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U.S. Consumer Cash Use, 2012 and 2015: An Introduction to the Diary of Consumer Payment Choice

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Abstract:
U.S. consumer cash payments averaged 26 percent of all U.S. consumer payments by number (volume share) from 2008 to 2015, according to the Survey of Consumer Payment Choice (SCPC), and were essentially unchanged between 2012 and 2015. New estimates from the Diary of Consumer Payment Choice (DCPC) show that the volume share of consumer cash payments is higher than estimated in the SCPC and suggest that the cash volume share was 8 percentage points lower in 2015 than in 2012. The DCPC most likely does not provide an accurate estimate of the actual change in the cash volume share, however, due to changes in survey methodology. Counterfactual simulations controlling for survey and economic changes suggest the cash volume share declined approximately 2 to 5 percentage points due to changes in consumer preferences between 2012 and 2015.

Keywords: Cash, money, payments, consumer behavior, Diary of Consumer Payment Choice, Survey of Consumer Payment Choice

JEL Classifications: D12, D14, E42

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1. Introduction

Cash does not appear to be "dead," or even "dying," in the United States despite widespread diffusion of electronic payment networks and proliferation of consumer payment instruments in recent decades. Using the Federal Reserve Bank of Boston's Survey of Consumer Payment Choice (SCPC), Greene, Schuh, and Stavins (2016) show that the volume share (number) of U.S. consumer payments that are cash averaged about 26 percent from 2008 to 2015; the cash share was notably higher in 2015 than it was in 2008 and about flat from 2012 to 2015. Using the Diary of Consumer Payment Choice (DCPC), which was co-sponsored by the Federal Reserve Banks of Boston, Richmond, and San Francisco, Bagnall et al. (2016) reported that the U.S. cash volume share of payments in 2012 was 41 percent—15 percentage points higher than the volume share reported in the 2012 SCPC.

This paper provides a more detailed, official introduction to the DCPC, reporting new results for 2015 to compare with 2012 and focusing on consumer use of cash (or currency, that is, notes, bills, and coins). The DCPC represents an improvement in the measurement of consumer payment choices over the SCPC in two ways. The DCPC asks respondents to record every payment they make each day, whereas the SCPC asks respondents to recall from memory how many payments they typically make during a longer period of time (week, month, or year). Thus, the DCPC is expected to produce more accurate estimates of consumer payments. In addition, the DCPC collects data on not only the number of payments but also the dollar value of each payment. Accordingly, the DCPC adds a second dimension of payment use—the value—that enriches understanding of consumer payment decisions.

SCPC and DCPC estimates of the volume of cash use in 2012 and 2015 are quite different statistically and economically. The SCPC estimates indicate that the cash volume share was virtually unchanged between the two years (0.3 percentage points higher in 2015). Matheny, O'Brien, and Wang (2016), however, reported preliminary and unofficial 2015 DCPC estimates that suggest cash volume was 8.2 percentage points lower than in 2012 (40.7 percent in 2012

versus 32.5 percent in 2015).[1] Due to substantial changes in survey methodology, the 2012 and 2015 DCPC raw data estimates are unlikely to be an accurate estimate of the actual change in cash share. Thus the implied change in U.S. consumer cash use, a decline of eight percentage points in volume, almost surely does not accurately reflect actual changes in consumer preferences for cash between 2012 and 2015.

Differences in survey methodology and economic conditions between the 2012 and 2015 DCPC likely contributed to differences in the DCPC estimates of consumer payments during this period. The survey methodology of the 2015 DCPC includes two improvements over 2012: revisions to the DCPC questionnaire and a switch to a better sampling frame. These improvements likely affected the measurement of consumer payments; both had some implementation flaws (described below). Moreover, U.S. economic conditions changed between 2012 and 2015, with falling unemployment and diminishing uncertainty from the financial crisis. While changes in economic conditions could affect measurement of consumer payments by the SCPC and DCPC, the latter may be more susceptible to economic fluctuations because it measures actual daily activity, whereas the former measures typical behavior that presumably abstracts from high-frequency developments.

The DCPC motivates an enhanced view of consumer payment choices relative to the SCPC, providing estimates of the dollar value and number (volume) of payments. According to the DCPC, the consumer value shares of cash payments were similar in 2012 and 2015 (12.4 percent and 11.4 percent, respectively). This 1.0 percentage point difference is modest compared with the difference of 8.2 percentage points in the cash volume share. Thus, the value shares suggest little change in consumer cash use, while volume shares point to a potentially large decline. This apparent discrepancy in the picture of cash volume and value shares over time implies another intriguing development: the average value of consumer cash payments (the

[1] These unofficial estimates use the entire two-month survey period from 2015, October 16 to December 15, as opposed to the comparable 2012–2015 16-day period, October 16 to October 31, used in this report. See below for discussion of survey administration periods.

total value of payments divided by the total number) was higher in 2015 than in 2012 ($77 versus $70, respectively).[2]

Economic intuition suggests that consumers likely choose the value and number of payments intentionally and simultaneously. Economic theory offers considerable guidance about the determination of payment values, which represent consumer spending from income (see Schuh forthcoming). However, neither economic theory nor the economics literature provides much guidance for understanding how consumers choose the number of payments they make during a period of time. The economics literature has demonstrated empirically that the choice of payment instrument correlates with the dollar amount of payment. As first shown by Klee (2008), consumers tend to use cash more often for small-value payments. Thus, consumer joint decisions about the value and volume of payments determine the average payment value. Even without measurement challenges, it is difficult to decompose and interpret changes in the total value, total volume, and average value of payments without a rigorous economic model.

Although we do not present such a model in this paper, we conduct two analyses to assess observed DCPC data. First, we describe how the value, volume, and average value of consumer payments changed over time at the aggregate U.S. level and for individual consumers. These data begin to suggest how changes in economic conditions may have influenced consumer payment choices and how changes in survey methodology may have influenced the measurement of consumer payment choices. Second, we conduct counterfactual simulations to quantify a likely range of estimates of the actual change in consumer preferences for cash between 2012 and 2015. We estimate standard models of consumer choices of payment instruments that depend on individual payment values, other factors related to economic conditions (for example, income and employment status), and survey methodology. These estimated models show very little change between 2012 and 2015 in consumer payments defined by the probabilities of choosing particular instruments at various payment values. We

[2] Throughout the paper, all dollar values are expressed in constant 2015 dollars to adjust for inflation.

then simulate the effects of substituting the actual 2012 and 2015 distributions of individual payment values into the models of consumer payment choices for alternate years (that is, 2012 distributions into the 2015 model and vice versa). We conclude that a reasonable estimate of the decline in cash volume shares attributable to changes in consumer preferences for cash is approximately two to five percentage points, a smaller decline than the observed change (−8.2 percentage points) and closer to the SCPC estimate (+0.3 percentage points).[3] The remainder of the observed change in cash volume share is likely attributable to changes in survey methodology, changes in economic conditions, or both, but we do not estimate these influences separately.

The remainder of this paper is organized as follows. Section 2 introduces the DCPC in greater detail and describes its relationship to the SCPC. Section 3 presents aggregate time series data on the number and value of payments and the average payment value from the SCPC and DCPC. Section 4 reports the microeconomic distributions of these same payments data for individual consumers, cumulated over each consumer's three diary days. Section 5 describes the estimated models of consumer choice of payment instruments in 2012 and 2015 and reports the results of the counterfactual simulations. Section 6 concludes, and an appendix contains the technical details.

2. Diary of Consumer Payment Choice

This section briefly introduces the DCPC and provides a high-level comparison with the SCPC. The purpose is not to provide an exhaustive description of the DCPC or a comprehensive report of all DCPC data in 2012 and 2015.[4] Instead, the goal is to summarize key similarities and

[3] Although we estimate the aggregate change to be modest, changes for individual payees could differ from the aggregate. For example, Wang and Wolman (2016) report a 2.5-percentage-point-per-year decline in the volume shares of cash at a discount retailer between 2010 and 2013. For the same time period, 2010 to 2013, the SCPC finds a smaller 0.75-percentage-point-per-year decline in aggregate cash use (volume).

[4] More publications doing so will come later. Previous research using the 2010, 2011, and 2012 DCPC includes Bagnall et al. (2016), Briglevics and Schuh (2016), Briglevics and Shy (2012), Fulford, Greene, and Murdock (2015), Greene and Schuh (2014), Shy (2014), Shy (2013), and Shy and Stavins (2013).

differences between the DCPC and SCPC and between the 2012 and 2015 DCPC, focusing on estimates of consumer cash use.

2.1 Brief History

Since 2008, the Federal Reserve Bank of Boston has conducted the annual Survey of Consumer Payment Choice (SCPC) to provide reliable and representative time-series data on U.S. consumer response to the transformation of payments from paper to electronic. The SCPC was designed to measure the adoption and use of traditional and emerging payment instruments by U.S. consumers. A key contribution of the SCPC is the inclusion of currency or cash (notes, bills, and coins), which had not been tracked for U.S. consumers since the mid-1980s (Avery et al. 1987). By including cash with all noncash payment instruments, the SCPC provides comprehensive data about consumer payment choices.

Despite providing time-series data that offers a unique measure of U.S. consumer payment trends, the SCPC has two potential shortcomings. The SCPC questionnaire asks respondents to recall from memory their payment choices in a typical week, month, or year rather than relying on recordkeeping or the use of electronic transaction files. Thus, the SCPC is potentially vulnerable to measurement error stemming from poor respondent recall, rounding of numbers, and related difficulties. The SCPC also collects only the number of payments made by consumers and not the dollar values of those payments. The latter is particularly limiting for research and projection of trends because of the empirical correlation between payment value and consumer choice of payment instruments.

In 2010, the Federal Reserve (hereafter, the Fed) Banks of Boston, San Francisco, and Richmond began fielding pilot versions of the Diary of Consumer Payment Choice (DCPC) that complement and enhance the measurement of consumer payments in the SCPC. Based on early success, the Fed Banks decided to field an official version of the DCPC in 2012. In contrast to recall-based surveys, payment diaries ask respondents to record their daily payment choices

and cash withdrawals, so bank researchers are likely to obtain better measurement of consumer payments.[5]

The primary motivation for the DCPC was to test the SCPC's ability to accurately measure the number of consumer payments. Results of the 2012 DCPC, which revealed a much higher estimate of the cash volume share than in the 2012 SCPC (41 percent versus 27 percent, respectively) appeared to support the presumption that the DCPC provides better estimates of payments than the SCPC, especially for small-dollar-value cash payments. A preliminary analysis by Hitczenko (2013) found that the optimal period of recall for cash is less than one week, which is the highest frequency recall period in the SCPC; thus, daily diaries likely give better estimates of cash use.

The 2012 DCPC cash volume estimate seemed to receive further support from the estimate of the value share of cash payments. At 12.4 percent, the estimated cash volume share revealed that the average value of cash payments is relatively small ($21) and thus perhaps more likely to be overlooked in a recall-based survey. In addition, Schuh (forthcoming) demonstrated that the aggregate value of payments in the 2012 DCPC approximately matched the estimate of personal income from the National Income and Product Accounts and generated more accurate estimates of consumer expenditures than the Consumer Expenditure Survey. Based on this relative success of the 2012 DCPC, and armed with a better understanding of the character and merits of payment diaries, the Fed Banks fielded the DCPC again in 2015 and 2016, enabling a quantitative comparison of changes in cash use over time with the SCPC estimates.

2.2 Comparison of SCPC and DCPC

The SCPC and the DCPC are complementary data collection tools that aim to measure consumer use of payment instruments (Table 1 and Figure 1). The SCPC and DCPC both estimate the number of consumer payments, the number of cash deposits and withdrawals, and

[5] See Bagnall et al. (2016) for an introduction to payment diaries in seven industrial countries, most of which were sponsored by central banks.

the value of cash holdings. Beginning in 2016, the DCPC also collected other account balances (checking, PayPal, GPR prepaid card). Both SCPC and DCPC distinguish between bills, online and offline purchases, and person-to-person payments.

Important differences between the SCPC and DCPC, however, could lead the two instruments to produce different estimates of the total number of payments and of cash use. These differences include recall versus reporting (described above), payment information that is collected, survey mode, and survey administration period. The SCPC and DCPC also have different reporting periods for measuring payments. The SCPC asks respondents to estimate numbers of payments in typical time periods—for example, a typical month—and estimates the total number of payments made by U.S. consumers in a typical month. The DCPC asks respondents to report every payment they make over an assigned three-day-period and reports an estimate of the total number and value of payments made by U.S. consumers during the survey administration periods:, October 2012 and October 16 to December 15, 2015. In contrast to the SCPC, and as noted above, the DCPC asks respondents to report information about specific payments, including dollar values. Consumers also report the payment date and time, payee, and whether or not a device such as a mobile phone or laptop was used.

The SCPC and DCPC also differ in survey methodology. The SCPC is an online survey; respondents are asked to take the SCPC and DCPC but receive no instructions about the SCPC before they begin. The DCPC is mixed-mode, with respondents receiving various supporting documents and information. Before the DCPC begins, consumers receive an introductory email describing its multi-day structure, are sent written and video instructions for reporting payments, and receive two types of paper memory aids (large format including instructions and pocket-sized) as well as a pouch for collecting receipts. These additional supports are expected to lead to more precise reporting of consumers' actual activities. Respondents take the SCPC in one sitting; DCPC respondents go online over the course of three or four days to record payment activity, cash holdings, income receipt, deposits and withdrawals, etc. The DCPC

builds its monthly estimate of payments from three-day waves of respondents randomly distributed throughout the month.

2.3 Improvements to DCPC Survey Methodology

The 2012 and 2015 DCPC estimates could differ due to several improvements in survey methodology between the two periods: revisions to the survey questionnaire (Figure 1) and a switch to a better sampling frame (Table 2). In addition, some of the questionnaire improvements had practical flaws, and the sampling frame was so new that the 2015 sample was limited to a smaller size than desired. Furthermore, the changes in survey methodology make it difficult to identify economic changes that could be affecting consumer expenditures and changes in consumer preferences for payment choice over the three years. Therefore, readers should not treat the difference between the 2012 and 2015 DCPC estimates as an unbiased estimate of the actual change during this period. This warning applies to the total number of payments, the numbers and shares of payments by payment instrument, and potentially other estimates from the DCPC for 2012 and 2015.

2.3.1 Questionnaire Revisions

Changes to the 2015 DCPC questionnaire include new questions and improvements to existing questions. New questions were added to collect additional information about consumers' assets and income available for making payments, to capture information about noncash deposits and withdrawals, and to expand understanding of consumers' payment preferences. Improvements were designed to refine classification of consumer expenditures and to improve recall and reporting of bill payments. New questions likely did not play a role in the measurement of the main consumer payment choice variables (volume, total value, and average value) for 2015 relative to 2012. Improvements, while important for the DCPC in the long run, may have reduced comparability of the 2015 and 2012 DCPC data. Important additions and improvements are described below and summarized in Figure 1.

There are four important additions. First, a 10-minute night-before survey was added to ensure accurate reporting of cash holdings and other financial assets before consumers began

reporting payments. In 2012, consumers were asked to report cash in their pockets, purses, or wallets but not cash they stored elsewhere or their balances of other financial assets. The 2015 night-before reporting makes it possible for researchers to maintain a running tally of cash, checking account balances, GPR prepaid card balances, and PayPal balances as consumers make payments during the three-day reporting period; the night-before reporting also enables researchers to cross-check that tally against consumers' reported holdings and balances. This is valuable for error-checking and for understanding consumers' payment choices in the context of their available financial resources and flows into and out of their accounts.

