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Evidence from Bank Account Transaction Data in Japan

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Effects of Bank Branch/ATM Consolidations on Cash Demand: Evidence from Bank Account Transaction Data in Japan

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Abstract

This study considers the retrogression event of convenience for bank users as a natural experiment and analyzes the effect of this event on cash demand. Using bank account transaction data, we find that branch/ATM consolidations reduce not only the amount of cash withdrawals by past users but also the total expenditure and inflows that include non-cash transactions by the same amount. This implies that the retrogression in convenience possibly caused users to shift to other banks for their daily payments. We also document facts about cash withdrawals from ATMs using bank account transaction data.

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Keywords: money demand, ATM, natural experiment

*Waseda University (E-mail: kozo.ueda@waseda.jp). The data was made available through a strict contract between Mizuho Bank and Waseda University in the form of a consignment agreement, and was analyzed in a setting where measures were taken to prevent the identification of individuals, such as masking and other anonymous processing. The author would like to thank Hiroshi Fujiki, So Kubota, Yuta Toyama, the staff at Mizuho Bank, and workshop participants at Yokohama City and Waseda Universities for comments and Ichiro Sakurai and Haruka Takei for their research assistance. The author is also grateful for financial support from the JSPS (16KK0065, 19H01491). The views and opinions expressed in this paper are solely those of the author and do not reflect those of Mizuho Bank.

1 Introduction

Although the development of financial technology has led to the substitution of cash with non-cash, the importance of cash remains large. In fact, the ratio of the amount of cash in circulation to nominal GDP continues to rise in Japan and the U.S. (Figure 1). In particular, Japan has a high cash preference (low cashless ratio) compared to other countries (Figure 2). Nevertheless, the trend toward non-cash transactions is steadily progressing. In addition to the improvement of cashless payment technology, the need for contactless payments is increasing due to the COVID-19 pandemic in 2020. Further, private banks are decreasing the number of branches and Automatic Teller Machines (ATMs), partly owing to the need to reduce costs under the long-term recession and low interest rates, although new type of banks, whose main business is to provide ATM services, such as Seven Bank, are emerging by taking advantage of the large number of convenience stores they own (Figure 3). How and to what extent does the decline in the number of private banks' branches and ATMs affect the shift from cash to non-cash behavior?

In this paper, we focus on the retrogression event of convenience for bank users as a natural experiment and analyze the effect of this event on the cash demand by bank users. We use the transaction data of bank users provided by Mizuho Bank, one of the three largest banks in Japan. The data record all transactions conducted by Mizuho Bank users, such as ATM withdrawals, salary receipt, utility bill payments, and bank transfers. In addition, for teller windows and ATMs, branch and terminal information are also available, making it possible to extract individuals affected by branch and ATM consolidation. Retrogression events are macroscopically endogenous. However, for individual users they are exogenous and their timing is random. Therefore, by conducting a difference-in-differences (DID) analysis with time dummies, we can analyze the causal effect of the event of branch and ATM consolidation on user behavior, especially cash demand.

The main results are as follows. First, the consolidation of a bank branch reduces the amount of cash withdrawals by about 30% for those who have used that branch in the past. The impact increases with the distance between the branch to be consoliated and the branch to be consolidating: the magnitude is about four percentage points stronger for each additional kilometer of distance. Further, the impact is persistent and heterogeneous among users. In terms of age, older adults were more severely affected by the discontinuation of branches than the young. In addition, users with smaller assets and income were relatively more affected.

The second and most important finding is that branch consolidations do not necessarily reduce cash demand at the macro level. Past users decrease their total expenditure (outflows), including non-cash payments, by the same amount as they decrease their cash withdrawals.

Furthermore, they decrease their total inflows by the same amount. This suggests that they may have switched their daily payments to other financial institutions, for example by changing their payroll accounts resulting from the discontinuation of branches, and that the economy as a whole may not be experiencing a decline in cash demand.

This paper's secondary contribution is to use valuable bank transaction data to present basic facts about cash demand, especially ATM use. While most existing studies are based on questionnaires, the Mizuho Bank data provide a picture of actual transactions. The impact of the COVID-19 can also be analyzed. We find that there is significant heterogeneity in cash use across demographics. Differences by age are particularly large. The data show that the younger the age, the more frequently they use ATMs and the higher is the percentage of their cash use. Although the COVID-19 pandemic caused a sharp decline in the number of ATM visits and the ratio of cash use among young people, it was only a temporary movement under the declared state of emergency. In contrast, there was no change in cash demand among older adults.

Relevant previous studies are as follows. The most relevant studies on cash demand in Japan are by Fujiki and Tanaka (2014, 2018) and Fujiki (2021), who use the results of surveys to consider cash and non-cash demand (see also Japanese Bankers Association 2012). Humphrey (2010) surveys the impact of price factors such as surcharge and loyalty reward on individuals' choice of payment method and finds that evidence is mixed: price effects are large in Hannan et al. (2003), Borzekowski et al. (2008), and Zinman (2009), while they are small in Humphrey et al. (2001), Bolt et al. (2008), Ching and Hayashi (2010), and Simon et al. (2010). Institutional environment, geographical size, or culture, and sociodemographic factors are taken into account in Humphrey (2010) and Bagnall et al. (2016). This study considers branch and ATM consolidation events as a factor for determining cash demand and payment method, which is the factor that sets back the convenience of cash for bank users. Not to mention, it is different from the above factors. Branch and ATM consolidation is an exogenous event whose timing differs from user to user, making it possible to conduct a clear causal analysis. In addition, the above studies analyze the results of the survey based on questionnaires to some subjects. We use bank data to analyze cash demand based on actual transactions.[1]

There has been a steady increase in the number of studies using bank transaction data. In particular, a previous study using the same Mizuho Bank data is that of Kubota, Onishi, and Toyama (2021). They measure the marginal propensity to consume, associated with the

[1] Aragno and Welte (2012) and Wakamori and Welte (2017) use the Bank of Canada Methods-of-Payment survey data, which include a 3-day shopping diary. Chen et al. (2021a) measure the distances between First Nations reserves and their closest cash sources such as ATMs, which could be useful to study how shoe leather costs influence cash demand.

government's lump-sum benefit payment under the COVID-19. In this study, we also refer to their causality analysis method. The effects of the COVID-19 are also studied using bank transaction data by Cox et al. (2020) for the U.S., Andersen et al. (2022) for Denmark, and Landais et al. (2020) for France. As surveyed by Andersen et al. (2022), there are many other analyses using financial apps and credit card transaction data. However, to the best of our knowledge, there is no analysis of cash demand using actual bank transaction data rather than surveys, especially no causal analysis using natural experiments. In this regard, the contribution of this paper is that it reports the stylized facts about cash demand using bank transaction data.

The structure of this paper is as follows. Section 2 describes the data and then summarizes the facts about cash demand. Section 3 explains the analytical methodology. Section 4 reports the results of the analysis, and Section 5 concludes.

