Evidence on the Use of Checks and other Noncash Payments in the United States: Have Checks Peaked?

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Abstract

Electronic payments in the United States, especially by debit card, have experienced phenomenal growth during the past few years. At the same time, estimates from three surveys of depository institutions suggest that the number of checks, long the dominant noncash payment method, reached a peak during the mid 1990's. In fact, the annual number of noncash electronic payments may now exceed the number of checks. The processing cost of an electronic payment is often less than that of processing a paper check. Reluctance on the part of some consumers and businesses to replace checks with electronic payments, however, make the future rate of decline in check writing uncertain. Despite the continued evolution of institutions and technology favoring electronics, sunk capacity for paper check clearing may delay efforts to implement electronic check clearing. Scale and network economies make the timing of investments in electronic processing important. This paper provides estimates for the number and value of checks paid from 1979 to 2000, and explores trends and cross-sectional differences in the use of checks in the United States. Data from the surveys and other sources support the view that consumers and businesses have been replacing payments traditionally made by paper checks. Future surveys are important for gauging the pace of change in payments.

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1 Introduction

Over the past several decades, many countries have seen the introduction of new electronic payment instruments. In the United States, as with other countries, the means for making electronic payments has become increasingly available for use in everyday commerce. Further, the adaptation of technology has driven down the costs of processing electronic payments relative to check payments. Rates of growth have been significant since the introduction of every major electronic payment instrument. Nevertheless, at the beginning of the new millennium the paper check continued to be the most commonly used type of noncash payment instrument in the U.S. economy. High growth rates on a small base have not necessarily represented major shifts toward retail electronic payments (credit card, debit card, automated clearinghouse (ACH)). But increases in electronic payments reported by major payments networks now suggest that the absolute number of retail electronic payments initiated in the United States has now become substantial.

Current trends suggest that electronic payments as a group may have, by number, more recently begun to exhibit a larger share of noncash payments than checks. Furthermore, the number of checks being written has most likely begun to decline. Thus, growth in retail electronic payments may have begun to replace some payments formerly made by check.[1] The *value* of check payments, however, likely continues to be much larger than the value of retail electronic payments, and is second only to the value of payments on electronic large-value funds transfer systems which have, by value, have exceeded the value of checks for many years. (While small in number, the average value of large-value funds transfers is huge. These funds transfers are dominated by settlements for wholesale financial market transactions.)

Accurate estimates of the number and value of payments and the relative use of different payment instruments are necessary to gauge the cost-effectiveness of the payments system. As many have pointed out, the average cost of processing a paper check is large relative to the average cost of its electronic counterparts (Wells, 1996). Given that, as shown below, over 70 billion noncash payments are processed each year, even small savings on a per-payment basis can add up to a considerable share of economic activity. In cases where electronic payments are satisfactory substitutes for checks, a redirection of resources being used to process checks to other activities improves social welfare.

Banking organizations, correspondent banks, check clearinghouses, and the Federal Reserve Banks have large investments in infrastructure devoted to paper check processing. For their part, businesses and consumers that write checks and receive payments by check have varying levels of investment in technology connected with using them. While the trend toward the use of electronic

[1] Difficulties in measuring the number of payments made by cash do not currently allow an estimate of any replacement of cash payments with electronic payments.

payments is significant, in many cases paper checks may, in the short run, continue to provide more cost-effective means of making some payments simply because investments have already been made to physically clear the paper, and paper-based, for some checks, is literally cheaper. In addition, where electronic payments are imperfect substitutes for checks, costs in the form of disutility or other expenditures outside the payments system may make paper checks more efficient for some needs. Where paper checks are preferred for these reasons, taking the paper out of the clearing process may result in lower social cost than attempts to change business or household behavior.

Even when people choose which payment instrument to use based on individually rational cost-benefit analyses, choices may affect the costs experienced by other payments system users. Scale and network economies may have large effects on the relative costs of using and processing competing instruments. At times like the present, when the payments system appears to be undergoing substantial transition in the way that payments are being made, good business and public policy decisions need to be informed by data on the speed and character of that transition. This paper describes data that can help reveal how checks are actually being used, and relating that to the use of electronic payments and other socioeconomic data. While an earlier article (Gerdes and Walton II, 2002) provided many of the results and discussion provided in this paper at a high level, the present paper provides a fuller discussion of the methods used for estimation, sensitivity analysis, and more analysis of the finding from the surveys.