Second, in 2015 consumers provide more detailed information about their sources of income and directly report the timing of income receipt. Like the improved reporting of financial assets, this change makes it possible to examine payment instrument choices in the context of current and expected financial resources. In 2012, consumers reported their primary sources of income, their last receipt of primary income, and their next expected receipt of primary income. In 2015, this category of questions was expanded to include all sources of income and the frequency with which consumers received them. In addition, consumers were asked to report the dollar value of any income received on the date of their night-before surveys and also on each of their three diary days. In 2012, consumers did not report dollar values for income received.

Third, the scope of the DCPC was expanded to include more information about deposits and withdrawals. In 2014, the reporting of such transactions was limited to cash deposits and withdrawals. In 2015, consumers also reported transactions that affect noncash balances, including the dollar values of transfers from one account to another, the receipt of income by noncash payment methods, and noncash withdrawals.

Fourth, in 2015 questions about consumers' preferred payment method(s) were expanded to put preferences in the context of specific payment situations and dollar amounts. In 2012, consumers reported the payment method they most prefer to use. In 2015, as part of the night-before survey, consumers answered four sets of questions about their preferred payment

methods for bills, purchases, online payments, and in-person purchases conditional on dollar value (arranged in four groups by dollar value). Then, as consumers reported each payment over the next three days in 2015, they answered follow-up questions about their reasons for using (or not using) their stated preferred payment instrument(s), given the transaction type (bill or non-bill).

Two changes to methods of asking about payees and bills in the DCPC questionnaire could have affected measurement in 2015 and comparability to 2012. First, the change to the payee classification method made it possible to add follow-up questions dependent upon payee type (for example, medical or financial services) in order to more clearly distinguish among different types of consumer expenditures.[6] In 2012, respondents were asked to report what person or entity was paid in 44 categories according to North American Industry Classification System (NAICS) codes.[7] In 2015, nine filter categories were used for the initial identification of payee type and respondents received additional entry screens to further classify the payee type. Follow-up questions were conditional on which of the nine filter categories was selected.

Second, a new ten-minute module was added to 2015 DCPC reporting day three, where respondents were offered reminders about 42 types of bills in six categories.[8] Results of the 2012 DCPC compared to the 2012 SCPC suggested that the DCPC may have been undercounting bill payments[9]; this new module addressed that concern. Prior research in survey methodology predicted that these reminders would result in a larger number of bills

[6] Analysis of the 2012 DCPC found that it accurately estimated consumption expenditures and disposable personal income (Schuh forthcoming). In 2015, follow-up questions conditional on payee classification were used to identify consumption spending, purchases of durable goods, and the need to make a payment in response to an emergency.

[8] The Boston Fed conducted two experimental surveys in 2014, where consumers were offered lists of bill types as reminders (Zhang 2016), implemented as a module within the Financial Crisis Surveys described in Hurd and Rohwedder (2010). As a result of these experiments, reminders of the following categories of bills were added to the 2015 DCPC: household or utility payments; phone, cable, or internet payments; credit card or loan payments; insurance payments; other types of payments, including tuition and medical bills; and tax payments.

[9] Bill payments include bills paid automatically, bills paid electronically, and bills paid by mail, in person, or by phone.

being reported compared to the number reported in response to a more general question (Menon 1993; Winter 2004; Comerford, Delaney, and Harmon 2009; Jagger et al. 2012; Hitczenko and Tai 2014).

2.3.2 New Sampling Frame

The sampling frame for the DCPC was the RAND Survey Research Group American Life Panel (ALP) in 2012. Beginning in 2014, the Boston Fed began to implement the SCPC, and eventually the DCPC, with the University of Southern California's Understanding America Study (UAS) panel. The main reasons for the switch were to take advantage of UAS improvements in panel recruitment (hence representativeness) and to avoid some limitations in the ALP. While this panel change is expected to provide more representative results, the transition necessitated a different sample period and smaller sample size in 2015, both of which reduced comparability with 2012.

The UAS panel is being drawn with improved sampling methods, so it is expected to provide more representative results.[10] The ALP, used from 2008 to 2014 for the SCPC as well as for the 2012 DCPC, was recruited using a combination of 80 percent convenience (volunteers from existing panels), snowball (referrals to friends and relatives), and address-based sampling. In contrast, 100 percent of the UAS panel has been recruited using the address-based sampling method of Dillman (2014), which is expected to lead to a more representative group of respondents, including respondents who are not particularly interested in personal finance, who do not necessarily take surveys, and who may be English language learners.

Indeed, evidence from the 2014 SCPC suggests that differences between the ALP sample in 2012 and the UAS sample in 2015 could be affecting DCPC estimates. The 2014 SCPC was administered to samples of both the ALP and the UAS. The two questionnaires were identical, but some 2014 survey estimates are markedly different between the two samples. In particular, the UAS sample found greater shares of consumers adopting prepaid cards, money orders,

[10] For details about the discrepancies between estimates from the 2014 ALP and 2014 UAS, see Angrisani, Foster, and Hitczenko (forthcoming).

bank account number payment (BANP), and debit cards.[11] These differences in adoption rates were statistically significant and are not explained by observable demographic differences.[12] On the other hand, the 2014 SCPC estimates of payment instrument shares from the ALP and UAS are more similar.

In 2012, the DCPC was in the field from September 29 through November 2. In 2015, the DCPC was implemented later (October 14 to December 17) due to the transition from ALP to UAS and extended to study payment instrument choice during the holiday shopping period. This extended implementation period has some advantages, but it makes it more difficult to compare estimates for the two years. For purposes of this report, we look at the two 16-day periods of October 16 through October 31 to minimize discrepancies between the estimates due to seasonal effects from non-overlapping time periods.

One limitation of drawing a sample from the UAS panel in 2015 was that the available sample size was smaller than desired. The UAS panel only began in 2014, so it was still small and in the formative stages. By October 2015, the UAS contained fewer than 2,000 total panelists. Consequently, there were only 1,392 unique UAS respondents included in the 2015 SCPC and DCPC, although some DCPC respondents agreed to complete the diary twice to increase the number of responses. By contrast, there were 2,468 unique DCPC respondents in 2012. Thus, for the comparable time periods (October 16–31), there were 1,398 respondents in the 2012 DCPC and 390 respondents in the 2015 DCPC (see Table 2).

Table 3 describes the demographic composition of the two panels for the comparable periods. There are no statistically significant differences between the two years for the following observed variables: household income, age, race, education, and gender. While not

[11] Bank account number payment is defined as "a payment made by providing your bank account number to a person, organization, or business, such as an insurance or utility company. You can give your number on websites, paper forms, etc."

[12] Additional research is needed to understand the effects of panel differences. One possibility is survey experience. In 2014, ALP respondents had been taking surveys for seven years and the UAS panel was new.

statistically significant, the percentage of people employed was 3.5 percentage points higher in 2015, 60.4 percent. The panels differ, however, in the percentage of respondents who report making no payments during their diary days. In 2012, 7.8 percent unweighted (10.0 percent weighted) of respondents reported making no payments, compared to 12.6 percent unweighted (12.0 percent weighted) in 2015. This difference affects the number of payments and possibly their composition.

To evaluate the effect of a change in the share of the number of respondents with zero payments, we conduct the following exercise. Assuming that the 2015 sample is more representative of consumers with zero payments, we can adjust the share of consumers making zero payments in 2012 to equal the share making no payments in 2015, that is, 12.0 percent.[13] The simulated increase in the 2012 share of zero-payment consumers causes a decrease in the 2012 average number of transactions per month (to 56.7) and the 2012 average number of cash transactions per month (to 22.8). Under this simulation, the 2012 share of cash transactions would have been 40.3 percent instead of 40.7 percent (Table 4) and the percentage point decline from 2012 to 2015 would have been 7.8 percentage points instead of 8.2.[14]

2.4 Changes in Economic Conditions

In addition to changes in survey methodology, the U.S. economic expansion matured from 2012 to 2015, so consumers faced different economic conditions in which to make their payment choices. Without a structural economic model of consumer choice regarding the number of payments, it is not possible to identify exactly how these economic changes affected the DCPC estimates. However, some general economic conditions reported in the DCPC can be used to control for the economic changes in an approximate, reduced-form manner when estimating models of consumer payment choices.

[13] These percentages are weighted for the 2012 and 2015 diary, respectively. This simulation was also conducted for the 2015 diary, but the magnitudes of the results were similar.
[14] A detailed description of how the simulation was conducted is in the appendix.

Perhaps the clearest and most easily measured change was the decline in the unemployment rate of nearly 3 percentage points (from 7.8 percent in October 2012 to 5.0 percent in October 2015). Evidence suggests that consumers are less likely to have bank accounts and credit cards when unemployed (Cole 2016). Therefore, an increase in employment likely would lead to increased access to additional payment instruments (credit cards and the payment instruments linked to a bank account [paper checks, debit cards, BANP, and online banking bill payment]). Consumers with more choices are less likely to choose any individual option for a given payment. That is, consumers with only two or three choices of payment instrument are that much more likely to choose cash in any given situation. Lower unemployment could thus be related to a decline in the share of payments made in cash.

A second potential influence of economic activity is that economic expansion and growth change the opportunity cost of time for consumers. In theory, if it takes a substantial amount of time for consumers to shop and make payments, then shopping time competes with consumers' time at work earning wages and with their leisure time. If the value of work or leisure rises, consumers might be more inclined to spend less time shopping, which could manifest itself in the form of fewer shopping trips (and fewer payments) with larger average payment values and possibly different payment instrument choices. It is unclear, however, how large an effect the opportunity cost might have on the number and average value of payments.

Other types of economic changes may also have influenced the 2012 and 2015 DCPC estimates in ways that are harder to identify and explain. As economic growth stabilized and utilization of resources increased, risk likely declined and distress (bankruptcy, foreclosure, etc.) also likely eased. But it also became more evident that trend productivity growth was lower, which may have affected expectations of future income. Both risk and trend growth could affect savings and credit decisions, which may influence payment choices in complex ways. Finally, innovations in payment services almost surely are affecting payment choices.

2.5 Implications for Measurement of Payment Choices

Taken together, some of these changes in survey methodology and economic conditions could have affected the measurement of payment behavior in 2015. Table 5 provides qualitative assessments of the possible effects of these measurement changes. Many of the questionnaire improvements in 2015 were related to collecting deeper information about accounts and preferences. These changes were unrelated to the reporting of the total number of payments, small-dollar-value payments, shares of bill payments, and shares of payments by payee category. Two changes, a new way of collecting the payee type and new bill payment module, could have affected some of the measures listed in Table 5—in particular, the number and percentage share of bill payments and the change in the distribution of payee types.

As noted above, requiring consumers to indicate whether or not they had paid any of 42 types of bills would be expected to result in a larger number of bills being reported compared to the number reported in 2012. If the number of non-bills reported remained constant, this would increase the share of bill payments and, presumably, decrease the share of cash payments (because a relatively small share of bills is paid with cash).

As a result of the changes to the payee classification method, some popular categories of retail purchases were less prominently displayed in the online questionnaire. These included fast food, grocery stores, pharmacies, liquor stores, restaurants, bars, and gas stations—payees where cash is often used. Therefore, it is possible that these changes, while enabling other innovations, could have depressed the number of cash transactions reported. Compared to 2012, the 2015 DCPC finds fewer transactions in these cash-popular categories.

The change in the sampling frame appears likely to have been more influential. A more representative sample—composed of larger shares of respondents who are not necessarily interested in personal finance or regular survey-takers—could result in a different estimate of the total number of payments, share of respondents with zero payments, number and share of bill payments, number of small-dollar-value payments, total value of payments, and

distribution of payee types. In addition, changes in economic conditions also could affect many of these measures.

There are reasons to suspect that changes in survey methodology and economic conditions affected the comparability of the 2012 and 2015 DCPC estimates. However, precise identification of these effects is difficult and would require considerably more research and modeling of consumer payment behavior. Furthermore, the relative imprecision of the 2015 estimates due to smaller sample sizes makes it difficult to identify statistically significant differences from 2012.

3. Aggregate Time Series Data

This section compares and contrasts aggregate data from the SCPC and DCPC over time.[15] We focus on estimates of the number of payments per consumer and total value of payments per consumer (both per month, the latter in constant 2015 dollars). For each measure, we also present shares of payment instrument use by number (volume shares) and value (value shares). Finally, we examine the average dollar value of payments, which equals the value of all payments divided by the total number of payments. The analysis focuses on total payments and cash payments, but debit and credit cards are included in some comparisons.

3.1 Number of Payments

Time series estimates of the number of payments per consumer are plotted in Figure 2. Solid lines indicate the DCPC estimates; dashed lines represent the SCPC estimates. As indicated by the vertical line, data through 2014 are estimated from the ALP, and data from 2015 and 2016 are from the UAS panel. Tables 6 and 7 provide detailed estimates of the number, value, and average value of payments for 2012 and 2015 during their common sample period

[15] The Fed Banks also conducted pilot studies of the DCPC in 2010 and 2011, but we do not include that data here. Although the basic focus on the number and value of payments by instrument was the same, the 2010 and 2011 questionnaires were earlier, less complete versions of the 2012 questionnaire. Although the sample was administered to the ALP, the sample sizes were much smaller (less than 400) and much less representative than 2012.

(October 16–31), converted to a monthly rate. These tables include all of the estimates in Figures 1 through 5 for total and cash payments, as well as estimates for all other payment instruments.

DCPC estimates of the number of total payments per consumer are notably lower than the SCPC estimates. From 2008 to 2016, the estimated SCPC number of payments fluctuated in the range of 66 to 71 payments per month without any apparent major trend. In 2012, the DCPC estimate (57.8) was about 11 payments per month lower than the SCPC estimate. In 2015, the DCPC estimate (51.4) was about 18 payments per month lower than the SCPC. The relative magnitudes of the DCPC and SCPC estimates are surprising given that daily recording of payments in the DCPC is expected to provide a more accurate estimate than the SCPC's recall method of reporting. One possible explanation of these results is that the SCPC data cleaning procedure may not be handling unusually large numbers of payments properly.[16]

In contrast, the DCPC and SCPC estimates of the number of cash payments are more similar. Following a large increase in 2009, the SCPC estimate of cash payments was relatively steady at 18 to 20 payments per month. The 2012 DCPC estimate (23.5) was above the SCPC, and the 2015 DCPC estimate (16.7) was below. These results imply that the gap between SCPC and DCPC estimates of the number of total payments occurred primarily in the estimates for all noncash payments.

Comparing 2012 to 2015, Figure 2 shows a discrepancy between the data sources over time. In contrast to the DCPC, the SCPC estimates of total payments were about the same in 2012 and 2015 (68.9). The difference between the 2012 and 2015 DCPC estimates of the number of payments is larger than any three-year difference observed in the SCPC time series. This discrepancy remains when we look at the number of cash payments. The number of cash payments in the 2015 DCPC was 28.9 percent lower than the 2012 DCPC estimate (23.5 versus 16.7), while the 2012 and 2015 SCPC estimates were the same (18.6). Once again, the difference

[16] For details of the SCPC data cleaning procedure, see Angrisani, Foster, and Hitczenko (forthcoming).

between 2012 and 2015 DCPC cash estimates was larger than any difference between the SCPC estimates over any three-year period. Perhaps the SCPC's measurement of typical payments smooths higher frequency fluctuations that could be affecting consumer payments in the DCPC. However, the fact that the SCPC estimates of total payments did not decline in 2015 relative to 2012 raises doubts that the change in sampling frame or economic conditions can explain the DCPC result, since both types of changes occurred equally for the SCPC and DCPC.