2 Data

2.1 Data Descriptions

We use data from Mizuho Bank. Mizuho Bank is one of the three largest banks in Japan, with about 24 million accounts held by individual customers (one out of every five people).[2] The data record all transactions involving Mizuho Bank, including ATM withdrawals, payroll receipts, utility bill payments, and bank transfers. For teller windows and ATMs, the information on branches and terminals is also available, making it possible to extract individuals who have used discontinued branches and ATMs. In addition to the balance of deposits at the end of each month, information such as annual income, year of birth, gender, and registered address data (at the municipal level) is also recorded. The time frame is from June 2018 to March 2021, including the period of the COVID-19 pandemic. In the following analysis, we focus on two variables in particular. One is cash deposit withdrawals from ATMs. The other is total outflows (proxy for expenditures), which includes non-cash payments such as withdrawals from credit card payments, interbank transfers, and automatic utility bill withdrawals.

Here, let us explain the fees for cash withdrawals using ATMs. The fees are not necessarily zero, unlike what is widely seen in the West. When withdrawing cash from a Mizuho Bank ATM, there is no fee during daytime hours on weekdays. However, after-hours withdrawals incur a fee of 110 yen or 220 yen (around 1 or 2 US dollars). Withdrawals from ATMs of other banks, including convenience stores, also incur a fee of 110 yen or 220 yen, except for some affiliated banks. However, depending on conditions, such as deposit balance and whether one receives a salary, the fee may be reduced to zero for a limited number of ATM use.

[2] https://www.mizuho-fg.co.jp/saiyou/company/keyfigures/index.html

Some caveats in the data are as follows. Data prior to May 2018 are unavailable because of system modifications. Users are dispersed across the country but are concentrated in metropolitan areas when compared to the census. All cash withdrawals are recorded, but we cannot know the purpose of the withdrawals. For individuals who have credit cards linked to Mizuho bank, we can obtain a breakdown of their spending from their card statements. However, the coverage is not wide enough to be included in this analysis. In addition, information on transactions at other financial institutions, especially securities companies and postal savings accounts, is not available. Since many individual customers hold accounts at institutions other than Mizuho Bank, the deposits and withdrawals recorded in this data do not necessarily capture all of an individual's transactions. In particular, it should be noted that there is a large omission of information on financial assets such as stocks and transfers within the household (e.g., parent to child, husband to wife) are recorded as inflows or outflows.

2.2 Facts about Cash Demand

First, we use the data to organize the facts about bank account usage, especially ATMs. It should be noted that unlike previous studies such as Arango and Welte (2012) and Fujiki (2021), we observe actual bank transactions.

The users we analyzed in this section are as follows. To exclude dormant accounts, we select the accounts that record at least six outflows during 2019 and have the last account use date of 2020 or later. In addition, because of the large number of observations, we select the accounts that have a registered address in Chiba Prefecture (a prefecture adjacent to Tokyo). The number of accounts is 545,849.

Table 1 shows the descriptive statistics in 2019. The maximum and minimum values are not shown to maintain anonymity. The number of outflows is 96 in the mean and 80 in the median, whereas the number of cash withdrawals from ATMs is 42 in the mean and 25 in the median. Using the Nikkei Financial RADAR 2020 survey, Fujiki (2021) documents that around 30% of respondents use bank ATMs once a month and 2-3 times a month, respectively. In Canada, Arango, and Welte (2012) report that individuals use ATMs as often as once a week, which is comparable to our value. The ratio of cash withdrawals from ATMs to total outflows is 0.42 for mean. Wealth and income are the total deposits and yearly income of account holders recorded as of December 2019, with means of 3.5 million yen and 2.2 million yen, respectively. The mean age is 50.6 years.

Distribution There is considerable heterogeneity in cash use across demographics. Differences by age are particularly large. In recent years, younger people have been more active in adopting contactless payment methods and are said to be moving away from cash. Therefore, we check the heterogeneity in the number and amount of ATM use for the month of January 2019 by demographic group. Figure 4 depicts the distribution of the number of ATM use and the amount of cash withdrawals on the horizontal axis (for ease of viewing, it is not a histogram but a continuous density). The upper left panel shows that the younger the age, the more frequently they use ATMs. The upper right panel shows the distribution of the amount of cash withdrawn per ATM visit, showing that the younger the age, the smaller the amount withdrawn per visit. In particular, there is a peak at 10,000 yen and 20,000 yen. In contrast, the older adults show a peak at 100,000 yen. Due to the upper limit of the withdrawal amount, there are no withdrawals exceeding one million yen. The bottom two panels show the wealth and income categories: zero, over zero but less than 25%, over 25% but less than 50%, over 50% but less than 75%, over 75% but less than 90%, and over 90%. It can be seen that the lower their assets and income, the more frequently they use ATMs.

This is confirmed by a simple estimation in Table 2. The dependent variable is either the logarithm of (the number of ATM use +1) or the logarithm of (the amount of ATM cash withdrawn per visit +1) for January 2019. Meanwhile, the explanatory variables are various measures of users' characteristics. For the number of ATM use, the coefficients of both age and income are significantly negative, suggesting that the lower the age and the lower the income, the higher the frequency of ATM use. The coefficient for the dummy of a female is negative, suggesting that females use ATMs less frequently, and there is no significant relationship for wealth. For the amount of ATM cash withdrawal per visit, the signs of the coefficients are reversed, except for the coefficient on the gender dummy. This suggests that females withdraw a smaller amount of cash per ATM visit. According to Fujiki (2021), there is no significant relationship between the number of ATM use and income, wealth, or age at the 5% level. Nevertheless, it is important to note that he controls for variables that are not observable in this paper, and in particular, reports significant relationships with the presence of a spouse and whether or not a person works part-time. In a study in Canada, Arango and Welte (2012) report that younger people use ATMs more frequently and make smaller withdrawals per ATM visit. In terms of income dependence, individuals with much lower or much higher incomes tend to use ATMs less frequently.

Time-Series Developments The environment for cash demand is changing dramatically, with improvements in cashless payment technology, as well as the COVID-19 increasing the need for contactless payments. Therefore, we use Figure 5 to review the monthly changes from January 2019 to March 2021. The upper left panel shows the time-series change in the number of ATM use for each month. It demonstrates that the younger the age, the higher the level. In addition, it also shows that there was a sharp decline in the number of ATM use in April and May 2020. This overlaps with the period from April 7 to May 25, 2020, when the first emergency declaration was in effect in Tokyo and Chiba Prefecture. The second emergency declaration was from January 8 to March 21, 2021, and the figure shows a drop in the number of ATM use during the same period. The shift from cash to non-cash payments during the COVID-19 has been documented by a number of studies (see Coyle, Kim, and O'Brien 2021 for the U.S.; Chen et al. 2021b for Canada; Wisniewski et al. 2021 and Kotkowski and Polasik 2021 for Europe).

