Preliminary Draft

Cash Usage Trends in Japan:
Evidence Using Aggregate and Household Survey Data

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Abstract: We examine the trends in cash usage in Japan and its substitution with noncash payment means, such as credit cards, electronic money, and bank transfers, using both aggregate and individual household survey data. We find that cash hoarding could account for as much as 42% of total cash circulation in Japan. We also find that the extent of possible decreases in cash demand due to the substitution of cash for credit cards in both day-to-day transactions and regular payments would not be very large. In evidence, our back-of-the-envelope calculations used to infer the maximum impact of any possible decreases in cash demand would be for day-to-day transactions and regular payments at most 0.46% and 0.51% of the total cash in circulation in Japan, respectively.

***Keywords*:** cash demand, mattress deposits, credit cards, bank transfers
JEL codes: D14, E41, E52

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1. INTRODUCTION

Following the global financial crisis, many researchers have pointed out that currency usage has shown a surprising recovery in most advanced economies. For example, during the period from 2002 to 2017 (Figure 1), the currency to Gross Domestic Product (GDP) ratio increased from 14% to 19% in Japan, from 6% to 8% in the US, and from 3% to 10% in the Eurozone. Important exceptions to this trend are Canada, where the currency to GDP ratio has remained stable and Sweden, where the currency to GDP ratio has been falling.[1] A puzzle is that the ratio of currency in circulation to nominal GDP increased despite the advances in noncash means of payments in Japan, US and the Eurozone, which would induce people to choose to pay by credit cards or debit cards, rather than cash.

Figure 1 also indicates that currency to GDP ratios accelerated following the global financial crisis in Japan, US and Eurozone. However, the Japanese currency to GDP ratio was 14% in 2002, but only 6% in the US and just 3% in the Eurozone. Clearly, Japan is an advanced economy with a sophisticated banking system. Why was the Japanese currency to GDP ratio already so high in 2002?

To appreciate this finding better, the solid line in Figure 2 plots the long-run trend in the Japanese currency to GDP ratio from 1955 to 2017. By the middle of the 1990s, the currency to GDP ratio was about 6–8%, but since then it has increased steadily. In addition, it was not until 1995 when the Bank of Japan (BOJ) was the first advanced economy since World War II to face an effective zero-lower bound for the nominal interest rate, as depicted by the dashed line in Figure 2. Together, these suggest that we need to pay close attention to the factors unique to Japan prior to the global financial crisis to understand the reasons underpinning the steady increase in the currency to GDP ratio in Japan observed since 1995.

Why the ratio of currency in circulation to nominal GDP increased despite the advances in noncash means of payments in Japan? We argue that the cash demand for hoarding was so strong that it outweighed the negative effect of the substitution to noncash means of payment on the cash

[1] See Jobst and Stix (2017) and Goodhart and Ashworth (2017) for cross-country evidence. See Judson (2017) and Riksbank (2018) for the US and Swedish experiences, respectively. In Canada, the value of bank notes in circulation as a percentage of GDP has remained stable. Jiang and Shao (2014) provides a model that emphasizes that the substitutability between cash and other means of payment is uneven across different economic activities. If some agents use cash receipts in less cash-intensive sectors to finance spending in more-cash-intensive sectors, then the total demand for money may not decrease even if cash plays a diminishing role in transactions.

demand for day-to-day and regular payments. To support our argument, we examine the trends in cash usage in Japan with a special emphasis on cash hoarding and its substitution with electronic means of payment, such as credit cards, electronic money, and bank transfers, using both aggregate data since 1955 and household survey data after 2007. First, we begin by illustrating the steady increase in cash in circulation in Japan, especially after 1995. Second, after listing the possible reasons for this increase, we move to examining the extent to which this increase could be attributable to the increase in cash hoarding (so-called mattress deposits). Third, we examine whether there were any structural breaks in the Japanese aggregate cash demand function after the middle of the 1990s. We particularly test whether the income elasticity of aggregate cash demand increased substantially and consistently with the acceleration in cash demand. Fourth, after identifying data sources that provide breakdowns of cash holdings by individuals and firms in Japan, we provide estimates of the decrease in cash holdings for day-to-day one-off payments arising from the substitution of cash with credit cards and electronic money using the household survey data from Fujiki and Tanaka (2018a, 2018b). Finally, we cite evidence in Fujiki (2018), which examines the choice of payment method for regularly scheduled payments, such as utility bills.

Our main findings are as follows. First, our analysis using aggregate data suggests that cash hoarding could account for as much as 42% of the total cash in circulation in Japan. Second, assuming a semi-log cash demand function, there is a significant structural break in the Japanese cash demand function in either 1996 or 1999 depending on the specification of the interest rate. If we instead assume a log-log cash demand function, there are structural breaks in the cash demand function in either 2003, 2004, or 2006. Third, our back-of-the-envelope calculations to infer the maximum impact of possible decreases in cash demand for daily one-off and regular payments of the substitution from cash to noncash payment methods may not be so large, and at most 0.46% and 0.51% of the total cash in circulation in Japan, respectively.

Using these findings to forecast the trends in cash usage in Japan, we argue that the BOJ should be more concerned about the decline in cash hoarding, for example, because of the increase in the policy interest rate in the future, than any substitution of cash for credit cards in daily transactions or regular payments. An important reservation is that our evidence concerning the substitution of cash for noncash payments implicitly relies on the technology available in the period 2007–2014. Of course, it would be possible to further reduce the demand for cash for

person-to-person (P2P) transactions if some new technology were to prevail, say, P2P electronic bank transfers using a cellphone QR code app developed by three large Japanese banks.

Before moving on to the details of our analysis, let us briefly touch on the Japanese demand for cash literature. Empirical studies on the demand for cash as financial technologies evolve include Fujiki and Tanaka (2018a, 2018b, 2014) and Fujiki (2018), who used the Survey of Household Finance to examine the substitution of cash for electronic money and credit cards, while Nakata (2012) employed a panel data set and found that electronic money users held as much cash as did nonusers. Other studies employed Japanese aggregate time-series cash data, such as Kitamura et al. (2009) and Nanba and Watanabe (2011).

The remainder of the paper is organized as follows. Section 2 reports our aggregate data evidence. Section 3 discuss the Japanese data sources that break down cash demand by sector. Section 4 reports our evidence using the household survey data. Section 5 concludes.

2. AGGREGATE DATA EVIDENCE

2.1. Aggregate cash holdings

Figure 2 depicts the ratio of currency in circulation to nominal GDP in Japan (solid line) and Japanese policy interest rates (dashed line). As shown, the ratio of currency to nominal GDP was stable up until 1995 (averaging 6.8% from 1955 to 1995), but afterwards the ratio steadily increased, reaching 19% by 2017. Figure 2 also shows that Japanese policy interest rates have remained around zero since 1995 (averaging just 0.14% from 1996 to 2017). Several factors possibly drove the accelerating demand for currency well above the nominal economic growth rate in Japan after 1995, apart from this, policy interest rates were subsequently very low. From 1997 to 1998, Japan experienced a banking crisis (orange bars in Figure 2), which saw the removal of the blanket guarantee for bank time deposits in 2003 and bank ordinary deposits in 2005. While the major banks had restored much of their financial strength by 2006, the BOJ began its Quantitative and Qualitative Easing program in April 2013 and enacted a negative interest rate policy in January 2016. Note that the ratio of currency in circulation to nominal GDP increased despite the rapid increase in online purchases in Japan, which would induce people to choose to pay by credit cards, rather than cash. According to White paper on Information and Communications in Japan 2018, the percentage of households making online purchases increased from 5.3% in 2002 to 27.8% in 2016, as the solid blue line in Figure 2 shows.

In addition to these monetary factors, the rapid growth of foreign tourism in Japan after 2014 may also relate to the increase in cash demand. Some researchers also suggest that the introduction of a social security and tax number system (the My Number system) in 2016 may also have increased the demand for cash because information on financial institution accounts under this new system is passed to the authorities if an account holder has a My Number. As some wealthy people may prefer not to disclose their financial asset holdings to the government for other reasons, they may well have withdrawn bank deposits in exchange for cash and then retained the cash in safe-deposit boxes. One might wonder if the ratio of currency in circulation to nominal GDP increased due to the expansion of shadow economy, rather than cash hoarding. However, Medina and Schneider (2018) show that the size of shadow economy in Japan has remained stable from 1991 to 2015, as the dotted blue line in Figure 2 shows. These episodes suggest that cash hoarding, especially in the form of 10,000-yen notes (the largest denomination note) may be prevalent in Japan. We present an estimate of possible cash hoarding in Japan in the following subsection.

2.2. Cash hoarding

We update the estimates of cash hoarding by Fujiki and Tomura (2017) using the method proposed by Otani and Suzuki (2008). Otani and Suzuki (2008) assume that people only use 10,000-yen notes for cash hoarding, and that the transaction demands for 1,000-yen notes (the major means of day-to-day one-off transactions) and 10,000-yen notes are proportional to each other. Hence, they assume that the transaction demand for 10,000-yen notes will grow at the same rate as that for 1,000-yen notes. Otani and Suzuki (2008) set 1995 as the base year in which there is no cash hoarding in Japan and estimated cash hoarding as the difference between the total 10,000-yen notes in circulation and the estimated transaction demand for 10,000-yen notes. Figure 3 illustrates the estimates of cash hoarding in Japan using this method, with 8.2% of the 19.4% ratio of currency in circulation to nominal GDP in 2017 then categorized as cash hoarding. In other words, some 45 trillion of the 106 trillion yen in currency in circulation in Japan in 2017, or 42% of the total cash in circulation, could result from cash hoarding.

2.3. Long-term cash demand function

In this section, we examine the long-term relationship between cash, nominal GDP, and interest rates in Japan using standard time-series analysis. The main question is whether the income (GDP)

elasticity of cash demand is greater than unity after 1995, as suggested by Figure 2. Behind this observation lies the fact that the BOJ has kept the short-term interest rate close to zero since 1995. In this regard, several economists have examined whether Japan has been in a liquidity trap, in the sense that the demand for cash has increased substantially. For this purpose, these studies often estimate two types of money demand functions: either a semi-log money demand function as in equation (1) or a log-log money demand function as in equation (2):

$$\ln\left(\frac{Money\ stock}{PGDP}_t\right) = a0 + a1\ln(RGDP_t) + a2(Interest\ rate_t) + \varepsilon_{1t} \quad \textbf{(1)}$$

$$\ln\left(\frac{Money\ Stock}{PGDP}_t\right) = b0 + b1\ln(RGDP_t) + b2ln(Interest\ rate_t) + \varepsilon_{2t} \quad \textbf{(2)}$$

where *PGDP* is the GDP deflator and *RGDP* is real GDP.