The volume shares of payments provide a complementary perspective on the number of payments (Figure 3**)**. The SCPC data indicate that U.S. consumers made three-fourths or more of their payments from 2008–2015 using three instruments: debit cards, cash, and credit cards.[17] The most notable fluctuation in the SCPC shares occurred after the financial crisis, when the cash share increased and the credit card share decreased. As the economy recovered, these shares have moved back toward pre-crisis levels, although the cash share in 2016 remains above the share in 2008. The DCPC estimates of volume share indicate that the same three instruments—debit cards, cash, and credit cards—account for most consumer payments. The cash share is considerably higher in the DCPC than in the SCPC, however, and the debit and credit card shares are lower. Perhaps these higher estimates of cash volume shares reflect better measurement because respondents recorded smaller cash payments in the DCPC, rather than relying on recall, as in the SCPC. In any case, the implied changes in cash estimates from 2012 to 2015 are quite different: the 2015 DCPC cash share is 8.2 percentage points lower than in 2012 (40.7 versus 32.5 percent), and the 2015 SCPC cash share is 0.3 percentage points higher than in 2012 (26.8 versus 27.1 percent).

3.2 Value of Payments

Estimates of the real (inflation-adjusted) value of payments per consumer from the DCPC for 2010–2015 are plotted in Figure 4 (constant 2015 dollars); as noted above, the SCPC does not collect payment values. In 2012 and 2015, the average real value of total payments was approximately $4,000 per consumer per month, which implies average annual household

[17] For more details, see Greene, Schuh and Stavins (2016) and its predecessor reports cited therein.

spending of roughly $96,000.[18] This estimate is roughly comparable to average household income from the Survey of Consumer Finances and is close to estimates of personal disposable income from the National Income and Product Accounts after proper adjustments (see Schuh forthcoming). The estimated 2015 real value of total payments was 2.2 percent lower than it was in 2012, however, while real disposable income increased 6.2 percent during this same period.[19] The real value of cash payments is about one-eighth as large ($450–$500 per month) as the value of total payments and fluctuates similarly to total payments: The 2015 real value of cash payments was 10.0 percent lower than in 2012.

The value shares of payments for cash, debit, and credit are similar in magnitude, as seen in Figure 5, but lower than their corresponding volume shares. The three value shares range from about 11 percent to 20 percent in 2012 and 2015 and are relatively stable throughout time. In contrast to the corresponding volume shares, where these three instruments accounted for the vast majority of payments by number, their value shares sum to less than half of the total value of consumer payments. The cash value share in 2015 was 11.4 percent, only 1.0 percentage point less than in 2012, which is not surprising given the stability and correlation of the real values of total and cash payments. The credit card share also was moderately lower in 2015, while the debit share was about five percentage points higher—more than accounting for the lower shares of cash and credit.

3.3 Average Payment Values

Estimates of the average payment value (the total value of payments divided by the total number of payments) for 2010–2015 are plotted in Figure 6. Given that the number of total payments was lower in 2015 than in 2012 and that the value of total consumer payments was about the same in both years, it is not surprising that the average payment value was higher in

[18] This calculation assumes October is an average month in terms of seasonal factors and that there are approximately 2.01 consumers per household in the United States.

[19] The payments and income measures have not been adjusted for comparability yet, and the DCPC payments estimate does not include a portion of the personal savings part of income. Consequently, moderate deviations in the growth rates of these two estimates do not necessarily indicate error but do warrant further analysis.

2015. The average value of all payments in 2015 was $77, 13.2 percent higher than in 2012 ($70). Similarly, the average value of cash payments in 2015 was $27, 28.6 percent higher than in 2012 ($21). In contrast, the average value of credit card payments was lower in 2015 ($55) than in 2012 ($59).

4. Individual Consumer Data

This section reports and analyzes the underlying payment choices of individual consumers in 2012 and 2015. As noted earlier, the aggregate results may be influenced by changes in survey methodology (questionnaires or sampling frames), changes in the U.S. economy between 2012 and 2015 that influenced consumer economic behavior, or both.

4.1 Diary-Period Observations

To evaluate changes in individual consumer payment behavior, we constructed the total number of payments made by each respondent (consumer) during the respective three-day diary period and the sum of the dollar values of those payments, as well as the three-day average payment for each respondent (three-day value divided by three-day number). These individual diary-period observations are unique to the consumer for whom they are constructed and therefore summarize the behavior of one consumer over three days. Consumers'' three-day observed behavior is not necessarily representative of their behavior during the remaining days of the month.[20] Nevertheless, random sampling of diary respondents based on demographic characteristics throughout the month should produce estimates that reflect the average behavior of consumers for the entire month properly, as explained in Schuh (forthcoming).

[20] For at least two reasons, three days may not be representative of the month. Seasonal effects during a respondent's three-day period may influence payment behavior, and these seasonal effects may vary across consumers. Also, infrequent events—such as cash deposits (rare among consumers) or buying a new car (large-value purchases)—lead to small samples that do not reveal the full extent of consumer behavior.

Another reason for examining three-day behavior is to isolate and highlight important differences across consumers. For each individual payment, dollar values may range from one cent ($0.01) to an extremely large value (say $25,000 for a new car, $200,000 to pay off a mortgage, or even larger amounts). In contrast, the number of transactions for each individual payment is one. With wide cross-section variation in the value of individual payments but no variation in the number, adding all payments by an individual consumer over three days generates meaningful cross-section heterogeneity in the number of payments. At the same time, adding the values of all payments by an individual over three days actually reduces cross-section heterogeneity by combining large- and small-value payments to smooth out individual spending in a meaningful way. For example, consumers with very high income and very low income both make small-value payments, for example, a $2 cup of coffee, but their incomes may have little bearing on that particular payment choice. High-income consumers, however, are more likely to make payments with a higher total value over a three-day period.

The average consumer made between five and six payments during a three-day period (5.6 in 2012 and 5.0 in 2015), or slightly fewer than two payments per day (1.9 versus 1.7) (see Tables 6 and 7). It is difficult to assess the economic plausibility of these estimates; the number of payments is not included in basic economic theories about consumer expenditures, and the economics literature has little research addressing this topic.

4.2 Number of Payments

Distributions of the estimated three-day number of payments for individual consumers from the SCPC and DCPC in 2012 and 2015 are plotted in Figure 7. Comparing the SCPC and DCPC estimates of the number of payments serves two purposes here. First, consistent with the aggregate results in Figure 2, Figure 7 shows that the distributions of estimated payments in the SCPC (bottom panel) are shifted to the right of the distributions in the DCPC (top panel); thus, SCPC estimates are higher than DCPC estimates for reasons that are hard to explain. Second, Figure 7 shows that the distributions of estimated payments in 2015 relative to their analogous distributions in 2012 differ significantly between the SCPC and DCPC. The SCPC distributions

in 2012 and 2015 (bottom panel) are quite similar in mean and variance. Conversely, the DCPC distribution in 2015 is shifted to the left of the 2012 distribution, reflecting a lower number of payments—even conditional on omitting the zero-payment respondents. The 2015 DCPC distribution also reflects a greater proportion of lower-value payments (higher peak at low values) in addition to the reduction (leftward shift) in the number of payments.

The disparity between the 2015 SCPC and DCPC relative estimates of the number of payments and the 2012 relative estimates suggests that the change in the 2015 sampling frame may have a greater impact on the DCPC, since (as noted in Section 2) respondents may smooth higher frequency fluctuations that are not affecting payments reported in the SCPC. Although changes in economic conditions could have led consumers to reduce their number of payments, one might have expected this reduction in both the DCPC and the SCPC. This expectation relies on the assumption that the SCPC and DCPC measure the number of payments equally well. This assumption may not be true for several reasons, including differences between the recall and recording methods of reporting payments (see Section 2.2).

4.3 Value of Payments

Distributions of the estimated three-day value of payments for individual consumers from the DCPC in 2012 and 2015 are plotted in Figure 8. Unlike the DCPC distributions of number of payments, the distributions of three-day payment total values did not shift between 2012 and 2015, once again conditional on omitting the zero-payment respondents. This finding is consistent with the fact that the total value of payments over the comparable 16-day periods (October 16–October 31) increased only 0.8 percent between 2012 and 2015. However, the 2015 distribution of three-day payment values differs from 2012 in the frequencies of low- and high-value payments. In 2015, the share of consumers making total payments of less than about $500 during their three-day periods was higher than in 2012, especially for exceptionally low values ($100 or less). Conversely, the share of consumers making total payments of more than $500 was lower in 2015 than in 2012, especially in the range of about $500 to $1,500.

To summarize, Figure 8 indicates that while the estimated total value of payments was virtually unchanged between 2012 and 2015, the composition of payment values across consumers shifted. This change in composition may also be explained by the change in the 2015 sampling frame and sample. Again, if the UAS panel is more representative of U.S. consumers, it may reflect a larger proportion of consumers who spend less during three-day periods. It is much harder to imagine how the changes in the 2015 DCPC questionnaire might have produced this kind of shift in the composition of payment values across consumers. Likewise, no obvious economic model or even insight exists that might explain this mean-preserving distributional shift; similarly there is no obvious economic development that might suggest such a shift.

4.4 Average Payment Values

The distribution of average payment values shifted to the right (increased) in 2015, as seen in Figure 9, consistent with the increase in aggregate average payment value from $70 to $77. Generally speaking, this aggregate average increase resulted from fewer consumers making average payments less than $25 and more consumers making average payments greater than $25. However, the changes are not monotonic; more consumers made average payments between $25 and $75, but fewer made average payments between $75 and $150. It is difficult to provide further economic interpretation of these changes without a model and better identification of the effects of changes in survey methodology.

5. Individual Payment Data

This section deepens our analysis of the DCPC data by moving from the three-day estimates for each diarist (Figures 7–9**)** to the level of each individual payment. The literature provides empirical analyses of individual payments culled from various sources, such as merchants' checkout scanner data, that give some guidance about how to analyze payment choices of different types and values. Using similar econometric models to characterize consumer payment preferences from the DCPC data, we quantify the change in the number of

payments and the effects of changes in the distribution of individual payment dollar values on the volume share of cash between 2012 and 2015.[21]

5.1 Correlation between Payment Instrument and Amount

Recent studies have documented unconditional correlations between the values of individual payments and consumer choice of the payment instrument(s) for each value. Using scanner data from grocery stores, Klee (2008) showed that the probability of choosing cash was negatively correlated with payment value, and the probability of choosing debit and credit cards was positively correlated with payment value. This result was replicated by Briglevics and Schuh (2016) using 2012 DCPC data and by Wang and Wolman (2016) using scanner data from a non-grocery discount retailer. Cohen and Rysman (2013) used combined scanner and survey data for a longitudinal panel of consumers and showed that negative correlation between cash probability and payment value remained even with fixed effects. Using 2012 DCPC data, O'Brien (2014) and Stavins (2017) find the same relationship across all transaction types, even when individuals are sorted into self-identified payment preferences.

Similar unconditional correlations between payment values and instruments appear in the 2012 and 2015 DCPC, as shown in Figure 10.[22] The figure depicts the three most frequently used payment instruments—cash, debit cards, and credit cards—and a summary category for all other instruments covered by the SCPC and DCPC.[23] The probability of using cash for very small-value payments is high in both years (about 0.7 to 0.8), and it declines sharply up to about $50, where it settles at less than 0.2. Conversely, the probabilities of using debit cards and credit cards are well below 0.2 for small-value payments (less than $10) and rise notably up to about

[21] In principle, one could also conduct analogous simulations of the effects of changes in the actual distribution of the number of payments on the value share of payments. This exercise would require more models and estimation, which we leave for future research.

[22] Figure 10 is restricted to payment values of $150 or less because the local kernel-weighted polynomial smoothing function is not effective with the relatively small number of payment observations for values greater than $150.

[23] The "all other instruments" category includes prepaid cards, checks, money orders, travelers' checks, online banking bill payments [OBBP], bank account number payments [BANP]), and text message payments. See Greene, Schuh, and Stavins (2016) for detailed definitions of the instruments.

$25, while the probabilities of using other payment instruments (mostly for bills) starts near zero for the smallest values and rises steadily up to about $100 where it flattens near 0.4. These results are qualitatively similar to prior results from grocery and other retail scanner data but are not quantitatively the same because they include bill payments, in-person payments, and online payments to a wide variety of retail locations and service businesses as well as payments to other people. Comparing the 2012 and 2015 empirical probabilities, 2015 is qualitatively similar to 2012 but the probabilities of cash use observed in the data are lower in 2015 by about 0.1 in the smaller values (up to about $50) and less different for larger values. Naturally, the debit and credit probabilities are higher in 2015.

5.2 Modeling Payment Instrument Choice

Following prior empirical studies, we use limited dependent variable models to estimate the probabilities of consumer choice of payment instrument(s). Although relatively simple, these reduced-form models are sufficient for predicting probabilities of the use of cash and noncash instruments needed to conduct our counterfactual simulations. Also, our models generally are much simpler analogues of more sophisticated recent models of consumer payment choice, such as Koulayev et al (2016) and Wakamori and Welte (2017). As noted above, we focus on econometric models with four payment instruments: cash, credit, debit, and other payment instruments.[24]

The general functional form of our regression models is written as the probability $\Pr(.)$ of choosing payment instrument P_{jt}:

$$\Pr\left(P_{jt} = 1|X_t\right) = f_m\left(X_t; \beta_{jt}\right), \quad (1)$$

where subscript $j = \{1,2,3,4\}$ represents the four payment options, subscript $t = \{12,15\}$ represents each of the two calendar years, X_t denotes the set of independent explanatory variables for consumer payment choices, including the log of the dollar value for each payment,

[24] Qualitatively, the results of our econometric analysis are essentially the same for models with six instruments (dividing "other" into three parts: checks, OBBP+BANP, and all other instruments), especially with respect to cash choices, and quite similar quantitatively as well.

β_{jt} denotes the coefficients corresponding to each explanatory variable, and subscript $m = \{1,2,3\}$ indexes the three types of models (which are described below). In addition to payment value, X includes variables that control for economic conditions and, to the degree possible, survey characteristics that might reflect the influence of changes in methodology, as described in Section 2. Economic variables include a comprehensive suite of demographic variables plus employment status, whether debit or credit cards were carried, and whether the person carried enough cash to make the purchase. Variables potentially related to changes in survey methodology include payee- and transaction-specific variables, such as bill payments.[25]

A common model used to estimate payment choice probabilities is the multinomial logit. One key assumption inherent in the multinomial logit ($m = 1$) is the independence of irrelevant alternatives (IIA), which means that the relative probabilities of choosing between any two outcomes (odds ratio) is independent of the existence other potential choices. In the context of payment instrument choice, the multinomial logit model is valid only if the presence of a payment instrument does not affect the relative probabilities (odds ratio) of two other payment instruments being selected. For example, in a multinomial logit model with cash, credit cards, and debit cards, the estimated odds ratio for credit and debit cards is assumed to be the same, regardless of whether cash is included in the model. Whether this criterion holds depends on the nature of substitutability between cash, debit, and credit in consumer demand for payment instruments.