It is interesting to note that the decrease in the number of ATM use due to the COVID-19 is not observed among the older adult population. The older adults, who are more susceptible to the infectious disease, should have greater incentives to refrain from activities including visits to ATMs. However, the older adults do not use ATMs frequently (about once a month on average, as shown in the figure), and the effect of the infectious disease is not confirmed.

If the COVID-19 increases the shoe leather cost, then the amount of ATM cash withdrawn per visit should increase. However, the upper right panel does not show any such change. The lower left panel shows the time series of outflows, including non-cash payments, but there is no significant change either.

Finally, the lower right panel plots the cash usage ratio. The cash usage ratio is calculated by dividing the amount of cash withdrawn from ATMs in each month by the amount of outflows in the same month. From this figure, three facts can be observed. First, the cash use ratio is higher among the young: it is about 0.5 among those aged 15-29, while it is about 0.3 among those aged 60-74. This is likely because many younger people are unable to get a credit card. Even if they could get one, the limit would be too small, while older people use credit cards more and pay utility bills, communication charges, and send money to their children by direct deposit rather than cash.

A second observation is that when the COVID-19 first spread, there was a sharp decline in the proportion of young people using cash. However, the decline was temporary. The decline occurred in April and May 2020 but returned to March levels after the state of emergency was lifted. Using Japan's credit card JCB's transaction data, Omori and Watanabe (2021) conclude that the increase in online consumption is not irreversible, which is consistent with this result. They find that the increase in online consumption during the COVID-19 is due to the increase in online consumption among consumers who were already used to making purchases online and were worried about the risk of infection. This implies that the level of online consumption of these consumers is likely to return to pre-pandemic levels as the risk of infection recedes. Kotkowski and Polasik (2021) find similar results for Europe.

Third, the ratio of cash use is trending downward. This trend has already been observed before the COVID-19, since the beginning of our observation period. The decline in the cash use ratio is mainly pronounced among younger age groups, although a slight downward trend is also observed among older age groups.[3]

3 Effect of Bank Branch Consolidation on Cash Demand

In this section, we use bank branch consolidation as a natural experiment to draw causal inferences about its effect on cash demand.

3.1 Extraction of Consolidated Bank Branches and Users

In this and the following subsections, we explain the estimation method. First, we extract information on the consolidation of bank branches from the Mizuho Bank website. In this analysis, we consider a discontinued branch to be the one where a branch is consolidated within a different branch. The name of the branch remains, but is geographically consolidated into one. This excludes a mere relocation to a different address. Between December 2019 and November 2020, 33 branch consolidation events were observed. We also use Google maps to measure the straight line distance between the consolidated and consolidating branches. The average distance was about 10 km. See Appendix B for the detailed description of the data used for estimation, which includes the website that announces the consolidation of bank branches, the distribution of the timing of branch consolidation and the distance to the consolidation destination, and the descriptive statistics of the data.

Since the timing of consolidation is random and exogenous to the users, the causal effect of the branch consolidation can be examined by DID that includes the time effect. Of course, banks make endogenous decisions about which branches to consolidate and which to eliminate, and they must consider the fact that the branches to be eliminated have fewer users, are declining, or are closer to neighboring branches. However, such decisions are exogenous to the users and the timing is random.

After extracting the consolidated branches, we identify those who have used them in the past. First, we extract the store number of the consolidated branch. Second, we extract the ATM terminal number belonging to the store number whose last use date is recorded between one week before and the day of the consolidation. This is because some ATM terminals belonging to consolidated branches may continue to operate in the same location even after branch consolidation, which we exclude from the analysis. Third, we extract users who used the

[3]In Appendix A, we provide the fraction of users who did not withdraw cash for a certain period. From June 2018 to March 2020, the fraction is 13% for the age group of $60-74$, while it is only around 1.3% for the age group of $15-29$. However, the fraction of such users doubled for the latter age group for April 2020 to March 2021.

discontinued ATM terminals at least twice between June 2018 and the time of consolidation. Users who visited the branch but only conducted over-the-counter transactions and did not use the ATM terminal are not included in the analysis. The above steps identify 737,785 users.

3.2 Estimation Method

For each of the users (denote i), we record the amount of ATM cash withdrawals, outflows, and other variables of interest (denote y_{im}) on a monthly basis (denote m).

We estimate the following equation:

$$\Delta_{12}\log(y_{im}+1) = \alpha_m + \sum_{k=-4}^{12} \gamma^k D_{im}^k + \varepsilon_{im}, \tag{1}$$

where D_{im}^k is a dummy that takes one if $m - T_i = k$ and T_i denotes the month in which the branch for user i was consolidated. The index D_{im}^k takes zero otherwise. By including $k < (>)0$, we consider the effect of branch consolidation $|k|$ months before (after) the event. Coefficient γ^k indicates the extent to which y has changed before and after branch consolidation.

The user fixed effect can be eliminated by taking the log difference from the same month of the previous year, as shown in the equation above. The first term α_m represents the time effect. As we saw in Figure 5, it is extremely important to control for the time effect because there are considerable time changes in the estimation period. The data are a balanced panel of 22 months from June 2019 to March 2021. Even if a user stops using his/her Mizuho account after branch consolidation, his/her transaction records are in our data and used for estimation (in this case, $\log(y_{im}+1) = 0$ after branch consolidation). Estimation errors are clustered at the branch level.

Furthermore, we make a similar regression considering the distance between the consolidated and consolidating branches as

$$\Delta_{12}\log(y_{im}+1) = \alpha_m + \sum_{k=-4}^{12} \gamma^k D_{im}^k \times dist_{b(i)} + \varepsilon_{im}, \tag{2}$$

where $dist_{b(i)}$ represents the distance for branch $b(i)$ that was used by user i before consolidation. The coefficient γ^k indicates the magnitude of the change in the explained variable when the distance to the consolidating branch increases by 1 km.

3.3 Main Estimation Results

Columns (1) and (2) in Table 4 show the estimation results based on equations (1) and (2), respectively, where we use the amount of ATM cash withdrawals as y_{im}. Graphically, the left panel of Figure 6 plots the coefficient γ^k based on the regression of equation (1). The horizontal axis is k, indicating the month elapsed after branch consolidation, where 0 represents the month in which the branch consolidation occurred. This figure shows that branch consolidation causes a significant and persistent decrease in the amount of cash withdrawals from ATMs by users. The decrease is large, reducing cash withdrawals by about 30% on average for those who have used that branch in the past. In contrast, although not significant, we observe a rush to use ATMs before branch consolidation. One must note that according to the Mizuho bank website, Mizuho bank announces branch consolidation three to six months in advance. Thus, branch consolidation is an anticipated event for this period.