For example, Nakashima and Saito (2012) and Miyao (2002, 2005) both specified M1 (the sum of cash and demand deposits) as the money stock and the nominal overnight call rate as the interest rate to estimate interest rate elasticity in Japan by using equations (1) and (2) to identify any structural breaks in the demand function after 1995. Miyao (2002, 2005) set the income elasticity of M1 (*a1* and *b1*) to one, whereas Fujiki and Watanabe (2004) used cross-sectional data across Japanese prefectures to set its value. Both studies also assumed that the income elasticities were constant and tested whether the interest rate elasticities increased substantially after 1995. Elsewhere, Nakashima and Saito (2012) examined the Japanese money demand function assuming both unitary and nonunitary income elasticities. In this paper, we extend this literature to estimate real banknote rather than real M1 demand in Japan as in Fujiki and Tomura (2016). We also estimate equations (1) and (2) using cash holdings or the transaction demand for cash holdings as proxies for the money stock, and the policy or ordinary deposit rate in place of the call rate as interest rates.

Table 1 reports the mean, standard error (s.e.), minimum, maximum, and number of observations (N) of the variables of interest. Specifically, *lncr* is the log of cash in circulation deflated by *PGDP*, *lntranscr* is the log of the transaction demand for cash (the difference between cash in circulation and mattress deposits as estimated in Section 2.2) as deflated by *PGDP*. *Lnyr*

is the real GDP for the calendar year.[2] *Policyrate* is Japanese policy interest rates.[3] *Lnpolicyrate* is the log of *policyrate*. This series is only available up to 2015; thus, we have just 61 observations because policyrate takes negative values after 2016 given the BOJ's introduction of the negative interest rate policy in January 2016. As we cannot estimate equation (2) using the full GDP series if we employ the log of *policyrate* as an explanatory variable, we also use *orddep*, the deposit rate for bank ordinary deposits, as an explanatory variable, which remains positive as of 2018. Compared with the *policyrate* series, the mean of *orddep* is lower as detailed in Table 1.[4] *Lnorddep* is the log of *orddep*. Note that consistent availability from 1955 to 2018 restricts our specification of the short-term interest rate. For instance, we cannot use commercial paper or Treasury bill rates like many US studies estimating money demand functions because they are simply not available.

Table 2 reports the results of augmented Dickey–Fuller (ADF) tests of the eight variables listed in Table 1. As the P-values show, we fail to reject the null hypothesis of a unit root with a time trend. Table 3 reports the results of the Engel–Granger test for cointegration between log real cash demand, log real GDP, and interest rates. We consider equations (1) and (2) for using *lncr* or *lntranscr* as dependent variables, and *policyrate* or *orddep* as one of the independent variables; therefore, we have eight specifications to apply the Engel–Granger test. The results in Table 3 indicate that we cannot reject the null hypothesis of no cointegration in all models. Third, we apply Gregory and Hansen's (1996) test to the eight models listed in Table 3. The null hypothesis is no cointegration and the alternative hypothesis is cointegration with a structural break. We reject the null hypothesis of no cointegration for all specifications using the ADF and Z_t statistics when specifying *lncr* as the dependent variable, but only one of the four specifications using the ADF statistics if we specify *lntranscr* as the dependent variable (Table 4).

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[2] Real GDP in 2017 are first estimates, real GDP data from 1980 to 2016 use the 2011 National Accounts of Japan (SNA) database final estimates, and real GDP data from 1955 to 1979 are estimates from applying the annual growth rates in the 1968 SNA database to the 1980 data.

[3] The policy rate uses the following series: the basic discount and loan rate from 1955 to 1959, the call rate (collateralized overnight, average) from 1960 to 1984, and the call rate (uncollateralized overnight, average) from 1985 to 2017.

[4] *Orddep* uses the following data: from 1955 to 1969, the maximum limits under the Temporary Money Rates Adjustment Law, from 1970 to 1994, the BOJ guideline rates reported in the Long-Term Statistics by the Statistics Bureau, http://www.stat.go.jp/data/chouki/zuhyou/14-01.xls. As the regulation of interest rates for ordinary deposits ended in October 1994, the ordinary deposit data series after 1995 is from the Average Interest Rates Posted at Financial Institutions by Type of Deposit, as compiled by the BOJ.

Our findings are as follows. First, regarding the results using *lncr*, *lnyr*, and *policyrate*, the ADF and Z_t statistics suggest that this specification includes cointegration with a significant structural break in the constant and the slopes in 1999 at the 10% significance level. This structural break coincides with the commencement of the zero-interest rate policy by the BOJ in 1999. Second, regarding the results using *lncr*, *lnyr*, and *lnpolicyrate* from 1955 to 2015, the ADF and Z_t statistics indicate that this specification includes cointegration with a structural break in the constant and the slopes in 2006 at the 1% statistical significance level. This structural break coincides with an increase in the call rate associated with the end of the quantitative easing policy in 2006. Third, regarding the combinations of *lncr*, *lnyr*, and *orddep* from 1955 to 2017, the ADF and Z_t statistics suggest that this specification includes cointegration with a structural break in the constant and the slopes in 1996 at the 10% statistical significance level. This structural break coincides with the beginning of the low-interest rate period in Japan.

Fourth, for the results for the combinations of *lncr*, *lnyr*, and *lnorddep* from 1955 to 2017, the ADF and Z_t statistics suggest that this specification includes cointegration and breaks in the constant term in 2003 and 2004 at the 5% statistical significance level, respectively. Note that the previous three specifications identify structural breaks in both the constant term and slopes; therefore, we must employ different asymptotic critical values in this case. Fifth, regarding the results using *lntranscr* as the dependent variable, if we specify *policyrate* as the interest rate variable, only the ADF statistics suggest that this specification includes cointegration with a structural break in level in 2004 at the 10% statistical significance level. However, we fail to reject the null hypothesis for the remaining three specifications when using *lntranscr* as the dependent variable. Using these results, we move to estimating the cointegration coefficients using dynamic ordinary least squares (DOLS) and static ordinary least squares (SOLS) before the structural breaks following Hayashi (2000) and focus on the specification using *lncr* as the dependent variable.

Table 5 details the DOLS and SOLS results for equations (1) and (2), which use *policyrate* and *orddep* as one of the independent variables, respectively. The second to fourth columns provide the results for *lncr*, *lnyr*, and *policyrate* from 1955 to 1998 following Hayashi (2000). We chose this sample period because the Gregory and Hansen test suggests the structural break was just after in 1999 (Table 4). The estimation results are $a1 = 1.001$ (s.e. = 0.02) and $a2 = –0.037$ (s.e. = 0.004) with two lags and two leads in the differences of *lnyr* and the policy rates, where D

is the time difference, FND is the N-period forward difference, and LND is the N-period lagged difference in the first column. Wald test statics for testing the null hypothesis of $a1 = 1$, which is reported in the rows labeled as Test lnyr = 1 is zero, and the P-value, which is reported in the rows labeled P-value, is 0.9574. Hence, we conclude that the income elasticity of cash demand by 1998 was one. The estimation result for DOLS does not change significantly, even if we set the number of lags to one year. The SOLS estimate for $b1$ is 1.09, although we do not know the s.e. of this estimate.

The fifth through seventh columns provide the results for *lncr*, *lnyr*, and *lnpolicyrate* from 1955 to 2005. We chose this sample period because the Gregory and Hansen test suggests the structural break was in 2006 (Table 4). The parameter estimates are $b1 = 1.045$ (s.e. = 0.03) and $b2 = –0.097$ (s.e. = 0.002) with two lags and two leads. The Wald test statistics for testing the null hypothesis of $b1 = 1$ is 2.96, and the P-value is 0.0853. Hence, we conclude that the income elasticity of cash demand was one by 2005.[5] The estimation result using DOLS does not change this result majorly, even if we set the number of lags to one year; however, the DOLS estimates with one lag and one lead reject the null hypothesis of $b1 = 1$. The comparable SOLS estimate for $b1$ is 1.087.

The eighth through tenth columns show the results for *lncr*, *lnyr*, and *orddep* from 1955 to 1995. We chose this sample period because the Gregory and Hansen test suggests that the structural break was in 1996 (Table 4). The estimation results are $a1 = 0.996$ (s.e. = 0.016) and a2 = –0.068 (s.e. = 0.011) with two lags and two leads. Wald test statics for testing the null hypothesis of a1 = 1 is 0.07 and the P-value is 0.785. We conclude that the income elasticity of cash demand by 1995 was one; however, the DOLS estimates with one lag and one lead reject the null hypothesis of $b1 = 1$.[6] The SOLS estimate for $b1$ is 1.078.

Finally, the eleventh through thirteenth columns detail the results for DOLS and SOLS for variables *lncr*, *lnyr*, and *lnorddep* from 1955 to 2003. We chose this sample period because the

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[5] As a robustness check, we apply the Johansen procedure to obtain the cointegrating vector using the sample up to 2005, using Stata commands varsoc, vecrank, and vec. We have one cointegrating relationship using two years of lags, and obtain that the cointegrating vector, or long-run income and interest rate elasticity are 0.9918 (s.e. = 0.022) and –0.076 (s.e. = 0.006), respectively. These results are consistent with those obtained by DOLS.

[6] We also apply the Johansen procedure to obtain the cointegrating vector using the sample up to 1995. We obtain one cointegrating relationship using two years of lags and identify the cointegrating vector or long-run income and interest rate elasticities of 0.9683 (s.e. = 0.023) and –0.075 (s.e. = 0.019), respectively. These results are consistent with those using DOLS.

Gregory and Hansen test suggests the structural break was in either 2003 or 2004 (Table 4). The estimation results are $b1 = 0.964$ (s.e. = 0.032) and $b2 = -0.125$ (s.e. = 0.011) with two lags and two leads. The Wald test statistic for testing the null hypothesis of $b1 = 1$ is 1.21 and the P-value is 0.2706.[7] The DOLS estimates with one lag and one lead also accept the null hypothesis of $b1 = 1$. On this basis, we conclude that the income elasticity of cash demand by 2002 was one. The SOLS estimate for $b1$ is 1.049.