By and large, prior studies of payment choice using multinomial logit models have not examined or discussed the IIA assumption explicitly. However, given the proliferation of payment instruments and their complex similarities and differences, it is reasonable to question

[25] See the appendix for a detailed description of each model's specifications, the complete list of explanatory variables, and the estimated marginal effects of using cash from the main econometric model. Payees are grouped into three categories. Merchant (payee) category 1 contains food and personal care supply stores. Merchant category 2 contains auto and vehicle-related stores; general merchandise stores; entertainment and transportation businesses; medical, education, and personal service businesses; government and non-profits; and people. Merchant category 3 contains housing-related, financial, and professional services businesses and miscellaneous service businesses as well as payments labeled "other."

whether IIA holds and to test whether violations adversely affect the counterfactual simulations. The null hypothesis of IIA is evaluated with the Hausman test (Hausman and McFadden 1984) for differences in the estimated coefficients from the full model (four payment instruments) and the restricted model (omitting one instrument at a time). The null hypothesis of IIA is not rejected for the multinomial logit in 2015, but the null is rejected in almost every case in the 2012 model (typically at well less than a five percent level).

For this reason, we instead estimate a multinomial probit model ($m = 2$), which does not embody the IIA assumption, and primarily emphasize these estimates of payment choice probabilities for the counterfactual simulations. For robustness, we also estimate a univariate logit model ($m = 3$) of cash choice. The estimated marginal effects of all three types of models are qualitatively and quantitatively similar, as are the results of the counterfactual simulations described later.[26]

Overall, the econometric models fit the payments data reasonably well on average. This success can be seen by comparing the fitted (denoted by a caret, ^) probabilities of cash payments ($j = 1$), from the econometric models

$$\widehat{\Pr}(P_{1t} = 1|X_t) = f_m\left(X_t; \hat{\beta}_{1t}\right) \quad (2)$$

to the smoothed probabilities in the actual data (Figure 11). The regression fitted values are especially close to the actual data for small-value payments (under $25), which account for a large number of cash transactions, but the differences between the model and data are larger for high-value payments. The model generally fits the 2012 data slightly better than it fits the 2015 data, which wiggle around more as the payment value increases and there are fewer observations. Nevertheless, the fit of the model is not terribly different between years.

Qualitatively, the estimated marginal effects on cash in 2012 and 2015 are quite similar, though there are quantitative differences. In addition, the statistical significance is not always

[26] Estimates of all three models, as well as the Hausman tests of the multinomial logit model, are available upon request from the authors.

consistent across years. (See Appendix Tables A.1 and A.2 for the estimated marginal effects for cash.) In general, the marginal effects on the economic variables in the model tended to be statistically unchanged from 2012 to 2015, although there are exceptions. For example, the average marginal effect on the (log) payment value for cash is less negative in 2015 (−0.064 compared to −0.091), indicating that the correlation of cash with payment value weakened (after controlling for economic and survey conditions). In addition, the marginal effect of whether an individual carried enough cash to make the observed payment increased (from 0.196 to 0.346), while the marginal effect on whether an individual carried his or her debit card went from significantly negative to essentially zero (–0.157 to –0.023). The marginal effect on merchant (payee) groups also changed significantly, lending some support to the notion that the questionnaire revisions to classification of the payee in 2015 may have had an effect. Most of the marginal effects on demographic characteristics did not change significantly except for age, where there is some evidence of greater propensity of consumers ages 65 and older to choose cash in 2015.

These econometric results provide one way of characterizing changes in consumer preferences for cash. Although not a structural economic model that incorporates optimizing consumer choice, the probability estimates from these reduced-form models implicitly take into account the economic conditions and survey methodology specifications that might have influenced the DCPC estimates of the volume and value shares of cash. Therefore, we interpret the relative stability of the estimated marginal effects as an approximate indication that underlying consumer preferences for payment instruments were relatively stable between 2012 and 2015.

However, the explanatory variables (X_t) did change notably between 2012 and 2015; these changes would influence the estimated probabilities of cash use even if the marginal effects (preferences) did not change. In particular, the change in the distribution of individual payment values from 2012 to 2015 likely played a central role in the observed changes in the probabilities of cash use given their relative importance among all of the marginal effects. Next,

we characterize the changes in payment values between 2012 and 2015, and then perform counterfactual simulations using these values.

5.3 Distributions of Individual Payment Values

The distribution of individual payment values shifted considerably between 2012 and 2015, as shown in Figure 12**.** The most striking feature of these distributions is a large decline in small-value (less than $25) payments in 2015 relative to 2012. Since the probability of cash use is much higher for small-value payments, so a decline in the number of small-value payments implies a decline in the volume share of cash payments. Indeed, more disaggregated data (not presented) shows that the decline in small-value payments was concentrated in cash payments.

It is difficult to identify all of the reasons for the shift in payment values from 2012 to 2015. A comprehensive economic model is required to explain why consumers might change the volume and value and thus average value of their payments, in the absence of more specific identification of the possible results of changes in survey methodology. Nevertheless, it is certainly plausible that changes to survey methodology or the economic conditions discussed previously could have contributed to the observed change in the distribution, over and above any changes in consumer preferences estimated by the econometric model.

To quantify the effects of the change in the distribution of payment values on observed consumer payment choices, we use the estimated econometric models (section 5.1) and observed distributions of payment values (section 5.2) in 2012 and 2015 to conduct two counterfactual simulations. These simulations provide alternative estimates of the actual change in cash use attributable to likely changes in consumer payment preferences separated from the effects of changes in economic conditions and survey methodology.

5.4 Counterfactual Simulations

The counterfactual simulations involve two calculations with model estimates of the probabilities of payment instrument choice. For each model we calculate the counterfactual

probabilities of payment use each year ($CF_{j,t}$) using the estimated coefficients (consumer preferences) from the other year:

$$CF_{mj12} = \widetilde{\Pr}(P_{j12} = 1|X_t) = f_m(X_{12}; \hat{\beta}_{j15}) \quad (3)$$

$$CF_{mj15} = \widetilde{\Pr}(P_{j15} = 1|X_t) = f_m(X_{15}; \hat{\beta}_{j12}) \quad (4)$$

where a caret (^) indicates econometric estimates and a tilde (~) denotes a counterfactual probability.[27] These counterfactual probabilities represent likely payment choices in a hypothetical year where consumer preferences from another year were in place instead of the preferences that prevailed in the observed year.

In the second step, for each model we calculate for 2015 the difference (ΔCF_{jt}) between the counterfactual probabilities and fitted (actual) probabilities for the 2012 and 2015 data, respectively:

$$\Delta CF_{mj12} = f_m(X_{12}; \hat{\beta}_{j15}) - f_m(X_{12}; \hat{\beta}_{j12}) \quad (5)$$

$$\Delta CF_{mj15} = f_m(X_{15}; \hat{\beta}_{j15}) - f_m(X_{15}; \hat{\beta}_{j12}) \quad (6)$$

Taking the averages of ΔCF_{mj12} and ΔCF_{mj15}, respectively, yields the aggregate difference. By holding the actual data constant for a year, these calculations represent estimates of the change in the volume share of cash payments ($j = 1$) that are mostly likely attributable to changes in consumer payment preferences, rather than changes in economic conditions or survey methodology.

The fitted and counterfactual probability estimates for cash use in 2012 and 2015 are reasonably similar for all three models (Figure 13). This intuition is confirmed by the results in Table 8, which reports the actual, fitted, and simulated cash shares (and changes) for the data and for each model. The fitted models capture essentially all of the 8.2-percentage-point decline in cash share observed between the two years (model estimates are between -7.8 and -8.5

[27] See the appendix for the technical details of these counterfactual calculations.

percentage points). The simulated counterfactual differences for the 2015 data (in the 2012 models) range from −1.8 to −2.6 percentage points and for the 2012 data (in the 2015 models) range from −4.9 to −5.5 percentage points. We conclude that the most likely estimate of the change in U.S. consumer preferences for cash use between 2012 and 2015 is a decline of approximately two to five percentage points in the volume share, or roughly half of the measured decline of 8.2 percentage points.[28]

The simulations suggest that most of the actual change in cash share measured by the 2012 and 2015 DCPC can be attributed to changes in economic conditions and survey methodology rather than changes in underlying consumer preferences for cash. While these counterfactual simulations do not provide an exact measure of the true change in the share of cash payments, they do provide guidance on how consumer preferences for cash use likely changed, conditional on demographic and transaction-specific characteristics. Because they only account for the change in consumer preferences, not for economic changes that could include cyclical and trend forces relevant for understanding consumer demand for cash, the simulated changes in the shares of cash payments are conservative. However, the consistent level of the value share of cash from 2012 to 2015, together with the results of the counterfactual simulations, suggest that cash use may have remained more stable than a direct comparison of raw estimates from the DCPC would initially indicate.

6. Conclusion

Results in this paper demonstrate that reports of the death of cash in the United States are exaggerated. Data from the 2012 and 2015 DCPC, and from the 2008–2015 SCPC, show clear evidence that cash is still one of the three most common means of payment by U.S. consumers by volume. Consumer cash payments have a small dollar value on average, however, so the total value of cash payments is low despite consumers using cash to make a large number of

[28] In principle, we could conduct counterfactual simulations for the value shares of cash as well. However, this exercise would require more modeling and joint treatment of volume and value, which we leave for future research.

payments. The value share of cash estimated in the DCPC also shows no evidence of a decline in cash share from 2012 to 2015, but the DCPC raw data suggest that cash use as a share of the number of consumer payments was much lower in 2015.

Unfortunately, evaluating the change in U.S. consumer cash use between 2012 and 2015 is more difficult because of changes in survey methodology and economic conditions that affected the DCPC implementation in these two years. We cannot identify and explain all of the specific economic forces underlying the differences in the number, value, and average value of consumer payments because the literature does not offer an adequate model of consumer choice of these payment variables. However, DCPC data confirm prior evidence that consumer choice of payment instrument(s) correlates with individual payment values, with cash used most often for small-value payments; these data do not show evidence of large changes in consumer preferences for cash. Nevertheless, changes in observed consumer payment behavior resulting from changes in survey methodology and economic conditions manifest themselves through changes in the distributions of individual payment values. Counterfactual simulations suggest that the best estimate of the decline in cash volume shares from 2012 to 2015 that is attributable to changes in consumer preferences for cash use is approximately two to five percentage points. This estimate is reasonably close to the estimate from the SCPC (+0.3 percentage points) over the same period.

Estimates of consumer payment choice(s) from the DCPC for 2016 and beyond should be more comparable with the 2015 DCPC estimates because of fewer changes in survey methodology (same sampling frame). Two factors, however, will remain a challenge for interpreting DCPC data until satisfactory structural models of consumer payment choices are developed. It will be more difficult to identify separate cyclical and long-run trend components from the DCPC data than from the SCPC data; the latter is likely to produce smaller year-to-year changes due to its measurement approach (recall based on typical periods). There is also insufficient guidance about how to jointly interpret consumer choice(s) of the number and value of payments, so divergence in volume and value shares for an instrument will be puzzling.

In light of these challenges, it seems prudent to continue collecting data on consumer payment use from the SCPC and DCPC for now. The SCPC has a longer time series and may give greater clarity on trends in payment use until more data are available to rely on DCPC estimates. On the other hand, DCPC estimates provide potentially more accurate measurement of consumer payment choice, and the DCPC has the significant advantage of collecting data on payment values in addition to numbers. More effort is needed to develop structural models of consumer payment choices that can be estimated with the SCPC and DCPC data.

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Appendix

Counterfactual Estimates

The functional form of the model used to conduct the counterfactual simulations is included in the body of the paper. A more detailed explanation of how the regression models $m = \{1,2,3\}$—which correspond to logit, multinomial logit, and multinomial probit models, respectively—are used to construct the counterfactual estimates is included here. Let $j = \{1, \dots, J\}$ be an index of payment instruments where $J > 0$ is the total number of payment options included in each model. Let N equal the total number of payments for all respondents and days and K represent the number of explanatory variables in the model. For all three models, the explanatory variables are represented by the $N \times K$ matrix, X_t, which contains the transaction amount, payment-specific variables, and demographic variables for each year t in which the diary took place. The $K \times 1$ coefficient matrix, β_{jt}, contains the estimated coefficients for each respective payment instrument included in the regression.

Logit and Multinomial Logit

This section describes how the counterfactual estimates are calculated using both the logit and multinomial logit regression models.[29] For the multinomial logit, the total number of payment options on the left hand side of the regression is $J = 4$ (cash, credit, debit, and other) with the reference category for both the multinomial logit and multinomial probit defined as other payment instruments. This normalizes the set of coefficients $\hat{\beta}_{4t} = 0$ so the remaining $J - 1$ sets of coefficients $\hat{\beta}_{1t}, \hat{\beta}_{2t}$, and $\hat{\beta}_{3t}$, are estimated in the model.

The explanation here focuses on the multinomial logit model since the logit model is a special case of the multinomial logit where the number of choices is $J = 2$(cash or non-cash). The logit model uses the non-cash payment option $j = 2$ as the reference category so the model estimates the coefficients of cash use $\hat{\beta}_{1t}$, and normalizes the non-cash coefficient $\hat{\beta}_{2t} = 0$. The multinomial logit uses a logistic function to form a link between the response variable and the explanatory variables:

[29] See Greene (2003) for a detailed description of the multinomial logit.

$$\Pr(P_{jt} = 1|X) = \frac{e^{X_t\beta_{jt}}}{1 + \sum_{j=1}^{J-1} e^{X_t\beta_{jt}}} \tag{6}$$

The numerator for the logit and multinomial logit models are the same, but the denominator $1 + \sum_{j=1}^{J-1} e^{X_t\beta_{jt}}$ reduces to $1 + e^{X_t\beta_{jt}}$ for the logit since $J = 2$. Again, given that the logit is a special case of the multinomial logit model, the remainder of this section will only refer to the multinomial logit model.