The right panel of Figure 6 plots the coefficient γ^k based on the regression of equation (2), which uses the distance between the consolidated and consolidating branches. The estimation results are similar to those without using distance. That is, a significant decrease in the amount of ATM withdrawals is observed after the branch consolidation. Specifically, the amount of ATM withdrawals decreases significantly starting six months after the branch consolidation, and that the magnitude of the decrease is about 4% per kilometer.[4] In addition, there is a significant rush to withdraw cash from ATMs two months prior to the consolidation.

A key identifying assumption in our research design is the parallel trend in ATM withdrawals between the users that differ in the timing of branch consolidation. Although our assumption of a parallel trend is not directly testable, there is supporting evidence that leads coefficients γ^k for $k = -4$ and -3 are statistically insignificant. This implies that users do not rush to withdraw cash three or more months before branch consolidation and there is no pre-trend difference in ATM withdrawals. It should also be noted that users who live in areas unrelated to consolidated branches may have different trends from those who experience the consolidation of branches; however, only the latter group of users is the subject of this analysis. The treatment group differs from the control group in the timing of branch consolidation.

In the following, the benchmark will be the case where a cross-term dummy with distance is used, instead of a simple dummy as the explanatory variable. We employ the number of ATM use as the dependent variable and find that the estimation results are similar to those when we employ the amount of ATM cash withdrawals, although the effects are quantitatively smaller, as shown in the left panel of Figure 7.

[4] It should be noted that 16 events, or almost half of the 33 events of branch consolidation in our data, occurred in two months, October and November 2020, and since the end of the estimation period is March 2021, we cannot obtain information six months after the branch consolidation ($k \geq 6$) for these events.

3.4 Effects on Outflows and Inflows: Possibility of a Shift to Other Financial Institutions

Columns (3) and (4) of Table 4 and Figure 7 show the estimation results when all outflows or inflows, including non-cash transactions, are used as the dependent variables. After the branch consolidation, both outflows and inflows decrease significantly, and by almost the same magnitude as the amount of ATM withdrawals. This suggests that resulting from the branch consolidation, users reduce their expenditures including non-cash payments. Furthermore, users may have also moved their accounts from Mizuho Bank to receive inflows such as salary and pension payments, transfers from other banks, and transfers within the family. The decline in all outflows and inflows widens in the six months following the branch consolidation. This may partially be due to the long procedures for changing transfer accounts. Indeed, we confirm that users' salaries decrease significantly six months after the branch consolidation, as shown in Appendix B. Users who did not make any transaction also increased after the consolidation.

This result suggests that a retrogression event that reduces the convenience of cash for bank users does not necessarily reduce cash demand. Branch consolidation decreases past branch users' cash withdrawals from Mizuho Bank's ATMs. However, at the same time, they are shifting their means of transactions to other financial institutions, which may not have reduced cash demand from a macro perspective.

Since our data do not reveal transaction records of other bank accounts, we cannot provide direct evidence of a shift in the means of transactions. We make two additional considerations in this regard. First, we measure the straight line distance (denote $dist^*_{b(i)}$) from the branch to be consolidated by Mizuho Bank to the nearest competitor branch and add it as an explanatory variable. As competitors, we assume that they are branches of the remaining two of the three major banks. Specifically, we add $D^k_{im} \times (dist^*_{b(i)} - dist_{b(i)})$ as an explanatory variable to equation (2). The estimation results are shown in Appendix B. The estimated coefficient tends to be negative and significant for a large k. This suggests that the closer the distance to the competitor, the smaller the decrease in the amount of withdrawals from ATMs due to branch consolidation. This result is somewhat inconsistent with the hypothesis that users shifted their means of transactions to other banks. We suspect this is because the two distance measures of $dist$ and $dist^*$ are highly positively correlated. Places where there are only coarse branches of Mizuho Bank are places with low population density, and inevitably there are only coarse branches of other banks.

Second, we cite the results of a survey study by Fujiki (2021). According to the survey on the impact of the discontinuation of ATMs, the two most common responses were to use other ATMs of the bank and the ones at convenience stores, at about 40% and 30% respectively. About 20%

of respondents said they would use the bank's Internet banking service, suggesting a decline in cash demand. About 10% of the respondents said they would reduce their transactions with that bank, and about the same percentage said they would increase their transactions with other banks. Fujiki (2021) also finds through estimation that those who say they will reduce their transactions with that bank are significantly related to the fact that the bank is one of the big three banks (including Mizuho Bank) and that they are female. No significant relationship has been found for age, assets, or income.

3.5 Heterogeneity

We examine the effect of branch consolidation on the amount of ATM cash withdrawals by user demographics. Figure 8 shows the estimation results. The decrease of cash withdrawals after branch consolidation is relatively large for users over 60 years old. This may be because as people get older, it becomes more difficult for them to walk to other branches. This makes them use less cash or shift to another bank, which is more convenient. Younger populations are more likely to travel to distant branches and actively use alternative methods, such as ATMs at convenience stores and train stations. Therefore, they are less affected by branch consolidation. The figure also shows that the effect of branch consolidation on the amount of ATM cash withdrawals tends to be greater for female users with less wealth and lower incomes.

3.6 Robustness Checks

We did several robustness checks as shown in Appendix B and C. As explained in Section 3.1, we extracted users who used the discontinued ATM terminals at least twice. We estimate equation (2) by extracting users who used the discontinued ATM terminals only once. The estimation result shows that the effect of branch consolidation on the amount of ATM cash withdrawals is not significant at the 1% level.

Next, we extract information on the discontinuation of ATM terminals differently from that of bank branch consolidation. In the previous method, we focused on the event of branch consolidation, which is a reasonably large event for banks and users. In contrast, the discontinuation of unmanned ATMs (sub-branches) is a relatively small event for them and is expected to occur frequently.

Since the information on discontinued ATM terminals is not kept in the database, we take the following steps. First, we extract the last month of use for each branch's ATM terminal number from users' transaction records. We consider ATMs whose last month of use is recorded until March 2021, the end of our observation period, to be terminals that are still in operation, and thus, extract terminals whose last month of use was before February 2021, which is one month earlier. Second, we exclude the effects of terminal failures and updates. For this purpose, if a new terminal is recorded within the same branch (store number) in the same month or the next month as the last month of use, that terminal is excluded. Moreover, we limit the terminals to only those where two or more terminal discontinuations are observed in the same month within the same branch. This is because branches and sub-branches usually have two or more terminals, while the discontinuation of one terminal is likely a failure. To eliminate the possibility of updating terminals altogether, the total number of terminals observed in the same branch is limited to three or less. Finally, we exclude terminals under the jurisdiction of branches in the three central wards of Tokyo (Chuo, Chiyoda, and Minato), because these wards are densely populated with ATMs and are more of a workplace than a residential area.

In this way, 159 ATM discontinuation events were extracted. Users who have used these terminals at least twice are 636,351. The number of events is five times as large as that of branch consolidation, whereas the number of users is almost the same. This shows that ATM discontinuation occurs more frequently and affects a smaller number of users per discontinuation than branch consolidation. It should be noted that ATM discontinuation does not necessarily encompass branch consolidation because the latter often entails the installment of unmanned ATMs near the discontinued branch.