The collection of data on electronic payments is straightforward because the processing of electronic payments is largely centralized. Thus, though some measurement problems do exist, historical estimates of electronic payment activity have been reasonably accurate. The check-clearing system, in contrast, is far less centralized than the electronic payments processing system, and data are correspondingly difficult to collect. Although the number and value of checks cleared through and collected by the Reserve Banks each year are known, the number and value of checks presented directly or through other intermediaries are not routinely reported to any statistical authority. Further, such data are not included in reports filed by depository institutions (DIs), they must be estimated on the basis of voluntary surveys. To increase the accuracy of the estimates at reasonable cost, appropriate survey design and statistical estimation techniques must be employed.

For many years, the only published survey-based estimate of the number and value of checks paid was for 1979, when the Federal Reserve Bank of Atlanta collected data on checks for an analysis of the check-clearing system (*A Quantitative Description of the Check Collection System*, 1980). To provide more recent data on the use of checks and other noncash payment instruments in the United States, in 2001 the Federal Reserve sponsored three related surveys collectively referred to as the Retail Payments Research Project (*Retail Payments Research Project:A Snapshot of the U.S. Payments Landscape*, 2002). The survey data were used to estimate the number and value of

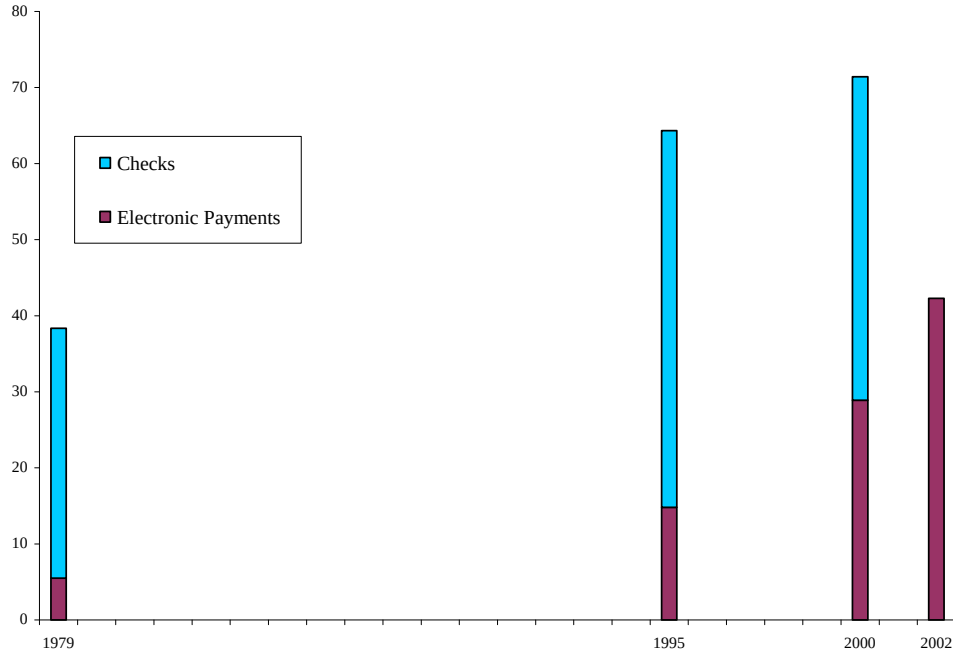


Figure 1: Billions of noncash payments in the United States, selected years. The number of checks paid in 2002 is not displayed because it is unknown.

payments made in 2000 using checks and several types of electronic payment instruments as well as to study the characteristics of individual checks paid in 2000. That report demonstrated that industry projections for the number of checks paid were over 50 percent larger in the latter part of the 1990's than implied by the estimated number of checks from the survey data.

In addition, the Federal Reserve Board surveyed depository institutions on checks in 1995 for a report to the Congress on funds availability and check fraud (*Report to Congress on Funds Availability Schedules and Check Fraud at Depository Institutions*, 1996). While no estimate of the number of checks paid was reported at the time, the present paper describes the more recent effort to use data from that survey to estimate the total number of checks for 1995.