The estimated probabilities for each payment instrument *j* in 2012 are denoted

$$\widehat{\Pr}(P_{j12} = 1|X_{12}) = \frac{e^{X_{12}\widehat{\beta}_{j12}}}{1 + \sum_{j=1}^{J-1} e^{X_{12}\widehat{\beta}_{j12}}} \tag{7}$$

and estimated probabilities for each payment instrument *j*, in 2015 are

$$\widehat{\Pr}(P_{j15} = 1|X_{15}) = \frac{e^{X_{15}\widehat{\beta}_{j15}}}{1 + \sum_{j=1}^{J-1} e^{X_{15}\widehat{\beta}_{j15}}} \tag{8}$$

The 2015 counterfactual probability estimates are calculated by replacing all of the 2012 coefficients in the numerator and denominator for payment instrument *j* with the estimated coefficients from 2015.

$$\widetilde{\Pr}(P_{j12} = 1|X_{12}) = \frac{e^{X_{12}\widehat{\beta}_{j15}}}{1 + \sum_{j=1}^{J-1} e^{X_{12}\widehat{\beta}_{j15}}} \tag{9}$$

The 2012 counterfactual probability estimates for payment instrument *j* are calculated much the same way, replacing all of the 2015 coefficients in both the numerator and denominator with the estimated coefficients from 2012.

$$\widetilde{\Pr}(P_{j15} = 1|X_{15}) = \frac{e^{X_{15}\widehat{\beta}_{j12}}}{1 + \sum_{j=1}^{J-1} e^{X_{15}\widehat{\beta}_{j12}}} \tag{10}$$

Multinomial Probit

The multinomial probit model is based on a utility function U_{ij} in which choosing payment instrument j gives random utility to respondent i:

$$U_{ij} = X_{it}\beta_j + \varepsilon_{ij} \tag{11}$$

where X_{it} is a $1 \times K$ vector of the characteristics of respondent i and ε_j is the stochastic error term. We assume that the $J \times 1$ vector of error terms $\varepsilon = [\varepsilon_1, \dots, \varepsilon_J]$ is jointly normally distributed, $\varepsilon \sim N(0, \Sigma)$. We define a general class of models defined by input parameters β, and X_t. For sample X_t with parameters $\beta = \{\beta_j\}$, a $N \times 1$ vector of probabilities is given by:

$$\Pr(P_{jt} = 1|X_t) = \Pr(U_{jt} \geq U_{kt}\,|X_t), \quad for\ all\ k \neq j \tag{12}$$

$$= \Pr(U_{kt} - U_{jt} \leq 0|X_t)$$

$$= \Pr(\varepsilon_{kt} - \varepsilon_{jt} \leq X_t\beta_j - X_t\beta_k|X_t)$$

$$= \Pr(\tilde{\varepsilon}_{tjk} \leq X_t\beta_j - X_t\beta_k|X_t)$$

In this example, the tilde symbol denotes the difference between the error terms of choosing payment instrument k over payment instrument j.

Both the probit and multinomial probit use the standard (univariate or multivariate) normal distribution as a link function. Thus, for the probit, the link function takes the form

$$\Pr(P_{jt} = 1|X_t) = \int_{-\infty}^{X_t\beta_j} \varphi(\varepsilon_t)\, d\varepsilon_t \tag{13}$$

where $\varphi(\varepsilon_t)$ is the standard normal p.d.f. Expanding the probit model from a two-choice model ($J = 2$) to a four-choice model ($J = 4$) means the equation to estimate the probability of using payment instrument j in year t is:

$$\Pr(P_{jt} = 1; \beta) =$$

$$\int_{-\infty}^{h_{tjk}(\beta)} \int_{-\infty}^{h_{tjk'}(\beta)} \int_{-\infty}^{h_{tjk''}(\beta)} g\left(\tilde{\varepsilon}_{tjk}, \tilde{\varepsilon}_{tjk'}, \tilde{\varepsilon}_{tjk''}\right) d\varepsilon_{tjk}\varepsilon_{tjk'}\varepsilon_{tjk''}, \qquad for\ k, k', k'' \neq j \tag{14}$$

where

$$h_{tjk}(\beta) = X_t\beta_j - X_t\beta_k$$

and the function $g(\cdot)$ is the trivariate standard normal p.d.f.[30] We calculate the estimated probabilities as:

$$\widehat{Pr}\left(P_{jt} = 1|X_t\right) = \Pr\left(P_{jt} = 1; \hat{\beta}_{jt}|X_t\right) \tag{15}$$

and the estimated counterfactual probabilities as:

$$\widetilde{\Pr}\left(P_{jt} = 1|X_t\right) = \Pr\left(P_{jt} = 1; \hat{\beta}_{jt'}|X_t\right), \quad t' \neq t \tag{16}$$

Simulation of Respondents with Zero Payments in 2012

The simulation aims to re-estimate the number of payments reported in 2012 assuming that more respondents in 2012 would have made no payments over the three-day reporting period if the 2012 sample completely matched the 2015 sample.

The following are the steps in the simulation:

(1) Divide the 2012 sample into two groups, those who made at least one payment over their three reporting days and those who made none.

(2) Divide each of these groups into six categories, three categories by income and two by age (Table A.3).

(3) For the group that made at least one payment, calculate the average number of transactions per month and the average number of cash transactions per month for each of the six income/age combinations (Table A.4). Individuals were chosen to be removed from the group that made at least one payment over the three reporting days based on an effort to closely match the population from the group that made no payments (columns 3 and 4 of Table A.4). For example, 41 percent of the individuals who were moved from the group who made at least

[30] See Cameron and Trivedi (2005) for a detailed description of the multinomial probit.

one payment over their three reporting days and those who made none were 45 and younger and had household incomes of less than $35,000.

(4) Adjust the number of respondents who made payments in 2012 for each of the six income/age combinations by removing the number of average transactions per person per month and the number of average cash transactions per month attributable to that group.

For example, in the "45 and under" and "Income under $35,000" category, the average individual made 1.7 payments per day and 11 individuals were removed from that group. Then (11 × 1.7) payments per day were removed from the total number of payments made by those who took the 2012 diary and 11 demographically representative individuals were moved from the payment to the non-payment population.

	SCPC	DCPC
Owner (co-sponsors)	FR Bank of Boston	FR Bank of Boston (FR Banks of SF, Richmond)
Frequency	Annual	Irregular
History	2008–present	2010–2012, 2015–2016
Reporting period	September–December	October (except 2015)
Questionnaires		
Observation unit(s)	Consumers, households	Consumers
Mode(s)	Online (internet, unaided)	Mixed—paper/online (Instructions, memory aids & internet, unaided)
Data collection	Recall (typical period: day, month, year)	Recording and recall (day)
Time burden	30 minutes	Up to 20 minutes/day, 3–4 days
Incentive	$20	$60–70
Summary of contents	Instruments, ratings of traits Adoption of accounts Account balances Adoption of instruments Cash balances Cash withdrawals Use of instruments (#)	Instruments, preferences Account balances Instruments carried/available Cash balances Cash deposits & withdrawals Use of instruments (#,$) Instruments, choice reasons
Measurement period	Typical period (week/month/year)	Daily (three consecutive, randomly assigned)

Source: Federal Reserve Bank of Boston.

Table 1: Overview of the Survey of Consumer Payment Choice (SCPC) and Diary of Consumer Payment Choice (DCPC)

	2012 DCPC	2015 DCPC
Vendor	RAND Corporation	University of Southern California
Target population	Age 18+, non-institutional	Age 18+, non-institutional
Sampling frame	American Life Panel (ALP)	Understanding America Study (UAS)
Frame recruitment	80% convenience sample, some referrals by panel members, some address-based sampling	100% address-based sampling
Frame size	~5,500	~1,400
Outsourced sampling frame	None	GfK Knowledge Panel
DCPC sample recruitment	Random representative subject to maximum matching with SCPC longitudinal panelists	Invite all panel members; random selection of UAS repeat diarist (509); random selections of GfK members
DCPC time period	October 1–31	October 16–December 15
DCPC sample size, # of respondents (# of completed diaries)	2,468 (2,468)	Total: 1,392 (1,901) UAS: 1,076 (1,585) GfK: 316 (316)
DCPC sample size in comparable time period (October 16–October 31)	1,398	390

Source: Federal Reserve Bank of Boston.

Table 2: Comparison of DCPC Sampling Frames and Samples, 2012 and 2015

		Full Sample			Did not make a payment			
		2012	2015	Difference	2012	2015	Difference	
Income	Less than $25,000	22.3	23.5	1.3	49.9	47.5	−2.4	
	$25,000–$49,999	25.4	25.2	−0.2	27.0	16.0	−11.0	
	$50,000–$74,999	17.8	16.6	−1.2	8.0	12.4	4.4	
	$75,000–$99,999	13.1	12.5	−0.6	10.1	10.2	0.2	
	$100,000–$124,999	9.6	8.5	−1.1	3.3	3.6	0.3	
	More than $125,000	11.7	13.5	1.8	1.7	10.2	8.5	
Age	Under 25	7.9	6.6	−1.4	15.1	8.6	−6.5	
	25–34	21.0	23.1	2.1	27.3	18.0	−9.3	
	35–44	16.6	16.7	0.2	15.3	15.1	−0.2	
	45–54	19.2	17.5	−1.7	15.8	21.3	5.4	
	55–64	16.9	17.2	0.3	10.2	19.5	9.3	
	Over 65	18.4	18.9	0.5	16.2	17.5	1.3	
Education	High school or less	41.8	40.9	−0.9	70.0	48.2	−21.9	*
	Some college	28.8	28.5	−0.3	20.9	32.6	11.7	
	Bachelor's degree	17.3	18.0	0.6	5.0	5.9	1.0	
	Graduate degree	12.1	12.6	0.6	4.1	13.3	9.2	*
Race	Black	12.6	13.7	1.0	19.3	27.6	8.3	
	Other Race	10.8	8.1	−2.7	11.0	11.4	0.4	
	White	76.5	78.0	1.4	69.8	61.1	−8.7	
Gender	Female	51.5	52.5	1.0	54.4	55.9	1.5	
	Male	48.5	47.5	−1.0	45.6	44.1	−1.5	
Employment Status	Employed	56.9	60.4	3.5	35.3	39.6	4.3	
	Unemployed	7.7	7.7	0.0	20.9	21.1	0.3	
	Out of Labor Force	35.4	31.9	−3.5	43.8	39.3	−4.5	

Source: Federal Reserve Bank of Boston. *Notes:* All values above are percentages. Values may not add to 100 due to rounding. For year-to-year comparability and to avoid holiday effects, the data for this comparison is restricted to respondents participating between October 16 and October 31 in each year. * Statistically significant at the 10 percent level.

Table 3: Demographic Composition of DCPC Samples, 2012 and 2015

	Actual	Adjusted[a]	Difference
Total Number of Transactions	57.8	56.7	−1.2
Number of Cash Transactions	23.5	22.8	−0.7
Share of Cash	40.7%	40.3%	—

Source: Authors' calculations. *Note:* [a] Adjustment makes the 2012 share of diaries with zero transactions equivalent to the 2015 share.

Table 4: Effect of Adjusting 2012 Share of DCPC Respondents with Zero Transactions to 2015 Level

Observed	2012–15 change	Possible factors in change		
		Questionnaire	Sampling frame	Economic change
Total payments	↑	○	●	?
Zero payments	↑	?	●	○
Bills (#, share)	↑	●	◒	●
Small-value payments (#)	↓	?	●	●
Total value of payments: nominal	—	○	●	●
Total value of payments: real	↓	○	●	●
Payee categories (share of # in cash intensive)	↓	?	?	●

Likelihood of influence: ● High ◒ Medium ○ Low ? Unknown

Source: Authors' analysis.

Table 5: Factors that Could Affect Changes in Estimates, 2012–2015

Table 6

All 2012 Payments from October 16 to 31 by Type of Instrument
Top: Number of transactions per consumer, dollar value per transaction, and dollar value per consumer
Bottom: Percent share of transactions and dollar value per consumer

Average	Number per consumer	Value	
		per transaction	per consumer
All payments	**57.8**	**70**	**4035**
Paper instruments	**27.6**	**57**	**1570**
Cash	23.5	21	500
Check or money order	4.1	262	1071
Check	4.0	265	1057
Money order	0.1	129	14
Travelers check	0.0	0	0
Payment cards	**25.2**	**48**	**1218**
Debit	13.8	43	597
PIN debit	7.0	40	277
Non-PIN debit	6.9	47	320
Credit	10.1	59	596
Prepaid/Gift/EBT card	1.2	20	24
Electronic payments	**4.1**	**274**	**1133**
Online banking bill payment	2.4	322	786
Bank account number payment	1.7	205	346
Other payment methods*	**0.9**	**126**	**113**

Percent share	Number per consumer	Value	
		per transaction	per consumer
All payments	**100.0**	**—**	**100.0**
Paper instruments	**47.7**	**—**	**38.9**
Cash	40.7	—	12.4
Check or money order	7.1	—	26.5
Check	6.9	—	26.2
Money order	0.2	—	0.3
Travelers check	0.0	—	0.0
Payment cards	**43.5**	**—**	**30.2**
Debit	23.9	—	14.8
PIN debit	12.0	—	6.9
Non-PIN debit	11.9	—	7.9
Credit	17.5	—	14.8
Prepaid/Gift/EBT card	2.1	—	0.6
Electronic payments	**7.1**	**—**	**28.1**
Online banking bill payment	4.2	—	19.5
Bank account number payment	2.9	—	8.6
Other payment methods*	**1.6**	—	**2.8**

Source: Diary of Consumer Payment Choice. *Note:* *Other payment methods include text message payments, unspecified payment methods, and unreported payment methods.

Number of Observations: 7,368
Number of Respondents: 1,398

Table 7

All 2015 Payments from October 16 to 31 by Type of Instrument
Top: Number of transactions per consumer, dollar value per transaction, and dollar value per consumer
Bottom: Percent share of transactions and dollar value per consumer

Average	Number per consumer	Value	
		per transaction	per consumer
All payments	**51.4**	**77**	**3948**
Paper instruments	**20.3**	**73**	**1474**
Cash	16.7	27	450
Check or money order	3.6	285	1024
Check	3.3	301	999
Money order	0.3	90	25
Travelers check	0.0	0	0
Payment cards	**24.7**	**55**	**1356**
Debit	14.1	54	769
Credit	9.3	55	510
Prepaid/Gift/EBT card	1.2	64	78
Electronic payments	**4.8**	**186**	**899**
Online banking bill payment	3.0	200	602
Bank account number payment	1.8	162	298
Other payment methods*	**1.6**	**140**	**218**

Percent share	Number per consumer	Value	
		per transaction	per consumer
All payments	**100.0**	**—**	**100.0**
Paper instruments	**39.5**	**—**	**37.3**
Cash	32.5	—	11.4
Check or money order	7.0	—	25.9
Check	6.5	—	25.3
Money order	0.5	—	0.6
Travelers check	0.0	—	0.0
Payment cards	**48.0**	**—**	**34.3**
Debit	27.5	—	19.5
Credit	18.2	—	12.9
Prepaid/Gift/EBT card	2.4	—	2.0
Electronic payments	**9.4**	**—**	**22.8**
Online banking bill payment	5.9	—	15.2
Bank account number payment	3.6	—	7.5
Other payment methods	**3.0**	—	**5.5**

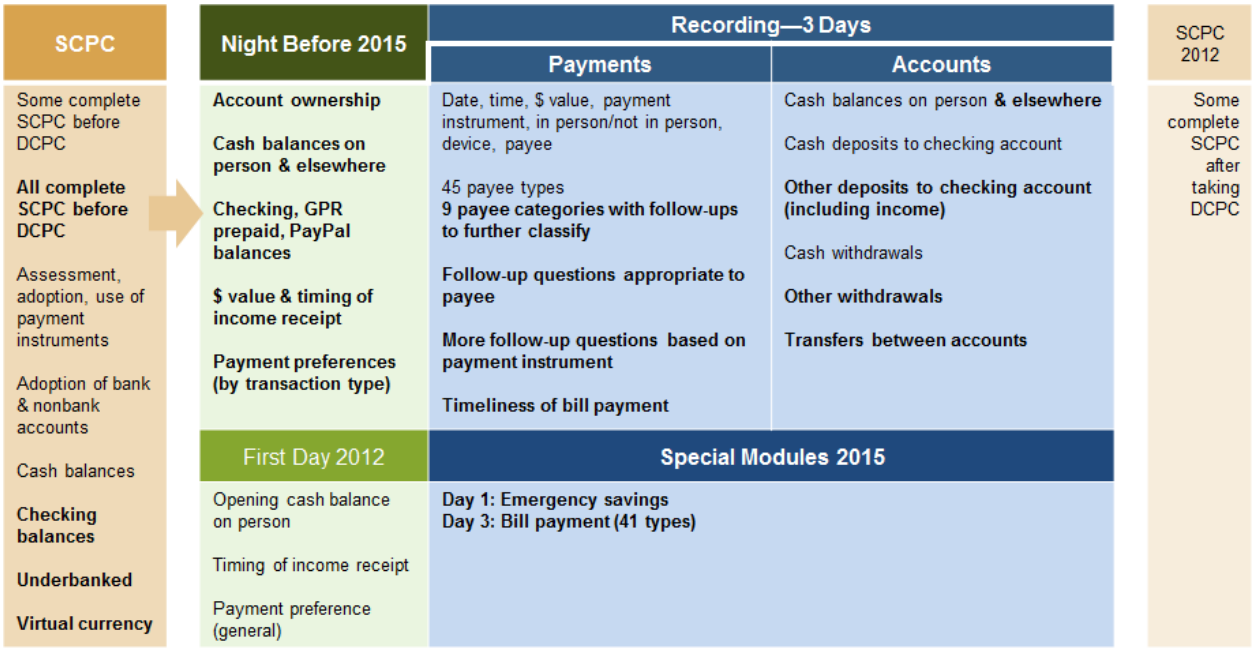
Source: Diary of Consumer Payment Choice. *Note:* *Other payment methods include mobile phone payments, account to account transfers, paypal payments, unspecified payment methods, and unreported payment methods.