We estimate equation (1) rather than (2) since the distance between a discontinued ATM and the nearest ATM cannot be measured. For information, we measure the shortest straight line distance between ATMs. We take all the ATMs located in the Tokyo metropolitan area (Tokyo, Saitama, Chiba, and Kanagawa prefectures, excluding the three wards, Chiyoda, Chuo, and Minato, of central Tokyo) that are listed on Mizuho Bank's website as still in operation as of September 2021. The total number of ATMs was 1173, and the shortest linear distances were 0.34 km and 0.93 km for median and mean, respectively.

Figure 9 plots the coefficient γ^k. This shows that ATM discontinuation causes a significant and persistent decrease in the amount of cash withdrawals from ATMs, which is similar to what we found in Figure 6. It also causes a rush to use ATMs from four months before the ATM discontinuation.[5] Furthermore, the amount of outflows and inflows decreased significantly after ATM discontinuation and the extent of the decrease was similar to the extent of the decrease

[5] This result can cast doubt on the assumption of common trends in our research design. In particular, the response of ATM cash withdrawals declines very smoothly over time, and the estimation period overlaps with the COVID-19 period and the period of increasing trends in non-cash expenditures. Thus, there may be some identification problems, even though we control for time dummies. Therefore, to verify the validity of the estimation results, especially the usefulness of the control by time dummies, we randomize the month of ATM discontinuation for each ATM within the estimation period and conduct the same estimation. The estimation results show that the coefficient γ^k is not significantly different from zero, which suggests the validity of the time dummy in eliminating the effect of macro changes through time.

in cash withdrawals.

4 Concluding Remarks

In this paper, we studied cash demand using bank account transaction data. First, as a fact about cash demand, we presented that the frequency and ratio of cash use are higher in younger age groups. However, the ratio of cash spending is decreasing partly due to COVID-19. Then, as a natural experiment, we focused on bank branch and ATM consolidation events and analyzed their effects on users' cash demand. The results show that when a bank consolidates its branches and ATMs, users decrease their cash use at that bank. However, at the same time, they decrease their total inflows and outflows at that bank to the same extent, suggesting that they move their payment accounts to other banks. Therefore, from a macroscopic point of view, it is highly likely that cash demand has not decreased.

The challenge for future research is to examine the macroscopic impact, including transactions at other banks. In this study, we only know the transaction data of a single bank. It is important to supplement this study with data from household accounts.

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Table 1: Descriptive Statistics

Statistic	N	Mean	St. Dev.	Pctl(25)	Median	Pctl(75)
No. of outflows	545,849	96.017	79.333	41	80	131
No. of ATM	545,849	41.847	56.082	7	25	56
Amount of outflows	545,849	5,613,553	38,814,597	1,246,441	2,911,757	5,500,954
Amount of ATM withdrawals	545,849	1,801,386	10,106,964	211,000	1,062,136	2,298,000
Ratio of ATM withdrawals	545,849	0.419	0.329	0.106	0.386	0.696
Wealth	545,849	3,474,534	19,333,760	129,000	588,000	2,818,000
Income	545,849	2,194,583	6,831,595	95,000	399,000	1,643,000
Age	545,849	50.552	16.971	37	50	63

Note: The table provides a summary of actual transactions in 2019 for users whose registered address is in Chiba Prefecture and who recorded at least six outflows in 2019. Wealth and income are the total deposits and yearly income of account holders recorded as of December 2019. The unit is yen for the amount of outflows, withdrawals, wealth, and income.

Table 2: Relationship between ATM use and Users' Characteristics

	Dependent variables (in log)	
	No. of ATM use	Amount of ATM withdrawals per visit
Intercept	1.928	8.386
	(0.005)	(0.010)
Log(wealth+1)	0.001	0.171
	(0.001)	(0.002)
Log(income+1)	-0.031	0.071
	(0.001)	(0.002)
Age	-0.014	0.009
	(0.000)	(0.000)
Female	-0.192	-0.149
	(0.003)	(0.005)
No. of obs	447,674	308,548
R2	0.089	0.152

Note: Figures in parentheses indicate standard errors.

Table 3: Estimation Results on the Effect of Bank Branch Consolidation

	Dependent variables			
	(1)	(2)	(3)	(4)
	ATM withdrawals	ATM withdrawals	Outflows	Inflows
Explanatory variables	Dummy	Dummy×distance	Dummy×distance	Dummy×distance
4 months prior	0.236	0.002	0.003	0.004
	(0.158)	(0.004)	(0.004)	(0.005)
3 months prior	0.083	0.005	0.012	0.000
	(0.176)	(0.004)	(0.005)	(0.004)
2 months prior	0.229	0.009	0.015	0.005
	(0.192)	(0.003)	(0.003)	(0.003)
1 month prior	0.297	0.013	0.022	0.011
	(0.215)	(0.003)	(0.005)	(0.004)
Month of consolidation	0.077	0.003	-0.001	-0.009
	(0.167)	(0.003)	(0.003)	(0.003)
1 month after	-0.121	-0.001	-0.014	-0.014
	(0.104)	(0.002)	(0.004)	(0.004)
2 months after	-0.146	-0.002	-0.015	-0.018
	(0.076)	(0.002)	(0.003)	(0.003)
3 months after	-0.173	0.000	-0.014	-0.015
	(0.069)	(0.002)	(0.003)	(0.003)
4 months after	-0.172	-0.001	-0.015	-0.018
	(0.061)	(0.001)	(0.003)	(0.003)
5 months after	-0.198	-0.003	-0.017	-0.018
	(0.069)	(0.001)	(0.003)	(0.003)
6 months after	-0.224	-0.029	-0.054	-0.065
	(0.106)	(0.005)	(0.006)	(0.006)
7 months after	-0.233	-0.037	-0.067	-0.073
	(0.128)	(0.005)	(0.005)	(0.006)
8 months after	-0.271	-0.039	-0.071	-0.065
	(0.134)	(0.006)	(0.005)	(0.005)
9 months after	-0.267	-0.028	-0.060	-0.051
	(0.130)	(0.008)	(0.006)	(0.007)
10 months after	-0.307	-0.035	-0.069	-0.055
	(0.135)	(0.005)	(0.005)	(0.004)
11 months after	-0.328	-0.029	-0.066	-0.047
	(0.101)	(0.006)	(0.005)	(0.004)
12 months after	-0.213	-0.014	-0.039	-0.024
	(0.091)	(0.005)	(0.004)	(0.004)
Month FE	yes	yes	yes	yes
No. of observations	16,231,270	16,231,270	16,231,270	16,231,270
months	22	22	22	22
accounts	737,785	737,785	737,785	737,785
R^2	0.207	0.206	0.401	0.346
No. of ATM use prior	2 or more	2 or more	2 or more	2 or more

Note: The dependent variable is the logarithm of the explained variable after adding one. Figures in parentheses indicate standard errors, which are clustered at the branch level.