Along with the 1979 estimate, the 1995 and 2001 data reveal the likely transition from mostly paper to mostly electronic noncash payments in the United States during the last two decades of the prior millennium and the first few years of the present one. Taken together, the data show that an estimated 32.8 billion checks were paid in the United States in 1979, 49.5 billion in 1995, and 42.5 billion in 2000. The exact year in which check use peaked is unknown, but it appears that the number of checks paid began to decline sometime in the mid-1990s. At the same time, the number of electronic payments has been increasing at an increasing rate. (See Figure 1.)

Electronic payments likely grew by more than 13 billion per year from 2000 through 2002,

suggesting that the number of electronic payments likely now exceeds 40 billion. While no data sufficient to estimate the total number of checks in 2002 exist, projections based on the implied trend in the number of checks between 1995 and 2000 (3 percent annual decline), suggest that the number of checks could have dropped below 40 billion in 2002. Thus, it appears highly probable that the number of electronic payments may have overtaken the number of checks, in part by replacing some payments formerly made by check.

The check payments most easily replaced with or most likely to benefit from replacement by electronic payments probably would have been replaced early on. Certain payment transactions in which checks are still used, on the other hand, may be difficult to complete with electronic payments in their current form. But scale and network economies in electronic payments should continue to increase the cost of checks relative to electronic payments, and businesses and consumers are likely to become more comfortable with them, increasing the likelihood that at least some remaining check payments will be replaced sometime in the near future. Furthermore, with the passing of legislation reducing barriers to the clearing of checks by electronic means, at some point in the future remaining checks will will be cleared in large numbers as *de facto* electronic payments.[2] In this changing environment, substantial costs might be incurred by depository institutions that move too quickly or too slowly in adapting their check infrastructure to accomodate new processing methods. As a result, businesses in the payments industry must pay careful attention to trends.

The remainder of the paper is organized as follows. Section 2 describes the methods used to sample and estimate the number and value of checks for 2000 and 1995. Section 3 provides some details on the estimation findings. Section 4 discusses the trends in check use implied by the estimates in the context of the socioeconomic environment. Section 5 concludes and discusses future directions for research.

2 Sampling and Estimation Methods

2.1 Overview

Whether checks are written on traditional checking accounts provided by depository institutions, on accounts provided at brokerages or other nondepository institutions, or are in the form of money orders, cashiers checks, rebate checks, or travelers checks, they are paid on transaction deposits held by depository institutions. Checks are paid by several types of DI—commercial banks, credit unions, savings institutions, and U.S. branches of foreign banks. To obtain payment for a check, the depository institution where the check is first deposited, usually the payee's DI, must present it

[2] See the Board's public web site http://www.federalreserve.gov/paymentsystems/truncation/default.htm

to the paying depository institution. Presentment commonly requires that the check be physically delivered to the paying bank to receive payment (though presentment can be made electronically if the paying bank agrees). Presentment can be done directly or through an intermediary such as a correspondent bank, a clearinghouse, or a Federal Reserve Bank.

The population of federally-insured depository institutions is tracked at the charter level and holding company level by the Federal Reserve Board and other regulators. While some DIs, such as certain very small credit unions, are not federally-insured, the number of checks paid by such institutions is very small. Thus, an estimate for the total checks paid by the population of federally insured DIs, for all practical purposes, captures all checks paid in the United States.

Because of differing characteristics and reporting requirements, the population of depository institutions was divided into commercial banks, credit unions, and savings institutions for sampling and estimation. Federally-insured depository institutions report balance sheet and income statement and other regulatory information at the charter level on a periodic basis. Commercial banks and savings institutions report data quarterly, while, until recently, credit unions were only required to report information every two quarters (June and December).

Commercial banks and savings institution charters are often controlled by holding companies. The check operations of holding companies that own several charters are generally conducted without special attention to the charter boundaries within the organization. For this reason, in the 2001 survey, multiple depository institutions owned by a holding company were treated as a single unit, and charter-level data was appropriately aggregated. As a result, the populations for commercial banks and savings institutions were a mix of holding companies and single charter institutions. (Like the 1979 study, the survey from 1995 did not aggregate holding companies into single entities. As explained below, the estimation procedure for that year was adjusted to account for this difference. While the different approach along with the number of entities that responded affected the precision of the estimates, the difference likely does not affect the comparability of the estimates.)