Number of Observations: 1,758
Number of Respondents: 390

	2012	2015	Difference	Difference Between Counterfactual Estimates
Actual Share	40.7	32.5	-8.2	—
Multinomial Logit Model	39.3	31.5	-7.8	—
Multinomial Probit Model	39.3	31.4	-7.9	—
Logit (Cash-Only)	39.3	30.8	-8.5	—
2012 Counterfactual Share - 2015 Data				
Multinomial Logit Model	—	33.4	-1.9	—
Multinomial Probit Model	—	33.2	-1.8	—
Logit (Cash-Only)	—	33.3	-2.5	—
2015 Counterfactual Share - 2012 Data				
Multinomial Logit Model	34.1	—	-5.2	-3.3
Multinomial Probit Model	33.8	—	-5.5	-3.7
Logit (Cash-Only)	34.4	—	-4.9	-2.4

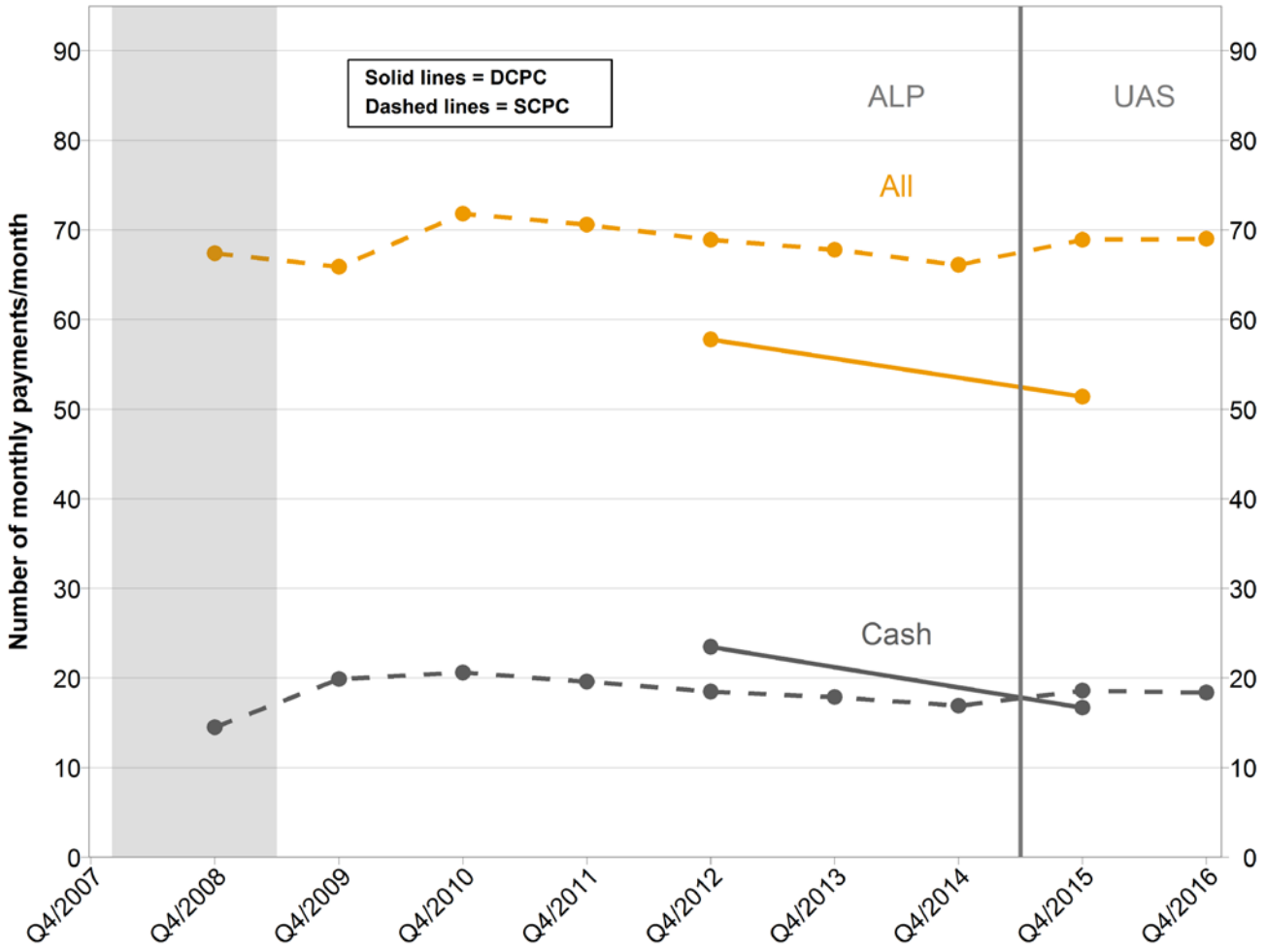
Source: Authors' analysis. *Notes:* Included in model: sample and questionnaire improvement, economic change. Simulations apply 2015 probabilities by value to 2012 value distribution and vice versa.

Table 8: Simulated Estimate of Change in Consumer Preference for Using Cash, 2012 to 2015



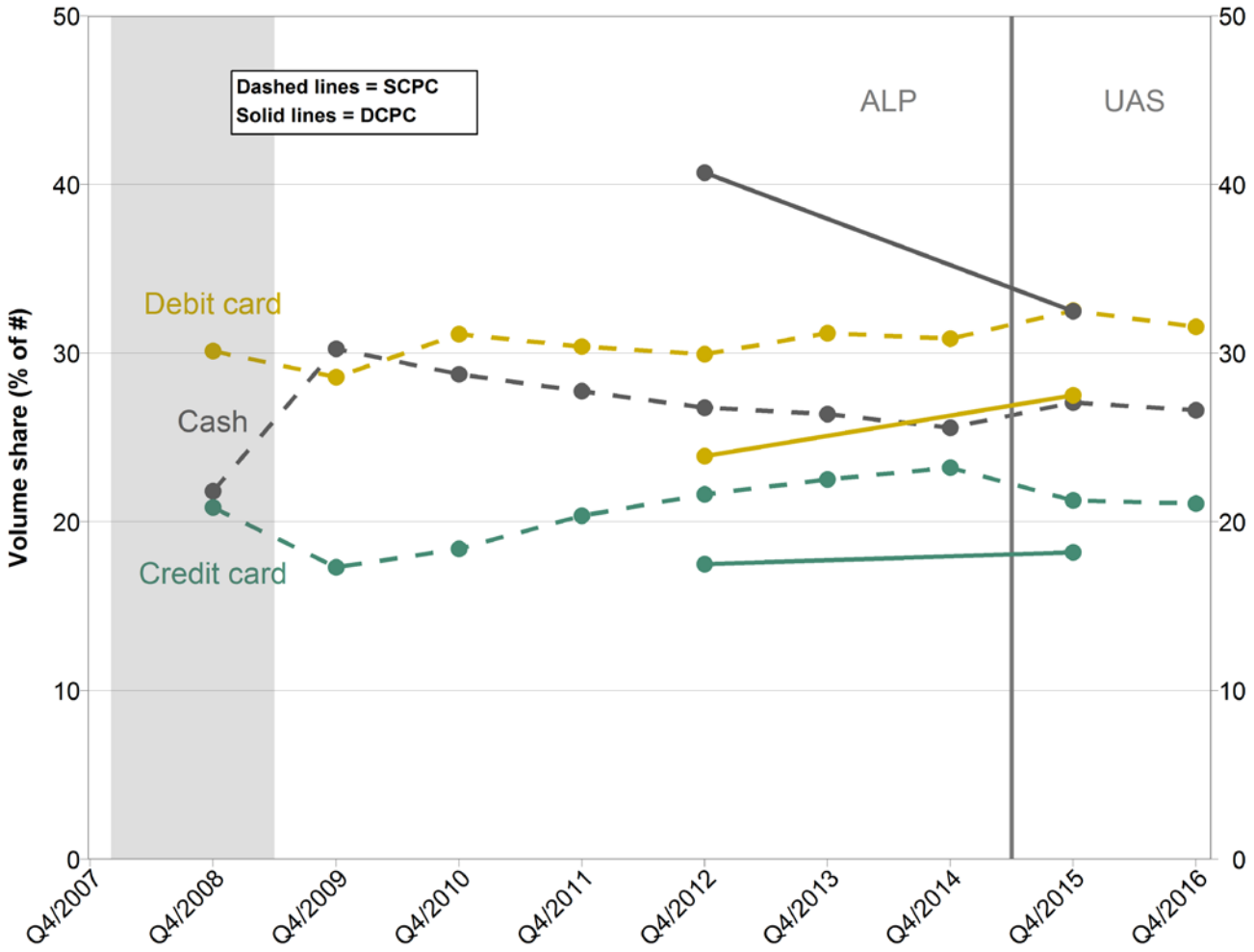
Source: Federal Reserve Bank of Boston. *Note:* 2015 additions and enhancements in **bold.**

Figure 1: SCPC and DCPC structure, including DCPC evolution, 2012 and 2015



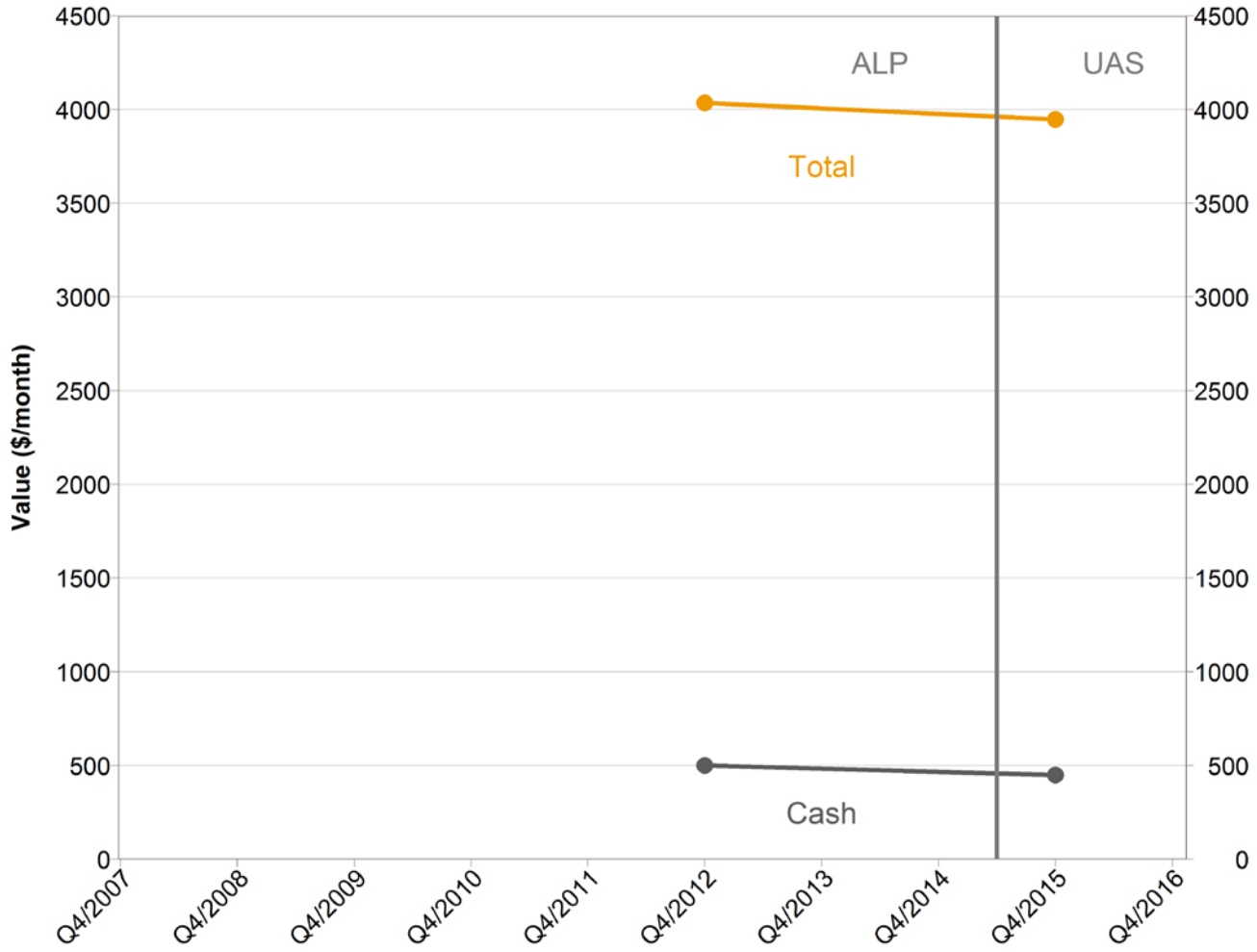
Source: Federal Reserve Bank of Boston.