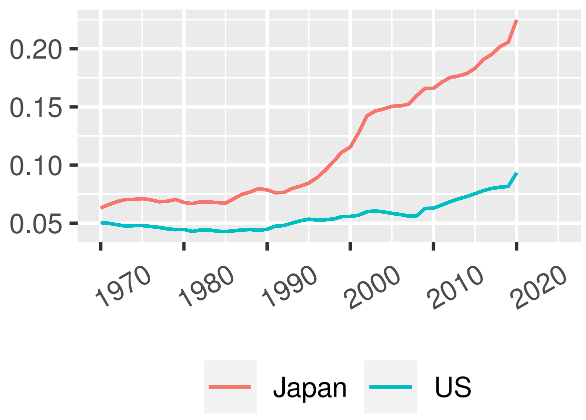

Figure 1: Currency in Circulation (Ratio to Nominal GDP)

Sources: Bank of Japan, Cabinet Office, St. Louis FRED

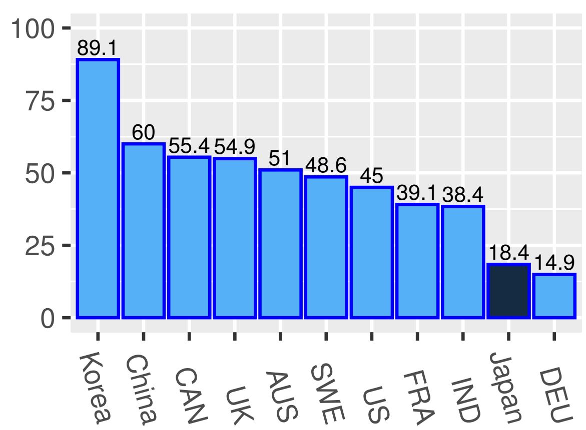

Figure 2: Faction of Cashless Settlements (as of 2015)

Source: Ministry of Economy, Trade and Industry for Japan "Cashless Vision," April 2018.

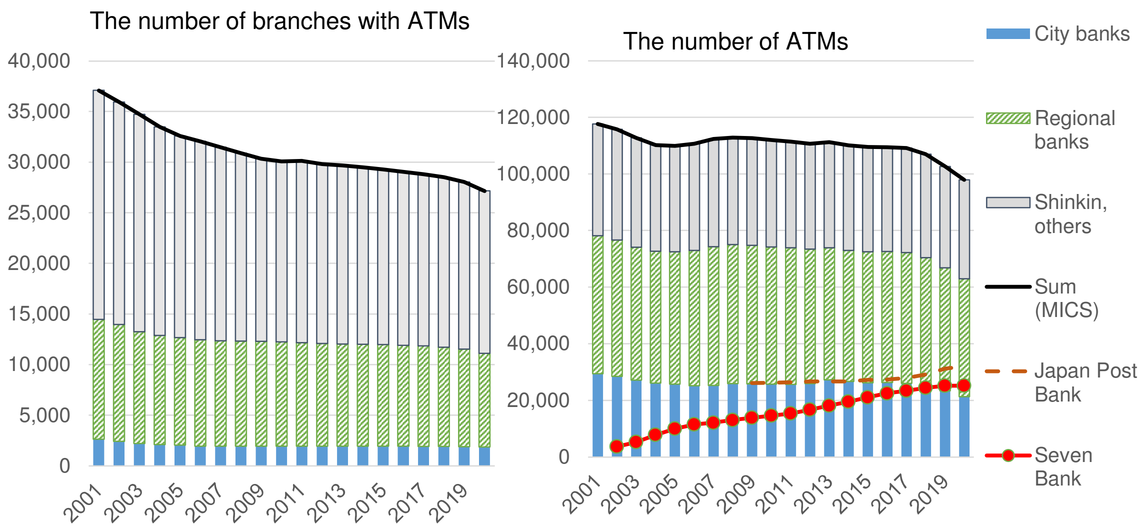

Figure 3: Number of Branches and ATMs

Sources: Japanese Bankers Association "Annual Report on Settlements", "Financial Statements of All Banks"
Note: The MICS, Multi Intigrated Cash Service, is aimed for facilitating the smooth operation of CD and ATM online services among private financial institutions. Japan Post Bank and Seven Bank do not participate in the MICS.