2.2 Estimation

The linear techniques of estimation used in this paper are standard and well known among survey statisticians. Economists and econometricians typically do not have a background in that literature. Thus, it is useful to provide some theoretical background in the estimation techniques.[3] A nonparametric technique for estimating a total for a population from a sample that does not appear to have been undertaken elsewhere in the literature is also introduced.

[3] For a thorough discussion of linear sampling and estimation techniques, see one of the standard textbooks such as Cochran (1977).

Let P be the population of DIs, and let S be the set of DIs that responded to the survey. The primary goal of the study is to use the number of checks y_s reported by sampled DI s (where $s \in S$) to estimate the total number of checks paid by all DIs (y_p where $p \in P$). Note that the sample is a subset of the population, i.e. $S \subset P$.

A general model for estimating the number of checks y for the ith DI may be written

$$\begin{aligned} y_i &= m(z_i) + \epsilon_i \\ E(y_i|z_i) &= m(z_i) \end{aligned} \tag{1}$$

where z is taken to be an exogenously given variable describing some characteristic correlated with y, and ϵ is a random error. Generally, z should be some measure of size connected with checks, such as transaction deposits, total deposits, or assets. (Of the three, however, transaction deposits are most closely connected to the number and value of checks.)

If y and z are continuous variables, the (actual but unknown) total number of checks is defined by

$$Y = N \int_{-\infty}^{\infty} d^P(z) m(z) dz, \tag{2}$$

$$\text{where} \int_{-\infty}^{\infty} d^P(z) dz = 1, \tag{3}$$

and $d^P(\cdot)$ is the probability density of characteristic z for the population of $N < \infty$ depository institutions.

Where diversity exists, it is often helpful for sampling and estimation to group the population into types with similar characteristics. Under such strategies, estimates of the total number of checks may be written as

$$\hat{Y} = N \sum_{h=1}^{H} \hat{d}_h^P \hat{m}_h, \tag{4}$$

$$\text{where} \sum_{h=1}^{H} \hat{d}_h^P = 1, \tag{5}$$

and where $\hat{d}_h^P$ is the observed or estimated population density and $\hat{m}_h$ is the estimated expected value of y for a DI in stratum h.

2.2.1 Approaches to estimation

Based on the general model, there are several possible approaches to estimating the total number of checks. In general the preferred approach is the one that minimizes the variance of the estimate without introducing excessive bias. The appropriateness of an approach is also dependent on the sampling procedure.

Most economists are familiar with variance formulas for infinite populations. In a reasonably large sample from a finite population of DIs, however, account should be taken of the fact that the values reported by responding DIs are not estimated by the statistician (or econometrician). In all of the variance formulas shown below variances are corrected for the fact that the population of DIs is finite. When an estimate for a finite population is made from a sample, standard practice is to multiply the variance by the factor $(1 - f)$ where $f = n/N$ is the ratio of the number of responses in the sample to the number of DIs in the population. The variances so defined accounts for uncertainty in the estimation of data for nonresponding DIs, but does not attempt to account for any errors in the data reported by respondents.[4]

Approach 1: Simple random sampling estimator The first possible approach is to estimate the sample mean with the population mean. If sampling by strata is ignored, the estimate for the number of checks is unconditional, i. e. $E(y_i) = \bar{y}$. In this case $\hat{m} = \bar{y}$, $\hat{d}^P = 1$, and $H = 1$ and the ratio N/n expands the sum of checks from the sample to the population. Thus the equation for the population total would be specified as follows:

$$\hat{Y} = N\bar{y} = \frac{N}{n}\sum_{s \in S} y_s. \tag{6}$$

The variance of this estimate is

$$v(\hat{Y}) = \frac{N^2(1-f)}{n}s^2 \tag{7}$$

where $s^2 = \frac{1}{n-1}\sum_{i=1}^{n}(y_i - \bar{y}_i)^2$. For the current sample, this approach does not apply because the response frequency varied with institution size. A variant of this approach which is applicable because it accounts for a stratified population and independent random sample within strata is to estimate separate totals for each stratum, where the population mean within strata is estimated with