Figure 2: Mean Number of Payments Per Consumer Per Month



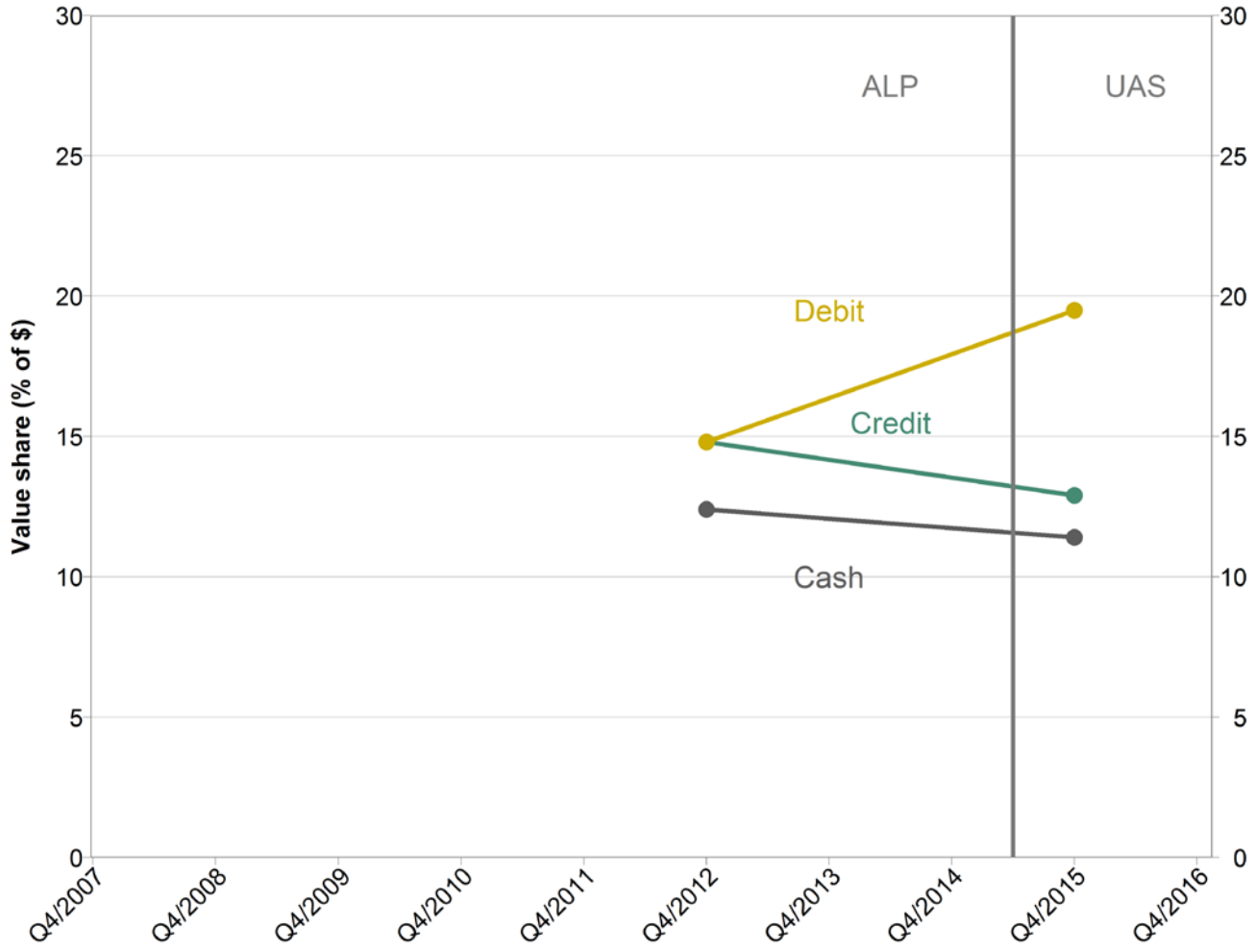
Source: Federal Reserve Bank of Boston.

Figure 3: Share of Consumer Payments Per Month (Number) by Type of Payment Instrument



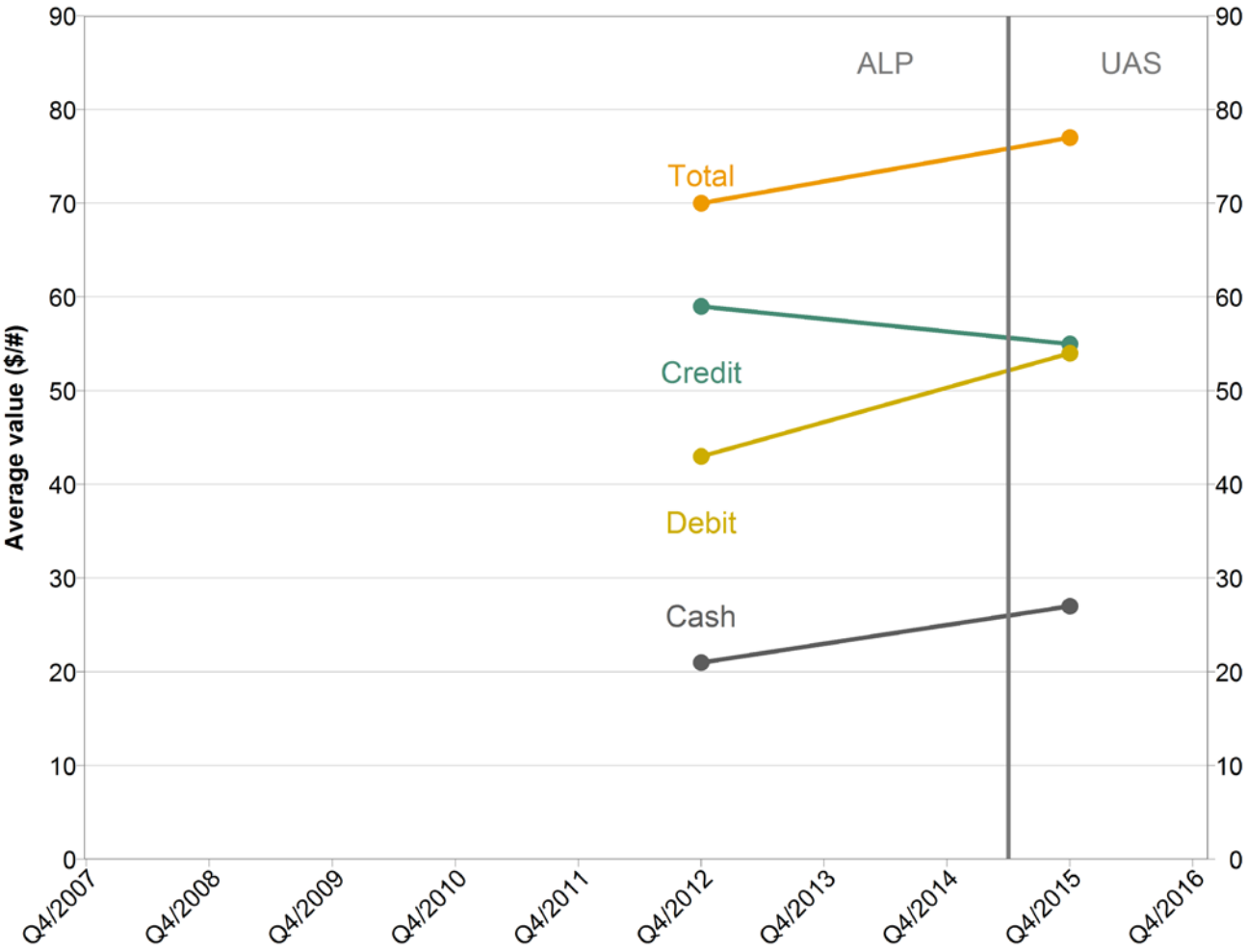
Source: Federal Reserve Bank of Boston. *Note:* Expressed in 2015 dollars

Figure 4: Dollar Value of Consumer Payments Per Month, for All and Cash



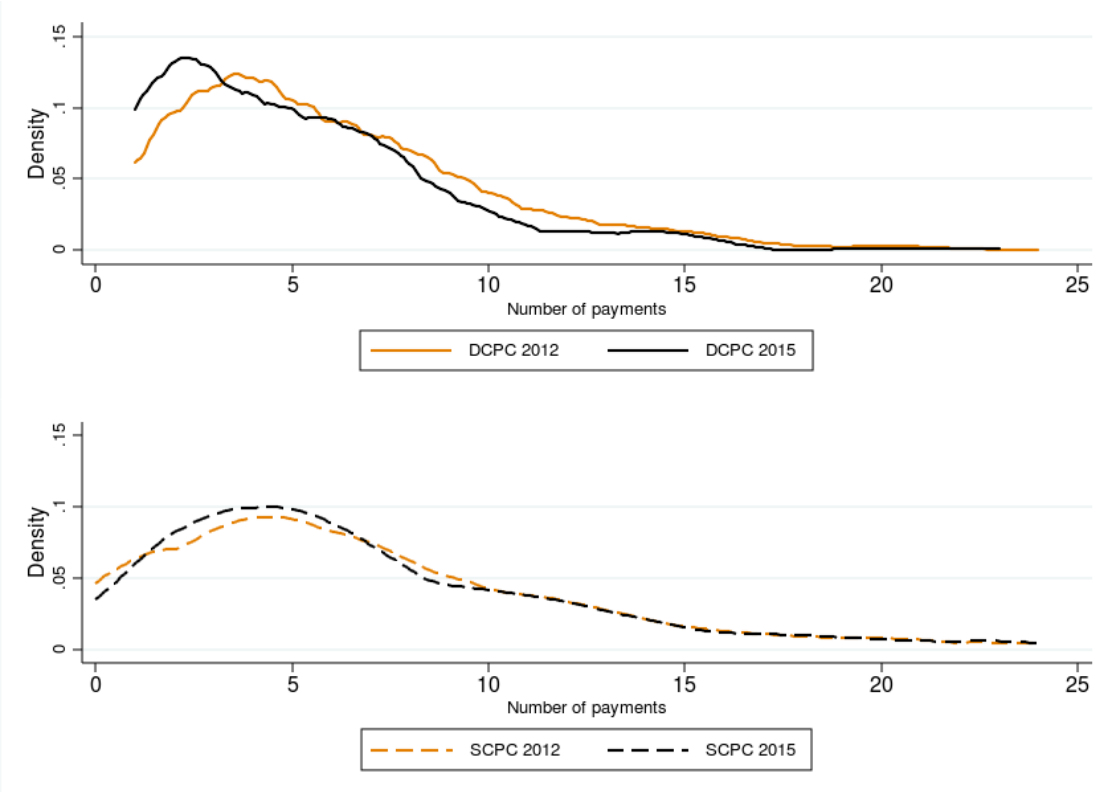
Source: Federal Reserve Bank of Boston. *Note:* Expressed in 2015 dollars.

Figure 5: Share of Consumer Payments Per Month (Dollar Value), by Type of Payment Instrument



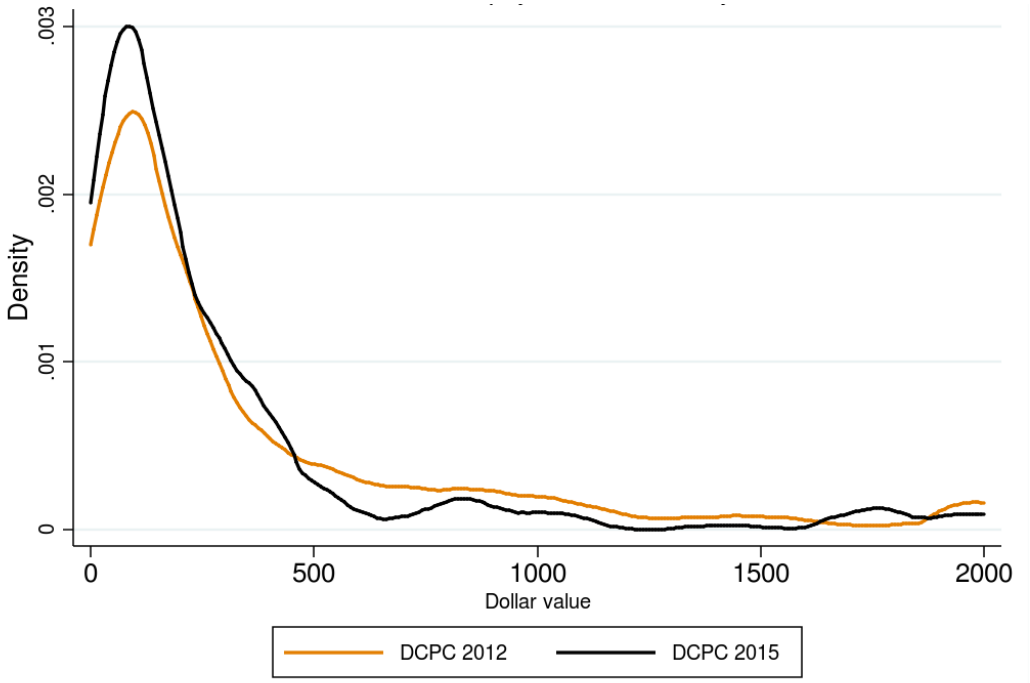
Source: Federal Reserve Bank of Boston. *Note:* Expressed in 2015 dollars.

Figure 6: Average Dollar Value of Consumer Payments, for All and by Type of Payment Instrument



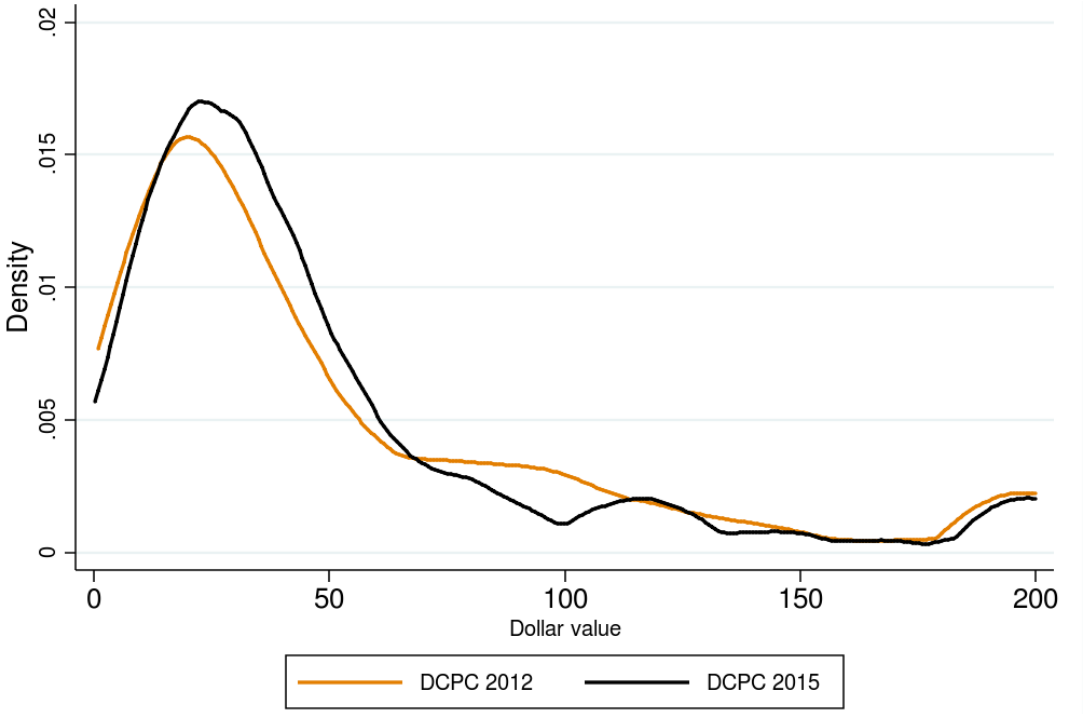
Source: 2012 and 2015 SCPC; 2012 and 2015 DCPC. *Note:* Consumers with zero transactions for their three days are omitted.