In summary, the results in Table 4 suggest that if we assume a semi-log cash demand function as per equation (1), there is a structural break in the demand in 1996 or 1999 depending on the choice of interest rate. This is broadly consistent with the assumption made by Otani and Suzuki (2008), who set 1995 as the base year marking the beginning of cash hoarding in Japan. If we instead assume a log-log cash demand function as per equation (2), there are structural breaks in either 2003, 2004, or 2006. The results in Table 5 indicate that the long-run income elasticity of demand for cash before the structural break is one using a DOLS with two periods each of leads and lags. Overall, we obtain evidence of an accelerating demand for cash beyond the nominal economic growth rate, in the sense that we have structural breaks in the cash demand functions, even after controlling for the low interest rates in Japan between 1996 and 2006. This 10-year period corresponds at the beginning to the introduction of the zero-interest rate policy and at the end to the commencement of the first round of quantitative easing by the BOJ.

The long-run stability of M1 demand has also been the subject of investigation in many other economies. In the US, for example, Ireland (2009) and Lucas (2000) are well-renowned studies of which of the semi-log or log-log money demand functions were the better specification assuming that the income elasticity of M1 is one. More recently, Benati et al (2017) explore the long-run demand for M1 using a dataset comprising 32 countries since 1851, including Japan. Our results suggest we should not take unitary income elasticity as given, not only for M1 as in Nakashima and Saito (2012), but also for cash demand. Our results are partly consistent with Jobst and Stix (2017), who find a stable cash demand in economies with no record of financial crisis and an increase in cash demand for economies experiencing financial crisis in 2008. Note that there were

[7] We use the Johansen procedure to obtain the cointegrating vector using the sample up to 2002. We find no cointegrating relationship using two years of lags in this specification and obtain no clear results for the long-run income and interest rate elasticities.

very few financial institution failures in 2008 in Japan; therefore, we should take the beginning of the Japanese financial crisis as dating earlier than 2008.

We could use our estimates to infer that the extent cash demand would decrease if the BOJ successfully achieved its inflation target of 2% and gradually increased short-term interest rates, such that cash demand would return to its long-run estimates as in Fujiki and Tomura (2017). Nevertheless, we may question if it is correct to consider that the estimates using pre-1996 data, which identify a cash–GDP ratio of about 8% with positive nominal interest rates, represent the normal condition of the Japanese economy. However, Saito (2017) shows that the cash–GDP ratio from 1930 to 1955 was stable at around 10% except for around World War II; therefore, 8% for cash–GDP may be a reasonable prediction in the future. Note that in 2016, Japan's Prime Minister Shinzo Abe announced a plan to increase Japanese GDP to 600 trillion yen by 2020. If his plan succeeds and if the BOJ succeeds escaping from its current liquidity trap in Japan, we could more readily believe that the demand for cash would fall to a level of 8% of nominal GDP. In this case, there would be 48 trillion yen (= 600 trillion yen of GDP × 8%) of cash in circulation in Japan, which is down 50% from the average cash in circulation in April 2018 of about 99 trillion yen. An additional concern is that to what extent some new form of payment instrument could reduce the demand for cash more than these estimates predict. It is for this reason we examine the substitution of cash and noncash payment methods in Section 4.

3. DEMAND FOR CASH BY FIRMS AND HOUSEHOLDS

In this section, we review Japanese statistics that break down the demand for cash by firms and households. We begin by discussing the Flow of Funds Accounts (FFA), which estimates the demand for cash by firms, and then move onto the Survey of Household Finances (SHF), which surveys the demand for cash by households.

3.1. Flow of funds accounts

The FFA, compiled by the BOJ, provides a breakdown of the cash holdings of households, private nonfinancial corporations, general government, and financial institutions. To prepare the FFA, the BOJ surveys the cash holdings of financial institutions and the general government, with the cash holdings of private nonfinancial corporations estimated using detailed information, including anecdotal evidence from private nonfinancial corporations, such as the ratio of cash holdings to

sales proceeds by industry. The cash holdings of households are the difference between the total currency in circulation and the estimated amount of cash holdings of nonfinancial private corporations, and the surveyed amount of cash holdings of financial institutions and the general government.

Figure 4 shows that as of the end of fiscal year 2016 (March 31, 2017), the share of cash holdings of financial institutions was 0.11, by private nonfinancial corporations 0.08, by households 0.78, and by general government 0.03. There is also a large increase in cash holdings by households and a large decrease in cash holdings by the private nonfinancial corporations in fiscal year 2004 (Figure 4). This is because the revision of the FFA in 2016 applied a new method of estimation to the cash holdings by sectors to the data after the first quarter of 2005.[8]

Note that the estimates after March 2005 use detailed information, including anecdotal evidence regarding private nonfinancial corporations. Among these, the FFA uses the results of the Survey of Private Enterprise Economy by Ministry of Internal Affairs and Communications to estimate the demand for cash by private nonfinancial corporations, especially the cash–sales ratio. The survey questions approximately 4,000 private enterprises about business conditions, sales, profits, inventories, the number of employees and their wages, and business investment, assets, and liabilities. As this survey focuses on private enterprises managed by families, the average number of employees reported in the survey is less than one person. Among the questions on business assets, the survey includes questions about the amount of cash holdings at the end of the year. Note that the definition of cash used in the survey includes cash holdings and checks; thus, the statistics overestimate the demand for cash by the firms. Table 6 provides the figures for sales, cash holdings, and the cash–sales ratio. As shown, the cash–sales ratio varies from industry to industry, but ranges between 0.03 and 0.06. Note also that the number of establishments surveyed varies from industry to industry, and the number of establishments that respond to the questions on sales and cash are not the same. The cash–sales ratio reported in Table 6 is the ratio of mean sales and mean cash holdings computed from a different sample establishment.[9]

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[8] Note that the data in Figure 4 are at the end of the fiscal year; therefore, the data in 2004 corresponds to the first data point of the revised data as of March 31, 2005. The breakdown of the cash holdings by sector before the fourth quarter of 2004 is an estimate using the data from the Survey of Household Finances, which resulted in a larger proportion of cash holdings held by firms.

[9] Besides the Survey of Private Enterprise Economy, major government statistics for private enterprises includes Economic Census by the Statistics Bureau, (conducted every five years) and Surveys for the Financial Statements

3.2. Survey of Household Finances

The Central Council for Financial Services Information (CCFSI) provides the average cash holdings of Japanese single-person households from 2007 and family households from 1991 to 1994, 1996, and after 1998 in their SHF statistics.[10] The survey method for the family household data changed in 2004 and 2007; therefore, we depict three series of cash holdings for family households in Figure 5: family household 1 (red line), family household 2 (blue line), and family household 3 (black solid line) respectively, along with a series for single-person households (black dashed line).

Figure 5 illustrates that the demand for cash increased after the middle of the 1990s (see the red and blue lines), which is consistent with the trends in the aggregate cash in circulation. However, the family household data after 2007 (black solid line) suggests average cash holdings of about 150,000–190,000 yen, a similar amount of cash holdings to the 1991–1994 data. Unfortunately, we have no information on the reduction in average cash holdings by family household data from 2006 to 2007 that can be explained by changes in the survey method. Another puzzling aspect of the data after 2007 is that the average cash holdings of single-person households (black dashed line) is always larger than that of family households (black solid line). Unfortunately, we cannot compare these directly because the compilation of the data series after 2007 employs different methods. For the family household data set, the SHF used a stratified two-stage random sampling method to select 500 survey areas and then randomly selected 16 households consisting of two or more people from each area, totaling about 8,000 samples. Of these, in each survey year, some 3,300 to 4,000 samples responded. The single-person household data set includes 2,500 respondents from a pool of individuals registered with a survey company through the Internet. The distribution of respondent ages (20 to 69 years), genders, and regions was then determined in such a way as to replicate the population in the Japanese Census. Therefore, the single-person household

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Statistics of Corporations by Industry by the Ministry of Finance (conducted each quarter). Unfortunately, these statistics only provide information on the sum of cash and deposits; therefore, we cannot estimate cash–sales ratio. For example, the ratio of average cash plus deposits to average sales as of fiscal year 2015 was 0.13 for manufacturing firms and 0.14 for nonmanufacturing firms. These numbers are far higher than reported in the Survey of Private Enterprise Economy.

[10] The Japanese government does not publish data on the demand for cash by households. The National Survey of Consumption by the Statistics Bureau (conducted every five years) does ask respondents about the stock of cash holdings, but the data is not available. The Family Income and Expenditure Survey by the Statistics Bureau (conducted each month) asks respondent about their outstanding amounts of financial assets, such as deposits, insurance, bonds, and stocks, but does not include a question about the amount of cash holdings.

data set tends to include younger people and others accustomed to using the Internet than the family household data set.

One may ask precisely why Japanese tend to use cash for daily transactions. Regarding this, the 73rd Opinion Survey on the General Public's Views and Behavior, conducted by the BOJ on March 2018 included an ad hoc question, "Why do you use cash to make daily payments? Choose all applicable answers." Figure 6 visually summarizes the results. According to this survey, 73.7% of respondents appreciated the finality of cash payment, 63.8% valued its general acceptance, 49.0% said the use of cash prevented overspending, and 37.8% preferred its low transaction cost. Note that Henk and Hernández (2017) (especially their Chart 37) reported a similar result regarding the reasons why people use cash for making daily transactions in the Eurozone.

4. DEMAND FOR CASH BY HOUSEHOLDS: EVIDENCE FROM THE SURVEY OF HOUSEHOLD FINANCES

In their respective analyses, Fujiki and Tanaka (2018a, 2018b) and Fujiki (2018) employed repeated individual cross-sectional data sets from the SHF from 2007 to 2014, which asked respondents to identify their two most frequently used payment methods for day-to-day transactions and regularly scheduled payments, along with their demographic information and their amount of cash holdings. These studies first examined the determinants of the choice of payment method by regressing an indicator variable of the choice of payment method, such as cash, credit cards, electronic money, or bank transfers, on the household demographic variables using a multinomial logit model. To quantify the effect of the substitution from cash and noncash payment methods for daily and regularly scheduled payments on cash demand, they compared the cash holdings of households that exclusively used cash for their daily or regularly scheduled payments (cash-only users) with the cash holdings of households that in addition used noncash payment methods. Both studies paid particular attention to the fact that the choice of payment method is an endogenous decision made by households.