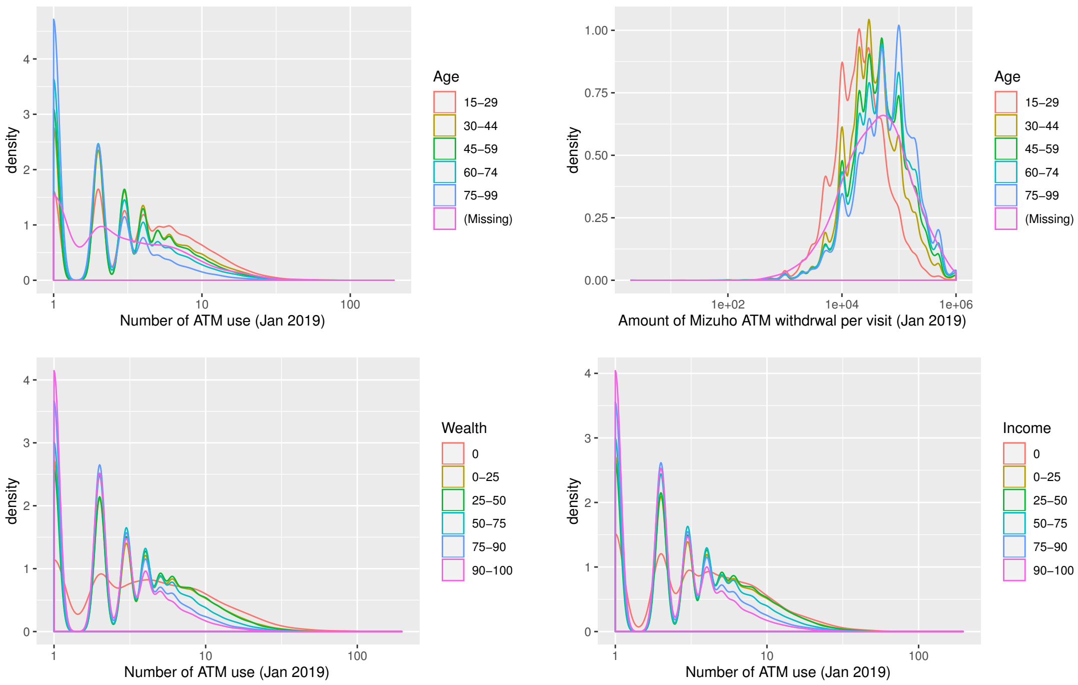

Figure 4: Distribution of ATM Use

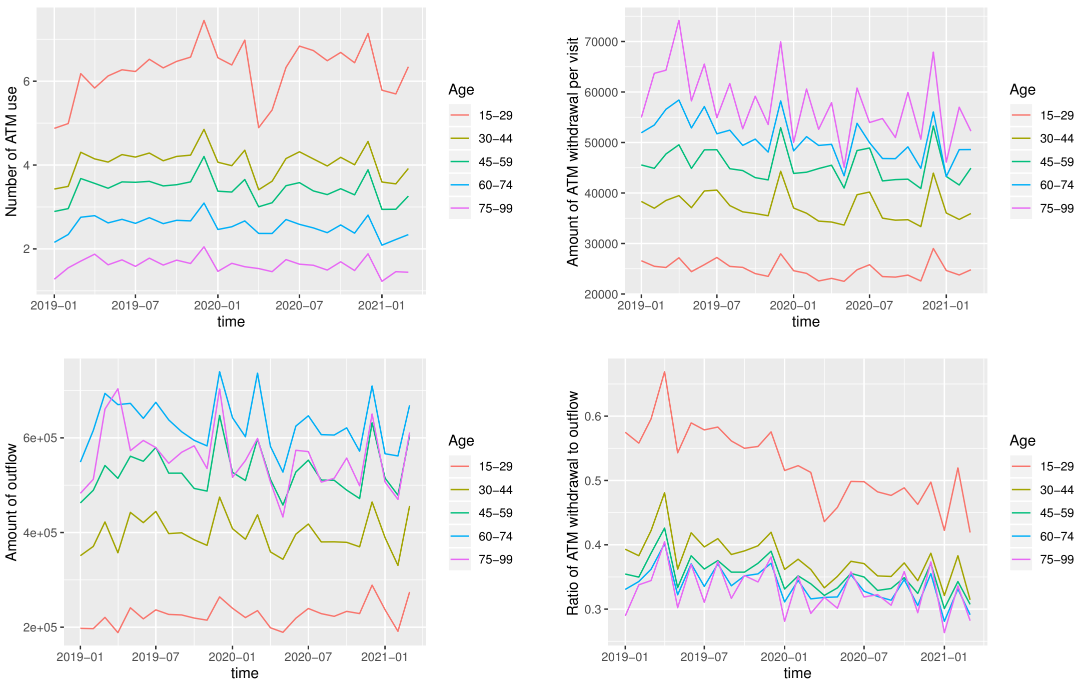

Figure 5: Time-Series Changes in ATM Use

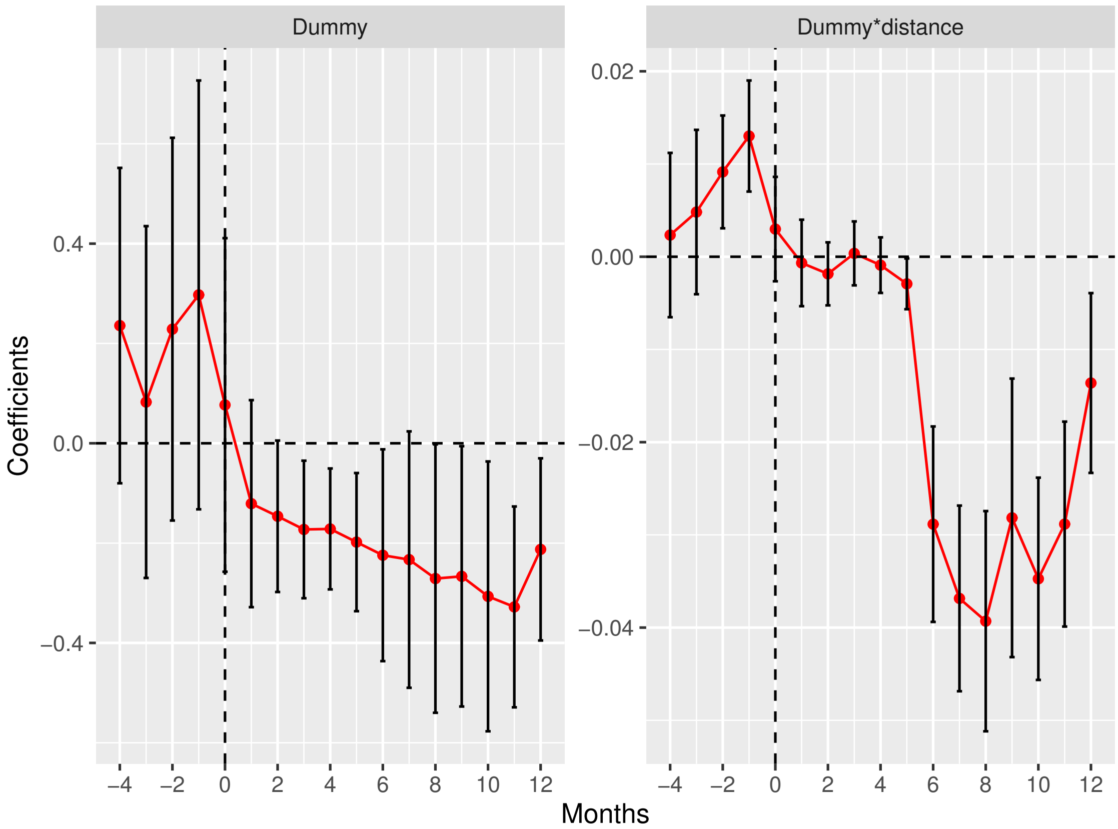

Figure 6: Effect of Bank Branch Consolidation on Cash Demand

Note: The figure displays the estimate of γ^k for $k \in -4, ..., -1, 0, 1, ..., 12$, which suggests the responses to branch consolidation. Bars indicate 95% confidence intervals. Standard errors are clustered at the branch level.