[4]The fact that variance estimates cannot account for these types of errors is one reason why the careful design of surveys and the fastidious collection and editing of data is of paramount importance.

the sample mean ($E(y_i|i \in P_h) = \bar{y_h}$). Thus, the population total is,

$$\hat{Y} = N \sum_{h=1}^{H} \frac{N_h}{N} \bar{y_h} = \sum_{h=1}^{H} N_h \bar{y_h} = \sum_{h=1}^{H} \frac{N_h}{n_h} \sum y_{s.} \tag{8}$$

In this case $\hat{m_h} = \bar{y}_h$, $\hat{d}_h^P = N_h/N$ and the ratios N_h/n_h expand the sum of checks from the sample to the population stratum by stratum. Thus, in the present application, the mean for stratum h ($\bar{y}_h$) is conditional on size and type of institution because the sample is stratified by PCD size and institution type. The estimated variance of this estimator is the sum of the variances of the individual strata, or

$$v(\hat{Y}) = \sum_{h=1}^{H} \frac{N_h^2(1-f_h)}{n_h} s_h^2. \tag{9}$$

Approach 2: Ratio estimator The ratio estimator obtains increased precision by taking advantage of the correlation between y_i and x_i, where x_i is known for each member of the population. Let $\hat{R} = \bar{y}/\bar{x}$.For a simple random sample, the ratio estimator is

$$\hat{Y}^R = \frac{\sum_{p \in P} x_p}{\sum_{s \in S} x_s} \sum_{s \in S} y_s = \frac{N\bar{X}}{n\bar{x}} \sum_{s \in S} y_s = N \frac{\bar{X}}{\bar{x}} \bar{y} = N\hat{R}\bar{X}. \tag{10}$$

Here, $\hat{m} = (\bar{X}/\bar{x})\bar{y}$, $\hat{f}^P = 1$, and $\hat{R}$ is an estimate of the ratio of checks to deposits for the population. The sample estimate of the variance of $\hat{Y}^R$ is

$$v(\hat{Y}^R) = \frac{N^2(1-f)}{n(n-1)} \sum_{i=1}^{n} (y_i - \hat{R}x_i)^2. \tag{11}$$

A comparison between Equation 7 and Equation 11 reveals why a high correlation between y and x increases the precision of the estimate. The ratio estimator for a stratified sample is

$$\hat{Y}^R = N \sum_{h=1}^{H} \frac{N_h}{N} \frac{\bar{X}_h}{\bar{x_h}} \bar{y_h} = \sum_{h=1}^{H} \hat{Y}_h^R = \sum_{h=1}^{H} N_h \hat{R}_h \bar{X}_h. \tag{12}$$

Here, $\hat{m_h} = (\bar{X}_h/\bar{x_h})\bar{y_h}$, $\hat{f}_h^P = N_h/N$, $N = \sum N_h$,and $\hat{R}_h = \bar{y}_h/\bar{x}_h$ is an estimate of the ratio of checks to deposits for the population in stratum h. The approximate variance for stratum h is

$$v(\hat{Y}_h^R) = \frac{N_h^2(1-f_h)}{n_h(n_h-1)} \sum_{i=1}^{n_h} (y_i - \hat{R}_h x_i)^2. \tag{13}$$

A "bias corrected" version of the variance, which accounts for the relative size of institutions in the stratum population and responses is $v^{bc}(\hat{Y}_h^R) = (\bar{X}/\bar{x})v(\hat{Y}_h^R)$ (Rao, 1978). The variance of the total is the sum of the variances for each stratum.

Approach 3: Linear regression estimator For a simple random sample the regression estimator is

$$\hat{Y}^{lr} = N(\bar{y} + \hat{\beta}(\bar{X} - \bar{x})) \tag{14}$$

where $\hat{\beta}$ is the fitted slope coefficient from a linear regression of y on x and a constant α. Thus, for the present application, $\hat{\beta}$ is an estimate of the change in y when x is increased by 1. The regression estimate is equivalent to the ratio estimator when $\alpha = 0$. The variance of the linear regression estimator is

$$v(\hat{Y}^{lr}) = \frac{N^2(1-f)}{n(n-2)}s^2 \tag{15}$$

where s^2 is the variance of the regression residual. For a stratified sample, the regression estimator is

$$\hat{Y}^{lr} = \sum_{h=1}^{H} N_h(\bar{y_h} + \hat{\beta}_h(\bar{X}_h - \bar{x_h})) \tag{16}$$

where $\hat{\beta}_h$ is an estimate for the increase in the annual number of checks paid for a \$1,000 increase in deposits in stratum h. The variance of the total is the sum of the variances for each stratum, i.e.,

$$v(\hat{Y}^{lr}) = \sum_{h=1}^{H} \frac{N_h^2(1-f_h)}{n_h(n_h-2)}s_h^2. \tag{17}$$

.