Specifically, Fujiki and Tanaka (2018a) focused on the substitution between cash and electronic money for low-value day-to-day transactions less than or equal to 1,000 yen (or about nine US dollars) using both the family and single-person household data. Later, Fujiki and Tanaka (2018b) examined the substitution between cash and credit cards for day-to-day transactions using family household data (they did not obtain consistent results using the single-person household

data). Fujiki (2018) examined the substitution between cash and noncash payment methods for regular payments, such as utility bills, using both the family and single-person household data sets. For our part, we begin our analysis by examining the major choice of payment methods for day-to-day transactions and then reporting whether the users of credit cards or electronic money would have lower average cash holding than the cash-only users. We then discuss the choice of payment method for regular payments, particularly whether users of credit cards for regular payments have lower average cash holdings than do cash-only users.

4.1. Choice of payment method for day-to-day one-off payments

Fujiki and Tanaka (2018a, 2018b) used the SHF 2007–2014 family household data set and examined the choice of payment method for day-to-day one-off transactions. The original survey asks respondents to identify their two most frequently used payment methods. These are for day-to-day transaction values of less than or equal to 1,000 yen, more than 1,000 yen and less than or equal to 5,000 yen, more than 5,000 yen and less than or equal to 10,000 yen, more than 10,000 yen and less than or equal to 50,000 yen, and more than 50,000 yen. The four different payment methods are cash, credit card, electronic money (including debit card), and other. Hereafter, we refer to these transaction values intervals as less than 1,000 yen, between 1,000 and 5,000 yen, between 5,000 and 10,000 yen, between 10,000 and 50,000 yen, and more than 50,000 yen. Note that for this question, the SHF's definition of electronic money (typically a prepaid card with noncontact IC forms based on near-field communication technology) includes debit cards (typically a cash withdrawal card accepted only within Japan, not an international brand debit card). Fujiki and Tanaka (2018a, 2018b) assume that the SHF data more effectively captures the use of prepaid cards than debit cards. This is because the value of transactions made by J-Debit, the major brand of Japanese debit card, has been steadily falling from a peak of 0.8 trillion yen in 2005 to just 0.5 trillion yen in 2014, while the value of transactions made by electronic money has increased from 0.8 trillion yen in 2008 to 4 trillion yen in 2014.

The main findings in Fujiki and Tanaka (2018a, 2018b) are as follows. First, survey respondents tend to select cash and/or electronic money for transactions of less than 1,000 yen and cash and/or credit card for transactions of more than 10,000 yen. The use of cash for low-value transactions and the use of noncash payment methods for higher value transactions is also evident in many other economies (see Henk and Hernández (2017) for the Eurozone, Greene et al. (2017)

for the US, and Fung et al (2015) for Canada). Second, Fujiki and Tanaka (2018a, 2018b) then construct an aggregate dummy variable for the choice of the five payment methods. These are cash (respondents chose cash exclusively), card (respondents chose credit card exclusively, cash and credit card, or credit card and other), electronic money (respondents chose electronic money exclusively, cash and electronic money, or electronic money and other), other (respondents chose other exclusively or cash and other), and card and electronic money (respondents chose credit card and electronic money). Figure 7 depicts the proportion of each dummy in the family household data set reported in Fujiki and Tanaka (2018b). As shown, cash (orange lines) and card (gray lines) are the major choices. The proportion of survey respondents that chose cash decreased over time, and of those that chose card increased for day-to-day transaction values of more than 1,000 yen.

Third, to examine the determinants of the choice of payment method, Fujiki and Tanaka (2018b) ran a multinomial logit model specifying the indicator variable of the five payment methods as the dependent variable. They included the following as independent variables: annual disposable income, the amount of financial assets, dummy variables for proxies for financial knowledge,[11] whether the individual is in debt, home ownership, age, gender, occupation, educational attainment, and the size of the city of residence. They also included dummy variables identifying respondents who made mattress deposits to reduce investment risk,[12] the log of passengers per kilometer to control for regional variation in the accessibility of electronic money or credit cards to gauge the ease of using electronic money issued by public transportation companies and credit cards in many shops or restaurants around train stations.

Fujiki and Tanaka (2018b) found a household with higher disposable income, more financial assets, better financial knowledge, a younger or female head, with higher educational attainment, not self-employed, living in a large city, and in areas with higher passengers per kilometer tend to be card users (households choosing credit card exclusively, cash and credit card, or credit card and other), rather than a cash-only user (households choosing cash exclusively). Regarding the choice of electronic money for the day-to-day payment values of less than 1,000 yen, Fujiki and Tanaka (2018a) ran a similar multinomial logit regression as Fujiki and Tanaka (2018b), and concluded

[11] The dummy variables assign a value of one for those who have heard about the Deposit Insurance Corporation of Japan and what it does, for those who place an emphasis on lower service charges, and for those who consider online banking services offered via the Internet when selecting a financial institution.

[12] They assign a value of one to respondents who increase cash holdings to reduce investment risk to themselves, either by reducing asset holdings or by suspending additional investment in other financial products.

that a household with higher disposable income, better financial knowledge, higher educational attainment, and living in urban areas tend to use both electronic money and cash.

4.2. Substitution from cash to noncash payment methods for day-to-day one-off payments

Could we expect that the average cash holdings of households preferring to use credit card or electronic money are lower than that for cash-only users? Fujiki and Tanaka (2018b) estimated the demand for cash conditional on the choice of card (credit card user cash demand for households choosing credit cards exclusively, credit cards and cash, and credit cards and other methods), and that conditional on the choice of cash exclusively (cash-only user cash demand) using an empirical model like Dubin and McFadden (1984). They found respondents making mattress deposits to reduce investment risk, with more income and financial assets, who know about the Deposit Insurance Corporation of Japan and what it does, who are not sensitive to service charges, have older household heads, have a self-employed or student household head, and are living in the 20-largest cities, tend to have larger average cash holdings conditional on the choice of payment method. The finding that older and rural area citizens prefer to use cash instead of noncash payment methods is also observed in many other economies (see Henk and Hernández (2017) for the Eurozone, Greene et al. (2017) for the US, and Fung et al (2015) for Canada).

Armed with their estimates of the cash demand functions, Fujiki and Tanaka (2018b) compared the forecast values of conditional cash demand for credit card or cash-only users. They found that holding household characteristics constant, credit card users tend to have smaller cash holdings by between 4,000 and 30,000 yen (3–20%) than cash-only users for day-to-day payment values more than 1,000 yen. Using these results, they then used a back-of-the-envelope calculation to infer the maximum impact on aggregate cash demand if all Japanese cash users turned into credit card users. First, according to forecasts by the National Institute of Population and Social Security Research, the number of Japanese non-single-person households was 35,257,000 in 2014.[13] Second, the SHF shows that about 40% of family households are cash-only users for day-to-day payment values exceeding 50,000 yen. Third, according to their estimations, a credit card user family household for payment values exceeding 50,000 yen tends to have a lower amount of

[13] For details of the projection of the number of Japanese households see the website of the National Institute of Population and Social Security Research at http://www.ipss.go.jp/pp-ajsetai/j/HPRJ2013/gaiyo_tab_20130111.xls. We use the 2014 estimates for the result in Table 1.

cash holdings by about 30,000 yen compared with a cash-only user household. Hence, if all Japanese cash-only user households for day-to-day transaction values exceeding 50,000 yen, corresponding to about 40% of Japanese family households, reduced their cash holdings by 30,000 yen as they became credit card user households, the resulting decrease in overall cash demand would be 35,257,000 households × 40% × 30,000 yen/household = 423 billion yen. However, this represents just 0.46% of the 92 trillion yen in cash in circulation in Japan in 2014.

Fujiki and Tanaka (2018a) estimated a multinomial logit model for the choice of payment methods for transaction values less than 1,000 yen, and estimated a linear cash demand function by pooling the sample of electronic money users (households that chose electronic money exclusively, cash and electronic money, or electronic money and other) and cash-only users to measure whether an electronic money user household tended to have larger or smaller cash holdings compared with an cash-only user household. They also included the predicted probability of the choice of electronic money from the multinomial logit model as an instrumental variable for electronic money users in their linear cash demand function. They found that a family electronic money user household did not have greater cash holdings than a cash-only user household, holding all other household characteristics constant. They found that a single-person electronic money user household had greater cash holdings than a single-person cash-only user household, with the results being statistically significant at the 10% level. Therefore, their results suggest that the substitution from cash to electronic money for day-to-day payments less than 1,000 yen would not reduce the demand for cash much because the average cash holdings of electronic money users and those of cash-only users are similar.

4.3. Substitution of cash and noncash payment methods in regular payments

What about the effects of the possible substitution of cash for noncash payment methods to make regular payments, such as utility bills, on overall cash demand? Fujiki (2018) analyzed the SHF family and single-person household data set on the choice of payment methods for regular payments. He obtained the result that the more frequent use of noncash payment methods for regular payments would not reduce the demand for cash substantially. Fujiki (2018) employed the question concerning each respondent's two major payment methods for payments made at regular intervals from the options of cash, credit cards, electronic money, bank transfers, and other. Fujiki (2018) found that the six major payment methods for regular payments were exclusively bank

transfers, cash and bank transfers, credit cards and bank transfers, exclusively cash, exclusively credit cards, and credit cards and cash in both the family and single-person household data sets (Figure 8). Figure 8 also illustrates that the proportion of respondents who selected choices including credit cards was increasing whereas the proportion of respondents choosing exclusively bank transfers was decreasing from 2007 to 2014.

Fujiki (2018) later run a multinomial logit model specifying the indicator variable for the six major choice of payment methods for regular payments as the dependent variable and similar demographic information variables to Fujiki and Tanaka (2018b) as independent variables. He found that a household with higher disposable income, more financial assets, and better financial knowledge tended to use noncash payment methods in addition to cash to make regular payments. In addition, an old household heads tended to negatively correlate with choices including cards and positively correlate with choices including bank transfers. Third, Fujiki (2018) also used propensity score matching to compare the cash holdings of users of noncash payment methods and those of cash-only users. Here he found that noncash payment users sometimes had lower cash holdings compared with cash-only users. For example, respondents who chose cards and bank transfers and those who chose cash and bank transfers tended to have smaller cash holdings than cash-only users by about 60,000–80,000 yen and 40,000–50,000 yen in the family household data set, respectively. Note that in the data the average cash holdings of family households was 132,000 yen; therefore, the difference in average cash holdings between respondents who chose cash and transfers and cash-only users was large relative to average cash holdings.