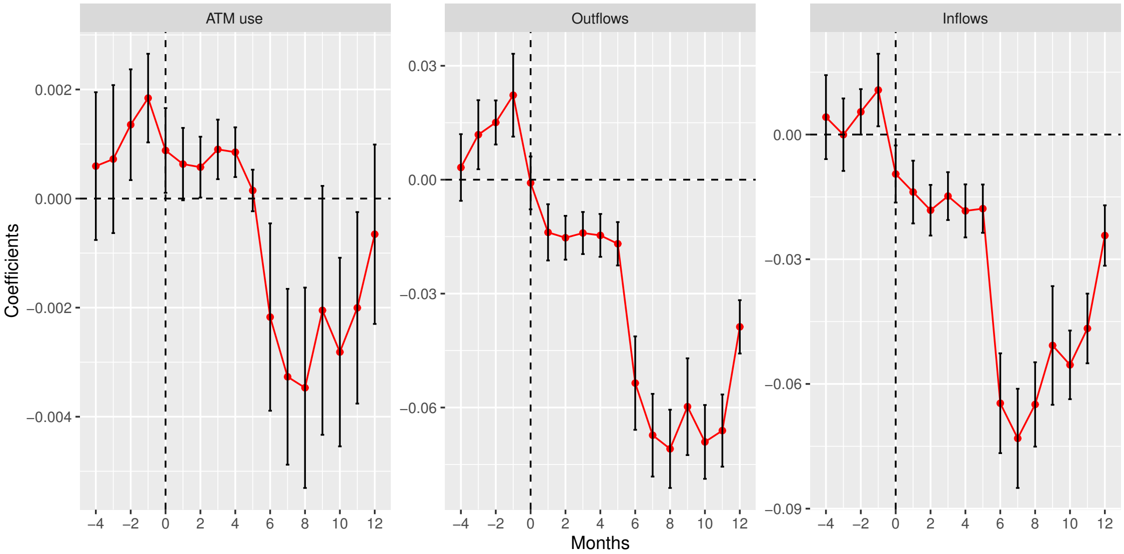

Figure 7: Effect of Bank Branch Consolidation on ATM Use, Outflows, and Inflows

Note: The figure displays the estimate of γ^k for $k \in -4, ..., -1, 0, 1, ..., 12$, which suggests the responses to branch consolidation. Bars indicate 95% confidence intervals. Standard errors are clustered at the branch level.

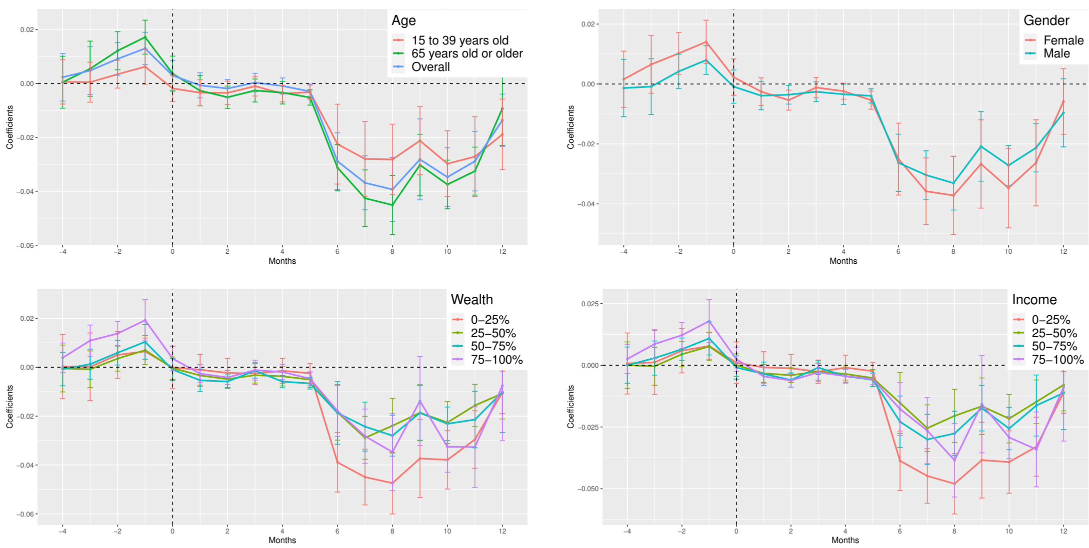

Figure 8: Effect of Bank Branch Consolidation on Cash Demand by User Demographics

Note: The figure displays the estimate of γ^k for $k \in -4, ..., -1, 0, 1, ..., 12$, which suggests the responses to branch consolidation. Bars indicate 95% confidence intervals. Standard errors are clustered at the branch level.

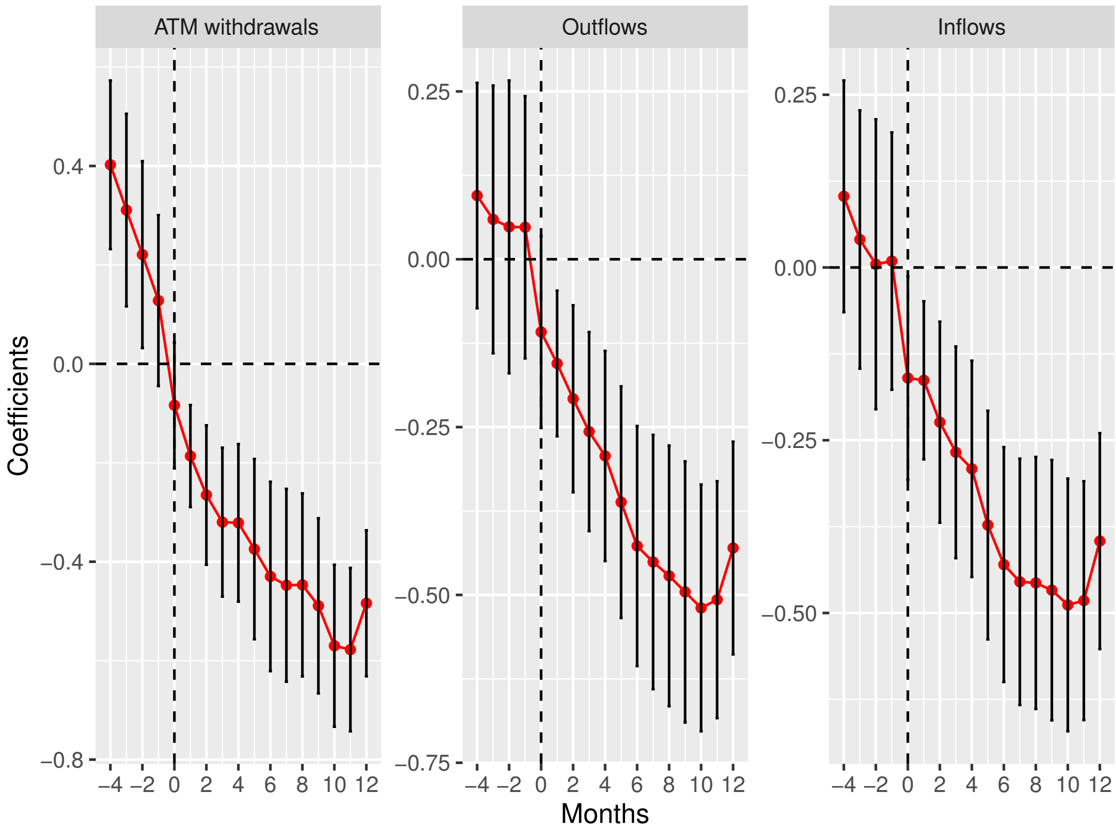

Figure 9: Effect of ATM Discontinuation on Cash Demand

Note: The figure displays the estimate of γ^k for $k \in -4, ..., -1, 0, 1, ..., 12$, which suggests the responses to branch consolidation. Bars indicate 95% confidence intervals. Standard errors are clustered at the branch level.