Figure 7: Distribution of the Number of Consumer Payments Per Three-Day Period



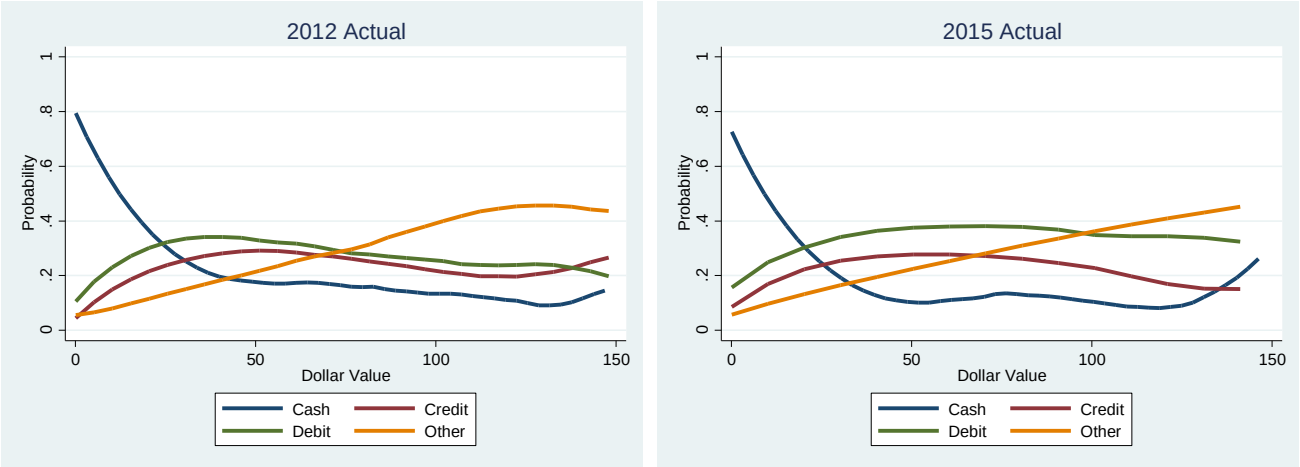
Source: 2012 and 2015 DCPC. *Notes:* Expressed in 2015 dollars. Consumers with zero transactions for their three days are omitted.

Figure 8: Distribution of the Three-Day Dollar Value of Consumer Payments



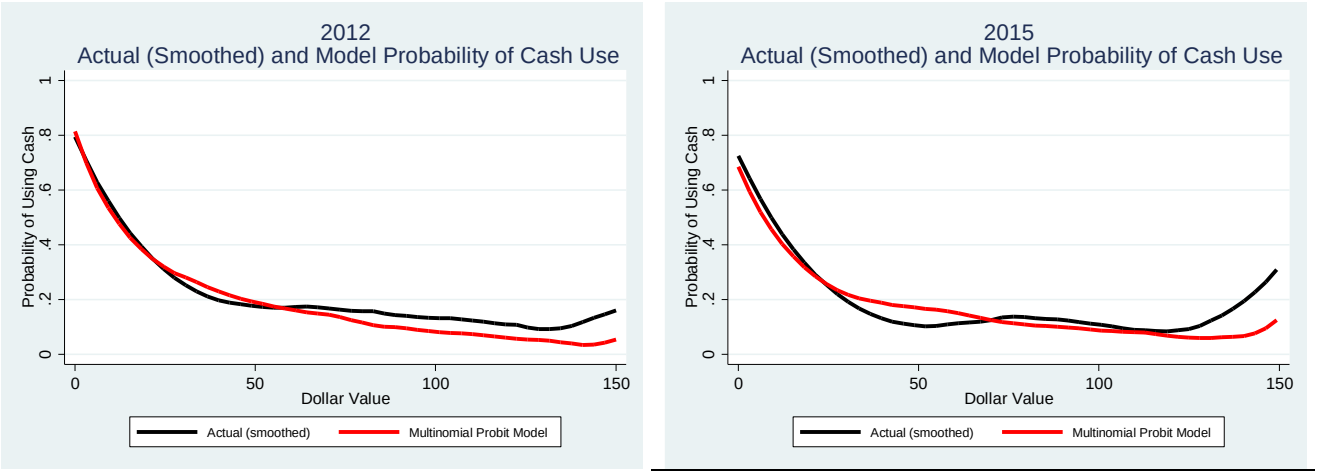
Source: 2012 and 2015 DCPC. *Notes:* Expressed in 2015 dollars. Consumers with zero transactions for their three days are omitted.

Figure 9: Distribution of Average Dollar Value Per Payment Per Consumer Three-Day Period



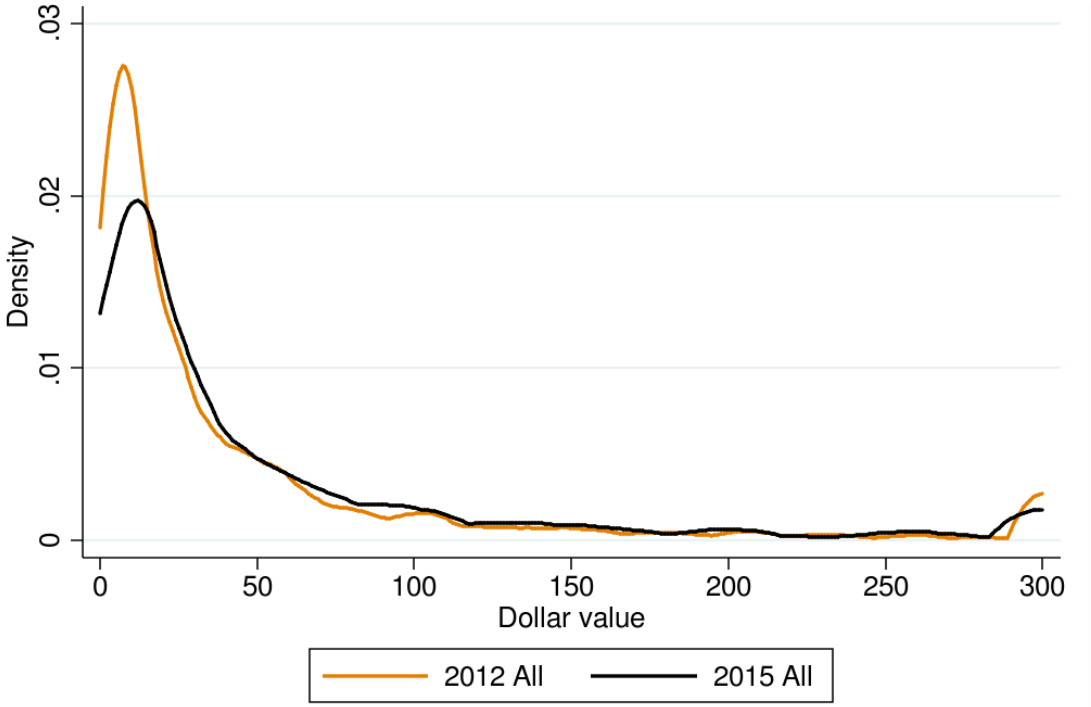
Source: 2012 and 2015 DCPC. *Note:* Expressed in 2015 dollars. All probabilities above are estimated using LOWESS (locally weighted scatter plot smoothing).

Figure 10: Probability of Payment Instrument Use by Dollar Value of Consumer Payment, 2012 and 2015



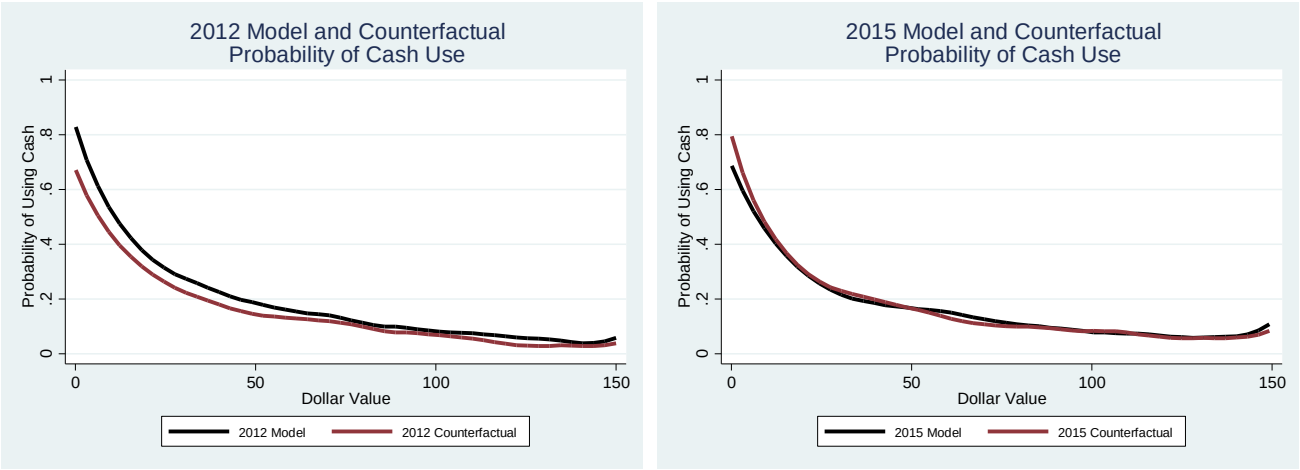
Source: Federal Reserve Bank of Boston. *Notes:* Expressed in 2015 dollars. The logit and multinomial logit estimates are qualitatively and quantitatively similar to the multinomial probit estimates.

Figure 11: Actual and Modeled Probabilities of Cash Use by Dollar Value of Consumer Payment, 2012 and 2015



Source: Federal Reserve Bank of Boston, authors' calculations. *Note:* Expressed in 2015 dollars.

Figure 12: Distribution of the Dollar Values of Payments



Source: Authors' calculations. *Notes:* Expressed in 2015 dollars.

Figure 13: Modeled and Counterfactual Probabilities of Cash Use by Dollar Value of Consumer Payment, 2012 and 2015

Appendix tables

	(2012) Payment instrument	(2015) Payment instrument	Difference	
Marginal Cash Coefficients				
Log Amount	-0.0912***	-0.0635***	0.028	***
	(0.00329)	(0.00661)	3.8	
Carried Credit	-0.133***	-0.109***	0.024	
	(0.00887)	(0.0251)	0.9	
Carried Debit	-0.157***	-0.0226	0.134	***
	(0.00901)	(0.0224)	5.6	
Carried Enough Cash	0.196***	0.346***	0.150	***
	(0.00853)	(0.0247)	5.7	
Unemployed	0.0397**	0.0801**	0.040	
	(0.0189)	(0.0406)	0.9	
Out of Labor Force	-0.00922	-0.00904	0.000	
	(0.0107)	(0.0225)	0.0	
In-Person	0.358***	0.358***	0.000	
	(0.0203)	(0.0358)	0.0	
Bill	0.0710***	0.0746***	0.004	
	(0.0269)	(0.0268)	0.1	
Tuesday	0.0204	-0.00894	-0.029	
	(0.0147)	(0.0335)	0.8	
Wednesday	0.0475***	0.00587	-0.042	
	(0.0145)	(0.0328)	1.2	
Thursday	0.0276*	0.0349	0.007	
	(0.0153)	(0.0325)	0.2	
Friday	0.0557***	0.0385	-0.017	
	(0.0152)	(0.0295)	0.5	
Saturday	0.0446***	0.0193	-0.025	
	(0.0162)	(0.0318)	0.7	
Sunday	0.0183	0.0104	-0.008	
	(0.0154)	(0.0301)	0.2	
Payment at Merchant Group 1	-0.0169*	0.0470**	0.064	***
	(0.00871)	(0.0199)	2.9	
Payment at Merchant Group 3	0.00808	0.143***	0.135	***
	(0.0199)	(0.0233)	4.4	
Observations	8647	2066		
Pseudo R- Squared	0.40	0.38		

Source: Authors' calculations. *Notes:* Standard errors in parentheses. * p<0.10; ** p<0.05; *** p<0.01

Table A.1: Economic and Survey-Related Variables, Probability of Using Cash

	(2012) Payment instrument	(2015) Payment instrument	Difference	
Marginal Cash Coefficients				
Income Less Than 25k	0.0614***	0.125***	0.064	
	(0.0152)	(0.0340)	1.7	*
Income 25k to 49k	0.0217*	0.00650	-0.015	
	(0.0124)	(0.0288)	0.5	
Income 75k to 99k	-0.00808	0.0169	0.025	
	(0.0141)	(0.0319)	0.7	
Income 100k to 124k	-0.00697	-0.0162	-0.009	
	(0.0164)	(0.0373)	0.2	
Income Greater Than 125k	0.0270*	0.00860	-0.018	
	(0.0149)	(0.0325)	0.5	
Age Under 25	-0.0811***	0.0725	0.154	
	(0.0267)	(0.0474)	2.8	***
Age 25 to 34	-0.0290**	-0.0595**	-0.031	
	(0.0139)	(0.0302)	0.9	
Age 45 to 54	0.0173	-0.00113	-0.018	
	(0.0136)	(0.0292)	0.6	
Age 55 to 64	-0.0132	0.0500*	0.063	
	(0.0137)	(0.0288)	2.0	**
Age 65 and Over	-0.0414**	0.0953***	0.137	
	(0.0175)	(0.0314)	3.8	***
High School & Lt. High School	0.0331**	0.0571*	0.024	
	(0.0138)	(0.0324)	0.7	
Some College	0.0354***	0.0282	-0.007	
	(0.0106)	(0.0243)	0.3	
Graduate School	-0.0103	-0.0115	-0.001	
	(0.0123)	(0.0249)	0.0	
Black	0.0589***	0.0264	-0.033	
	(0.0143)	(0.0404)	0.8	
Other Race	-0.0180	-0.00635	0.012	
	(0.0147)	(0.0289)	0.4	
Female	0.0202**	0.0304	0.010	
	(0.00888)	(0.0208)	0.5	
Married	-0.00747	0.0580**	0.065	
	(0.0101)	(0.0228)	2.6	***
No Bill Responsibility	0.0136	0.114***	0.100	
	(0.0189)	(0.0429)	2.1	**
Some Bill Responsibility	-0.00212	0.0542	0.056	
	(0.0193)	(0.0456)	1.1	
Most Bill Responsibility	0.0238	0.0683	0.045	
	(0.0209)	(0.0474)	0.9	
All Bill Responsibility	0.0145	0.0628*	0.048	
	(0.0146)	(0.0339)	1.3	
No Shopping Responsibility	-0.00287	0.0269	0.030	

	(0.0220)	(0.0450)	0.6
Some Shopping Responsibility	-0.00297	0.00686	0.010
	(0.0154)	(0.0341)	0.3
Most Shopping Responsibility	-0.00551	-0.0208	-0.015
	(0.0146)	(0.0344)	0.4
All Shopping Responsibility	-0.0137	0.0163	0.030
	(0.0133)	(0.0279)	1.0
Observations	8647	2066	
Pseudo R-squared	0.40	0.38	

Source: Authors' calculations. *Notes:* Standard errors in parentheses. * p<0.10; ** p<0.05; *** p<0.01

Table A.2: Demographic Variables, Probability of Using Cash

	Percent that Made at Least One Payment		Percent that Made No Payments	
	(1) 45 and Under	(2) Over 45	(3) 45 and Under	(4) Over 45
HH Income Under $35,000	14%	17%	41%	23%
HH Income Between $35,000 and $75,000	16%	17%	7%	14%
HH Income Over $75,000	16%	21%	10%	5%

Source: Authors' calculations.

Table A.3: Percentage of Population in Each Income Group, 2012 DCPC

	Total Number of Transactions per Person per Day		Number of Cash Transactions per Person per Day	
	45 and Under	Over 45	45 and Under	Over 45
Income Under $35,000	1.7	1.7	1.1	1.1
Income Between $35,000 and $75,000	2.2	2.1	1.2	1.1
Income Over $75,000	2.2	2.4	1.0	1.2

Source: Authors' calculations.

Table A.4: Transactions Per Person Per Day, 2012 DCPC