Alternatively, respondents who chose cash and bank transfers and those who exclusively chose credit cards had lower cash holdings by 40,000–60,000 and 110,000–160,000 yen compared with cash-only users in the single-person household data set. Note that the average cash holdings of single-person households was about 162,000 yen; therefore, the difference in average cash holdings between those who chose exclusively credit cards and cash-only users was large relative to the average cash holdings. However, the number of cash-only user households was just 7% of family households (35,257,000 households in 2014) and only 10% of single-person households (17,460,000 households in 2014). Hence, we do not expect large reductions in the total demand for cash, even if cash-only users switch to some form of noncash payment users, say, exclusively credit cards users, because households using cash exclusively for regular payments potentially represent a relatively small share of the population.

To elaborate on this point, we use a back-of-envelope calculation to infer the maximum impact on the aggregate demand for cash if all cash-only user family households (about 7% of all family households) reduced their cash demand by 80,000 yen by becoming card and transfers users, and all single person cash-only users (about 10% of all single-person households) reduced their cash demand by 160,000 yen by becoming exclusively credit card users. The estimates suggest that these substitutions from cash to noncash payment methods would lead to a reduction in overall cash demand by 35,257,000 family households × 7% × 80,000 yen per household + 17,460,000 single-person households × 10% × 160,000 yen per household = 477 billion yen, which represents just 0.51% of the total cash in circulation in Japan as of 2014.[14] Incidentally, the estimate is similar to the back-of-envelope calculation we performed in the previous section regarding the possible reductions in cash demand due to the substitution from cash to credit cards for daily one-off payments (0.46% of total cash in circulation in Japan as of 2014).

5. CONCLUSION

Why the ratio of currency in circulation to nominal GDP in Japan increased despite the advances in noncash means of payments? We argue that the cash demand for hoarding was so strong that it outweighed the negative effect of the substitution to noncash means of payment on the cash demand for day-to-day and regular payments through analyzing three types of demand for cash separately: for hoarding (Fujiki and Tomura [2017], and section 2 of this paper), for daily one-off payments (Fujiki and Tanaka [2018a,b]), and for regularly scheduled payments (Fujiki [2018]). Specifically, we obtained the following results.

First, using aggregate data on cash in circulation in Japan, we find that cash hoarding could represent as much as 42% of the total cash in circulation if we assume that the hoarding of 10,000-yen notes began in 1995 and that the transaction demand for 1,000-yen and 10,000-yen notes will increase at the same growth rate. If we assume a semi-log cash demand function, there is a structural break in the cash demand in 1996 or 1999, which is consistent with an accelerating demand for cash above the nominal economic growth rate at the time. If we assume log-log cash demand function, there is a structural break in cash demand in 2003, 2004, or 2006.

[14] See footnote 13 for the source of numbers of households in Japan.

Second, empirical evidence from the Japanese household survey data suggests that the possible decreases in cash demand from the substitution of cash for noncash payment means for both day-to-day transactions and regular payments would not be very large. Our back-of-envelope calculations suggest that the substitution effects represent just 0.46% and 0.51% of the total cash in circulation in 2014, respectively. Note that as cash hoarding could represent as much as 42% of the total cash in circulation, any reduction in cash demand, if it ever took place, should imply a reduction in cash demand for saving purposes.

Based on this evidence, we argue that the BOJ should be more mindful about any reduction in cash hoarding, for example, due to an increase in the policy interest rate in the future, than about the substitution of cash for credit cards for daily transactions or regular payments, when forecasting the trends in cash usage in Japan.

An important reservation is that our evidence concerning the substitution of cash for noncash payment methods draws on the technology available in the period 2007–2014. The existing settlement service offered by Japanese private banks facilitates safe and efficient daily transactions using cash and electronic money for small-value transactions, and credit cards for high-value transactions. It also makes possible safe and efficient regular payments using bank account transfers or credit cards. Going forward, the BOJ's continuing policy of Quantitative and Qualitative Monetary Easing with Yield Curve Control combined with population aging may change the retail payments landscape in Japan. This is because the costs of ATMs and bank branches could become prohibitive for Japanese banks wishing to retain the current structure of settlement services. It would certainly be possible to reduce the demand for cash for P2P transactions if some new technology were to prevail, such as P2P electronic money transfers using QR codes in a smart phone app developed by three large Japanese banks. Let us make another back-of-envelope calculation to infer the impact on aggregate demand for cash if all ATMs were displaced due to the spread of transactions based on QR codes. Suppose that ATMs held by Japanese banks and Japan post bank (136,994 units as of 2016) have 25 million yen of banknotes per each unit on average, and ATMs held by three major convenience stores and AEON bank (53,482 units) have 10 million yen of banknotes per each unit on average. If these ATMs were displaced, the demand for cash would fall by about 4 trillion yen, or about 4% of the total cash in

circulation as of 2014.[15] Note also that while the BOJ has not announced a plan to issue central bank digital currency (CBDC) to the public (see Amamiya (2018)), CBDC could reduce the demand for cash for daily transactions if it works as a costless medium of exchange. However, it is unclear whether CBDC could replace mattress deposits if they are account based and interest bearing because they lack anonymity.

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[15] See the currency in the ATM held by the Japanese banks http://www.oeildemouche.net/hokuyo17.html. I assume the banknotes in the ATMs in convenience stores are about 50% of those in the banks. The number of ATMs are taken from https://www.zenginkyo.or.jp/fileadmin/res/abstract/stats/year1_01/cont_2017/nenpo2907.xls for banks, and websites of Seven-bank, E-net, Lawson and Aeon bank.

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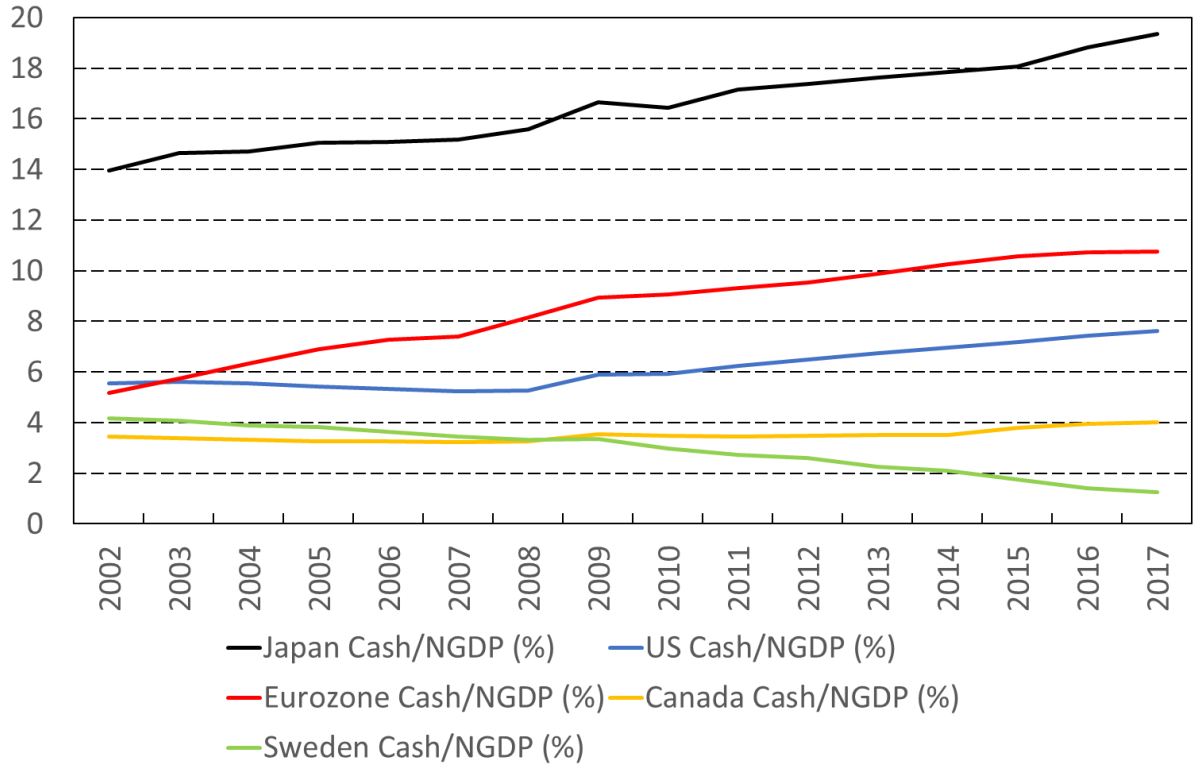
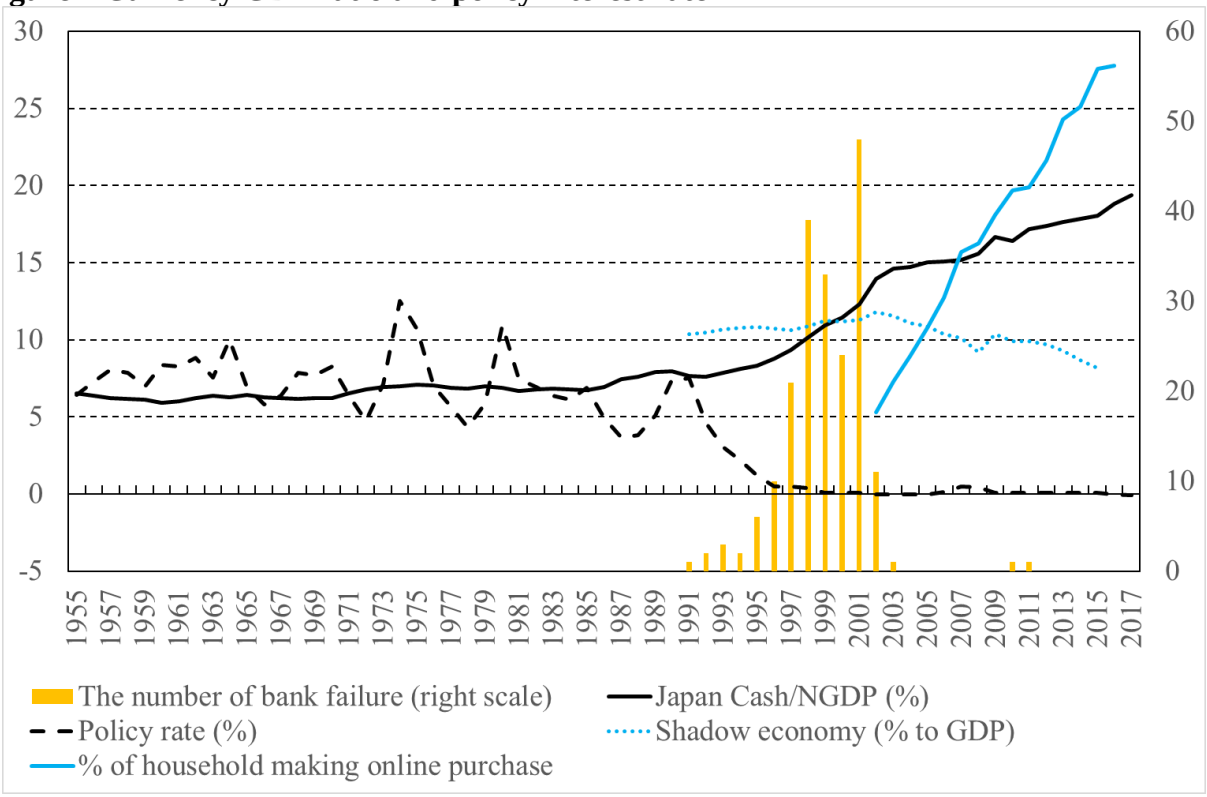
Figure 1 Currency to GDP ratio in Japan, US, Eurozone, Canada and Sweden



Source: Bank of Japan, Cabinet Office of Japan, European Central Bank, Board of Governors of the Federal Reserve System, Bank of Canada, International Monetary Fund, and author's calculations.

