do not use formal information sources, such as financial institutions or financial experts. In the regression analysis in Section 4, we used *S_do_not_choose* as the base case.