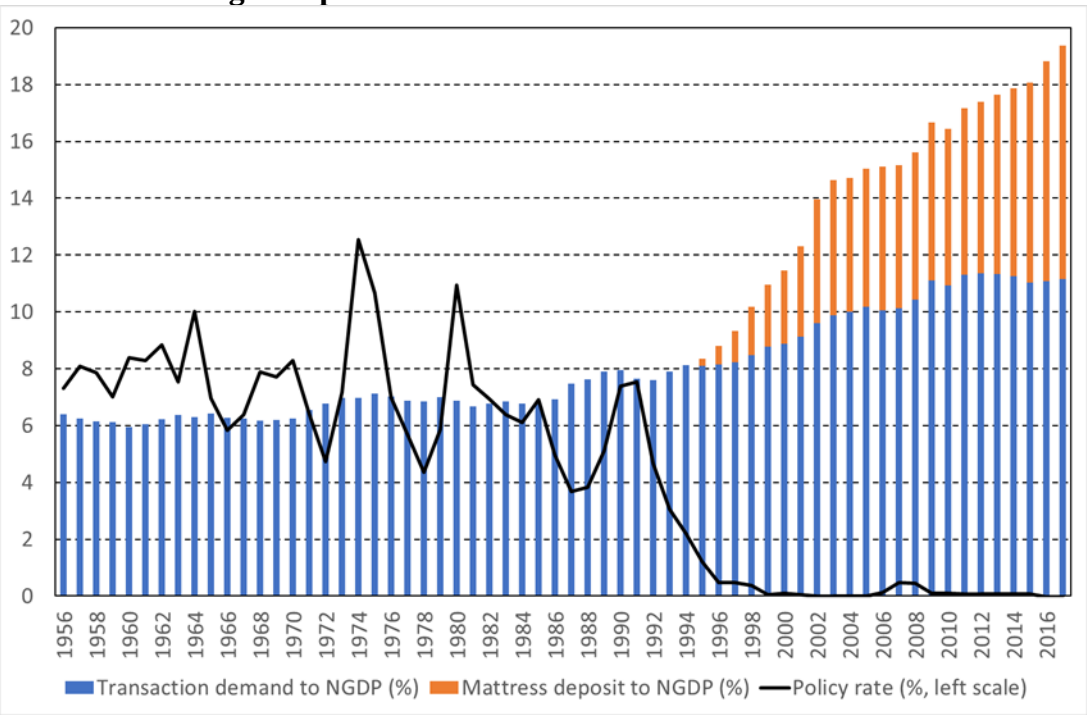
Figure 2 Currency GDP ratio and policy interest rate



Source: Bank of Japan, Cabinet office, Deposit Insurance Corporation of Japan, Medina and Schneider (2018), Ministry of Internal Affairs and Communications of Japan. .

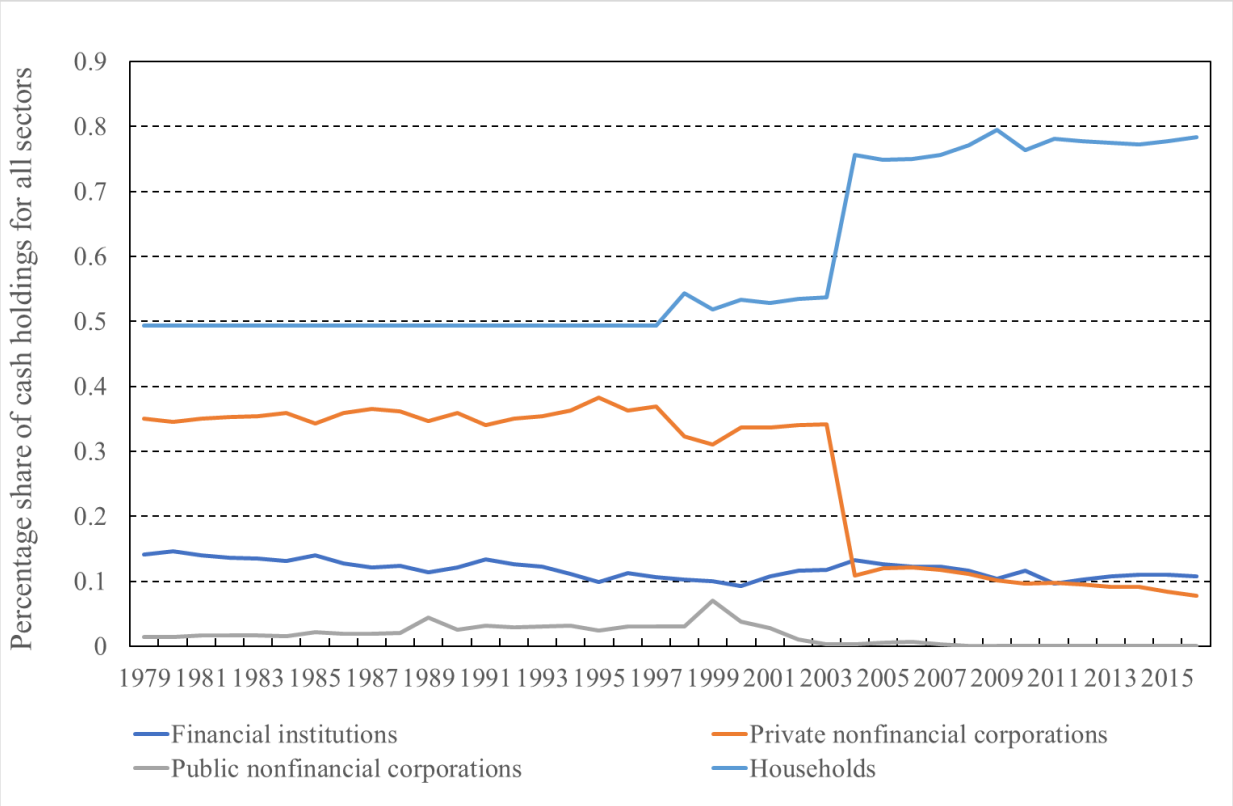
Notes: Japanese policy interest rates uses the following series: 1955–1959, basic discount and loan rate; 1960–1984, call rate, collateralized overnight, average; 1985–2017, call rate, uncollateralized overnight, average. Nominal GDP for each year uses the following series: 2011 SNA data for 1980–2017, extended with the annual growth rates in 1968 SNA data for 1955–1979, 2017 data uses first quick estimates. The number of bank failure is from the Deposit Insurance Corporation of Japan. The size of shadow economy is from Medina and Schneider (2018). The percentage of household making online purchases are from White paper on Information and Communications in Japan 2017, Ministry of Internal Affairs and Communications of Japan.

Figure 3 Cash hoarding in Japan



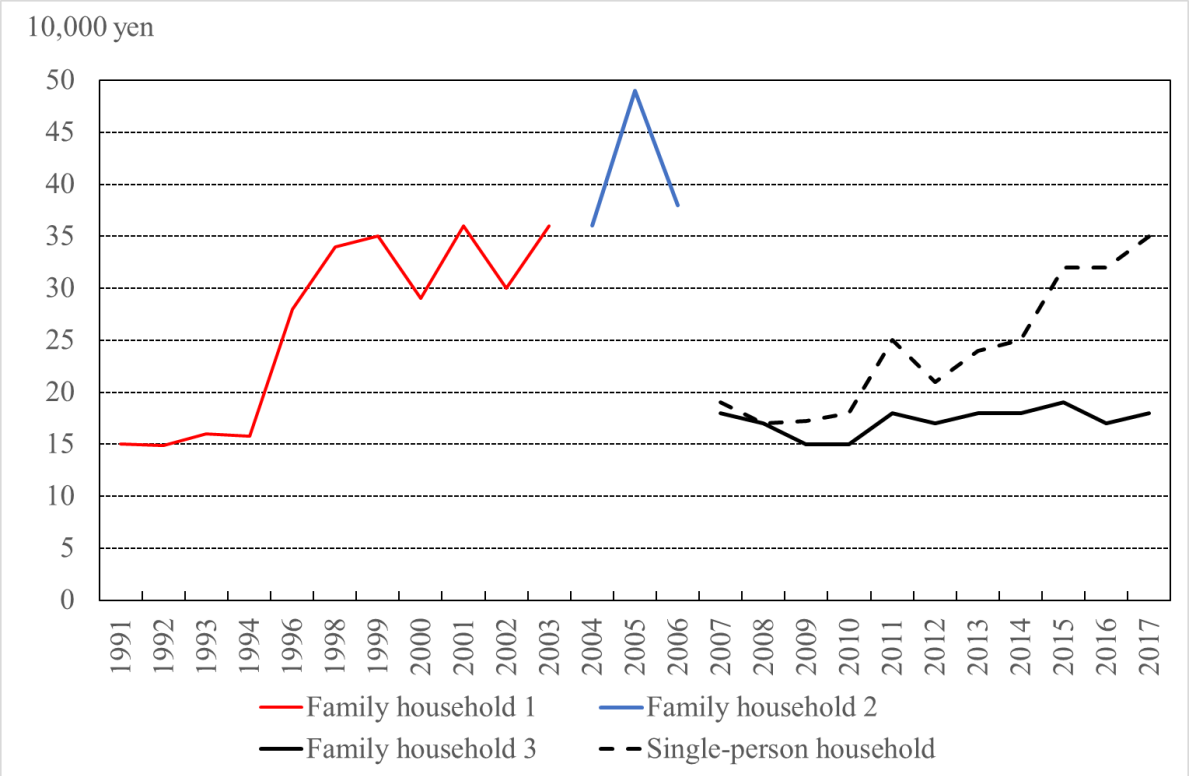
Source: Bank of Japan, Cabinet Office of Japan, and author's calculations.

Figure 4 Cash holdings by sector: the FFA



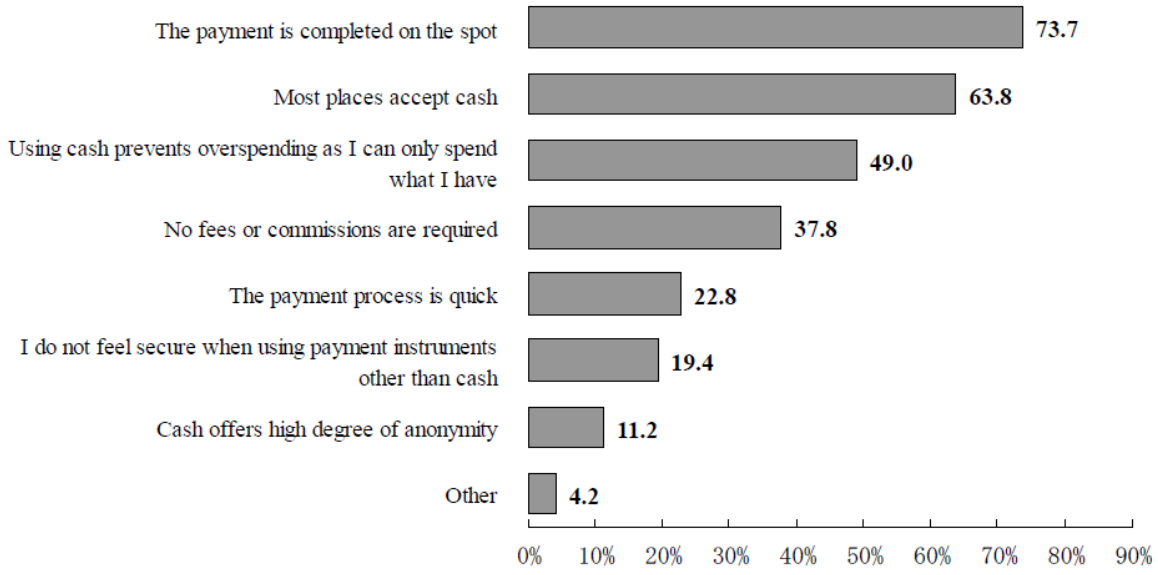
Source: Flow of Funds Accounts, Bank of Japan.
Note: Data in Figure 4 measured at the end of fiscal year; therefore, the data in 2004 corresponds to the first data point of the revised data as of March 31, 2005.

Figure 5 Average cash holdings by households



Source: Survey of Household Finances.

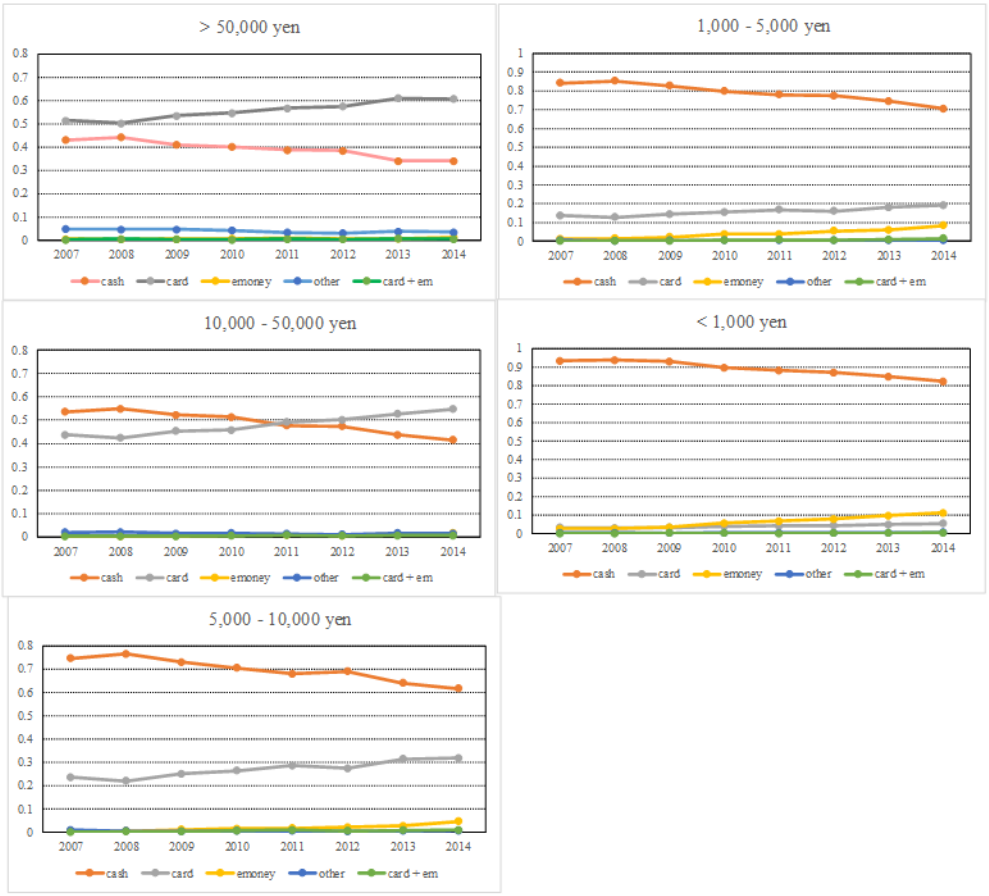
Figure 6 Reasons to use cash for daily payments



Note: 1. Multiple answers were allowed.

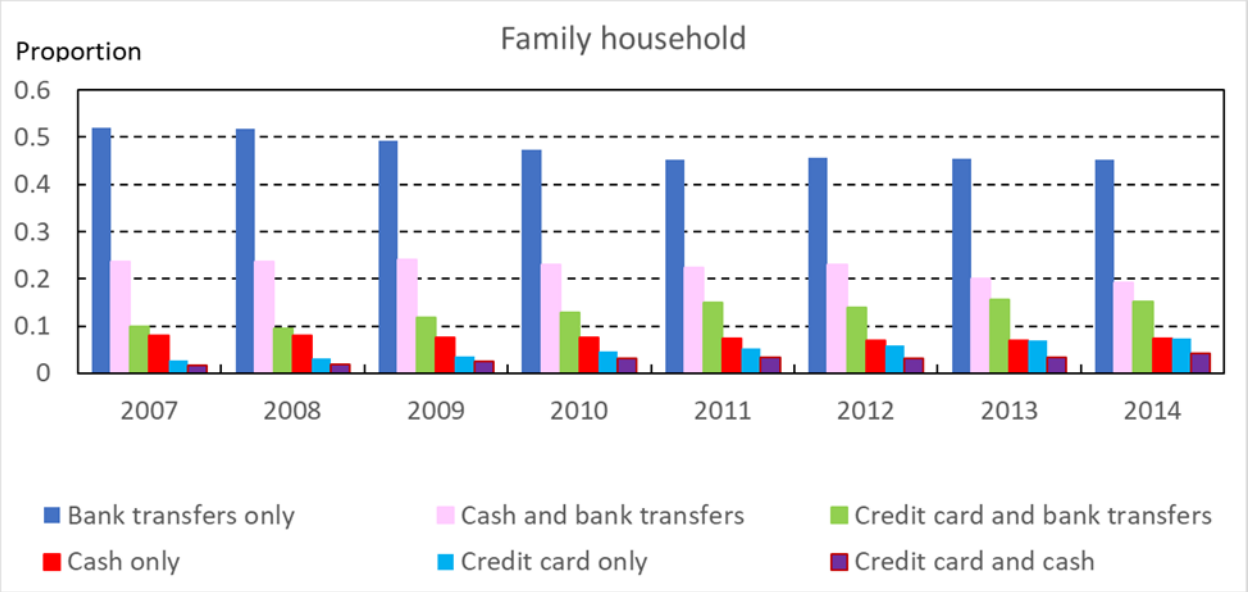
Source: Bank of Japan, 37rd Opinion Survey on the General Public's Views and Behavior, Question #24, http://www.boj.or.jp/en/research/o_survey/data/ishiki1804.pdf.

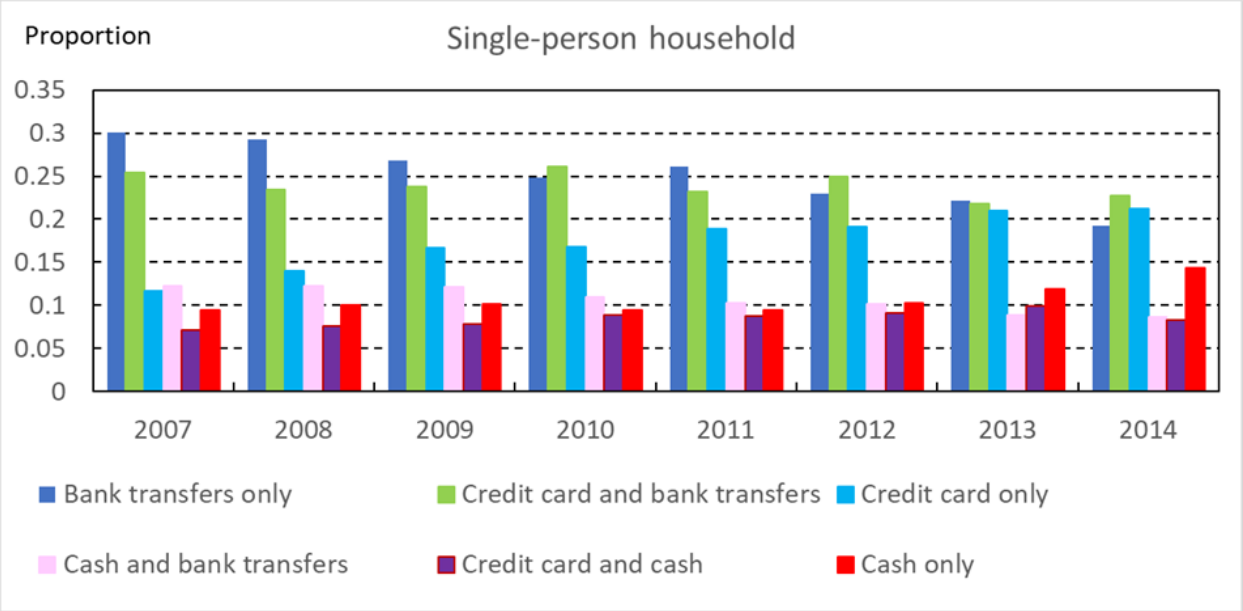
Figure 7 Proportion of observations for aggregate payment method choice for day-to-day transactions



Notes: ‘cash’ is respondents choosing cash exclusively, ‘card’ is credit card exclusively, cash and credit card, or credit card and other, ‘emoney’ is electronic money exclusively, cash and electronic money, or electronic money and other, ‘other’ is other exclusively or cash and other, ‘card + em’ is credit card and electronic money.
Source: Fujiki and Tanaka (2018b).

Figure 8 Proportion of observations for payment method choice for regular payments





Source: Fujiki (2018).

Table 1: Summary statistics

	Mean	S.E.	Minimum	Maximum	N
lncr	10.016	1.074	7.920	11.541	63
lntranscr	9.888	0.932	7.920	10.989	63
lnyr	12.439	0.755	10.650	13.182	63
policyrate	4.424	3.646	-0.048	12.539	63
lnpolicyrate	0.273	2.567	-7.195	2.529	61
orddep	1.177	1.074	0.001	3.000	63
lnorddep	-1.212	2.476	-6.908	1.099	63

Note: S.E. – standard error.

Table 2: ADF test results

	ADF statistics	P-value	Lag	Time trend	N
lncr	-2.057	0.570	1	yes	61
lntranscr	-1.440	0.849	1	yes	61
lnyr	-2.167	0.509	1	yes	61
policyrate	-4.130	0.225	3	yes	59
lnpolicyrate	-2.886	0.167	1	yes	61
orddep	-2.854	0.178	3	yes	59
lnorddep	-2.933	0.152	3	yes	59

Table 3 Engel–Granger test results

model	Z(t)	Critical values 1%	5%	10%
lncr lnyr policyrate	-2.221	-4.535	-3.881	-3.553
lncr lnyr lnpolicyrate	-1.486	-4.543	-3.886	-3.557
lncr lnyr orddep	-1.385	-4.535	-3.881	-3.553
lncr lnyr lnorddep	-2.725	-4.535	-3.881	-3.553
lntranscr lnyr policyrate	-2.485	-4.535	-3.881	-3.553
lntranscr lnyr lnpolicyrate	-1.686	-4.543	-3.886	-3.557
lntranscr lnyr orddep	-1.953	-4.535	-3.881	-3.553
lntranscr lnyr lnordep	-2.712	-4.535	-3.881	-3.553

Table 4 Gregory and Hansen test results

lncr lnyr policyrate				Asymptotic critical values		
	Test statistic	Breakpoint	Date	1%	5%	10%
ADF	-5.24	45	1999	-5.97	-5.5	-5.23
Zt	-5.27	45	1999	-5.97	-5.5	-5.23
Za	-37.02	45	1999	-68.21	-58.33	-52.85
lncr lnyr lnpolicyrate				Asymptotic critical values		
	Test statistic	Breakpoint	Date	1%	5%	10%
ADF	-6.28	52	2006	-5.97	-5.5	-5.23
Zt	-6.33	52	2006	-5.97	-5.5	-5.23
Za	-47.97	52	2006	-68.21	-58.33	-52.85
lncr lnyr orddep				Asymptotic critical values		
	Test statistic	Breakpoint	Date	1%	5%	10%
ADF	-5.44	42	1996	-5.97	-5.5	-5.23
Zt	-5.35	42	1996	-5.97	-5.5	-5.23
Za	-40.05	42	1996	-68.21	-58.33	-52.85
lncr lnyr lnorddep				Asymptotic critical values		
	Test statistic	Breakpoint	Date	1%	5%	10%
ADF	-5.09	49	2003	-5.44	-4.92	-4.69
Zt	-4.95	50	2004	-5.44	-4.92	-4.69
Za	-35.75	50	2004	-57.01	-46.98	-42.49
lntranscr lnyr policyrate				Asymptotic critical values		
level shift	Test statistic	Breakpoint	Date	1%	5%	10%
ADF	-4.87	50	2004	-5.44	-4.92	-4.69
Zt	-4.56	49	2003	-5.44	-4.92	-4.69
Za	-27.44	49	2003	-57.01	-46.98	-42.49
lntranscr lnyr lnpolicyrate				Asymptotic critical values		
level shift	Test statistic	Breakpoint	Date	1%	5%	10%
ADF	-4.47	52	2006	-5.44	-4.92	-4.69
Zt	-4.45	52	2006	-5.44	-4.92	-4.69
Za	-27.88	52	2006	-57.01	-46.98	-42.49
lntranscr lnyr orddep				Asymptotic critical values		
level shift	Test statistic	Breakpoint	Date	1%	5%	10%
ADF	-4.13	50	2004	-5.44	-4.92	-4.69
Zt	-4.23	48	2002	-5.44	-4.92	-4.69
Za	-25.41	48	2002	-57.01	-46.98	-42.49
lntranscr lnyr lnorddep				Asymptotic critical values		
level shift	Test statistic	Breakpoint	Date	1%	5%	10%
ADF	-4.32	49	2003	-5.44	-4.92	-4.69
Zt	-4.28	50	2004	-5.44	-4.92	-4.69
Za	-27.37	50	2004	-57.01	-46.98	-42.49

Table 5 Dynamic and static OLS results for equations (1) and (2)

	DOLS	DOLS	SOLS	DOLS	DOLS	SOLS	DOLS	DOLS	SOLS	DOLS	DOLS	SOLS
Choice of interest rate	policy rate			lnpolicy rate			orddep			lnordep		
lnyr	1.001***	1.019***	1.091	1.045***	1.048***	1.087	0.996***	1.026***	1.078	0.964***	0.982***	1.049
	(0.0220)	(0.0164)		(0.0264)	(0.0172)		(0.0164)	(0.00983)		(0.0322)	(0.0285)	
Interest rate	-0.0365***	-0.0310***	-0.0194	-0.0973***	-0.0872***	-0.082	-0.0684***	-0.0565***	-0.0333	-0.125***	-0.119***	-0.100
	(0.00427)	(0.00445)		(0.00263)	(0.00329)		(0.0119)	(0.0106)		(0.0111)	(0.0108)	
F2D.lnyr	-0.281			-0.318**			-0.440***			-0.347		
	(0.203)			(0.126)			(0.116)			(0.293)		
FD.lnyr	-0.425***	-0.624***		-0.111	-0.438***		-0.288***	-0.377***		-0.387*	-0.484*	
	(0.163)	(0.144)		(0.237)	(0.101)		(0.0761)	(0.109)		(0.215)	(0.289)	
D.lnyr	-0.789***	-0.623***		-0.499***	-0.493***		-0.624***	-0.511***		-0.628***	-0.595***	
	(0.138)	(0.105)		(0.157)	(0.129)		(0.0492)	(0.0604)		(0.115)	(0.156)	
LD.lnyr	-0.396**	-0.446**		-0.292**	-0.363**		-0.447***	-0.537***		-0.359***	-0.415*	
	(0.170)	(0.221)		(0.141)	(0.144)		(0.114)	(0.118)		(0.130)	(0.227)	
L2D.lnyr	0.0838			0.0271			-0.136			0.122		
	(0.271)			(0.159)			(0.0858)			(0.237)		
F2D.interest rate	-0.00198			-0.0164***			0.00704			-0.0225**		
	(0.00299)			(0.00408)			(0.00479)			(0.0109)		
FD.interest rate	-0.00298	-0.00349		-0.0214***	-0.0170***		0.00525	0.00681		-0.0275***	-0.0345***	
	(0.00440)	(0.00273)		(0.00394)	(0.00188)		(0.00548)	(0.00534)		(0.0104)	(0.0123)	
D.interest rate	0.0244***	0.0185***		0.0538***	0.0377***		0.0727***	0.0556***		0.0835***	0.0770***	
	(0.00647)	(0.00485)		(0.00885)	(0.00811)		(0.0132)	(0.0104)		(0.0117)	(0.0112)	
LD.interest rate	0.0145***	0.0131***		0.0382***	0.0185***		0.0339***	0.0314***		0.0493***	0.0504***	
	(0.00499)	(0.00403)		(0.00780)	(0.00631)		(0.00931)	(0.0103)		(0.00978)	(0.00897)	
L2D.interest rate	0.00930**			0.0179			0.0217***			0.0375***		
	(0.00386)			(0.0113)			(0.00503)			(0.00782)		
_cons	-2.342***	-2.604***	-3.650	-2.989***	-3.037***	-3.587	-2.389***	-2.816***	-3.571	-2.112***	-2.334***	-3.238
	(0.286)	(0.220)		(0.340)	(0.224)		(0.225)	(0.133)		(0.435)	(0.370)	
N	41	42	44	48	49	51	38	39	41	45	46	48
Test lnyr = 1	0	1.36		2.96	7.91		0.07	7.11		1.21	0.39	
P-value	0.9574	0.2442		0.0853	0.0049		0.785	0.0077		0.2706	0.5314	

Standard errors in parentheses

* p<0.10 ** p<0.05 *** p<0.01

Table 6 Cash demand by individual firms

Per establishment
In thousand yen

	Manufacture			Wholesale and retail trade			Accomodation, food services			Services		
Year	Cash	Sales	cash ratio	Cash	Sales	cash ratio	Cash	Sales	cash ratio	Cash	Sales	cash ratio
2011	551	10,572	0.052	497	17,669	0.028	390	8,424	0.046	295	4,874	0.061
2012	366	9,403	0.039	518	17,759	0.029	304	8,772	0.035	341	5,436	0.063
2013	334	9,455	0.035	467	17,202	0.027	246	8,666	0.028	244	4,712	0.052
2014	393	9,806	0.04	585	16,203	0.036	345	8,602	0.04	257	5,353	0.048
2015	428	9,994	0.043	456	15,650	0.029	395	9,457	0.042	255	4,888	0.052
2016	376	10,461	0.036	449	14,895	0.03	344	8,532	0.04	260	5,063	0.051

Source: Survey of Private Enterprise Economy, Ministry of Internal Affairs and Communications.