Approach 4: Nonparametric regression estimator In some cases, the assumption of a linear relationship between y_i and x_i within strata may be too restrictive. In addition, the selection of strata boundaries, while not arbitrary, is only approximately optimal. The ratio and linear regression estimators are based on linear parameterizations of the conditional expectation $E(Y|X = x) = m(x)$. A nonparametric extension of the idea behind the linear regression estimator shown above is possible using the Nadaraya-Watson estimator (NW), a nonparametric regression estimator.[5] The following estimate for the total is a variant of standard nonparametric techniques, but this author has not found an attempt to estimate a total by a similar technique in the literature. The model for the nonparametric estimate is

[5] Härdle and Linton (1994) and Pagan and Ullah (1999) provide good background discussions of this estimator and of nonparametric estimation methods in general.

$$y_i = m(y_i) + \epsilon_i, \quad i = 1, ..., n, \tag{18}$$

where ϵ_i is an independent random error satisfying $E(\epsilon_i|x_i = x) = 0$ and var$(\epsilon_i|x_i = x) = \sigma^2(x)$. The total number of checks paid for institutions of size x is $Nf^P(x)m(x)$ where N is the number of institutions in the population and $f^P(\cdot)$ is the probability density function for the population. The total number of paid checks is

$$Y = N \int_{\min(x)}^{\max(x)} f^P(x)m(x)dx, \tag{19}$$

where $\int_{\min(X)}^{\max(X)} f^P(x)dx = 1$.

The NW estimator is defined as

$$\hat{m}_h(x) = \frac{\sum_{i=1}^n K_h(x - x_i)y_i}{\sum_{i=1}^n K_h(x - x_i)} = \frac{\sum_{i=1}^n K_h(x - x_i)y_i}{n\hat{f^S}_h(x - x_i)} \tag{20}$$

where $K_h(\cdot)$ is a kernel function which is piecewise continuous, symmetrical around zero, and integrating to one and $\hat{f^S}_h(\cdot)$ is the estimated probability density function of the sample. The smoothness of $\hat{m}_h$ is determined by the bandwidth h.

Separating the population of DIs of a given type into a certainty group C and an uncertainty group $X\backslash C$, the total number of checks may be written as

$$\hat{Y}^{np} = (N - N_C) \sum_{x \in U} \hat{f}_h^{X\backslash C}(x)\hat{m}_h(x) + \sum_{c \in C} Y_c \tag{21}$$

where $U = \min(X), \min(X) + a, \cdots, \max(X_{X\backslash C})$ for $a = (\max(X\backslash C) - \min(X\backslash C))/(q - 1)$, $\sum_{x \in U} \hat{f}_h^U(x) = 1$ and q is a somewhat arbitrary choice of the number of points in the distribution to compute, but is the rough equivalent to the number of bins in a histogram.[6]

The specification may be thought of as dividing the population into q strata and estimating separate models for each. The data used to estimate the mean for each strata, however, is not restricted to members of the strata, and the weighting of observations within the strata is a function of the kernel and of the bandwidth h. The bandwidth h is selected to be approximately optimal for the estimation of $\hat{m}_h(x)$ and the same h is used for $\hat{f}^{X\backslash C}(x)$. In general, the sample bandwidth h is larger than would be optimal for the population. Depending on the complexity of the kernel function, the variance of this estimator may be estimated with its asymptotic variance or by bootstrap methods. In this paper, only bootstrap estimates are considered for the nonparametric estimator

[6]The choice of q involves a tradoff between precision and computational burden. The precision gain diminishes as q becomes large. For the results reported in this paper, $q = 200$.

and will be shown in the next section.

3 Data and Results

3.1 2001 Data

The three surveys conducted in 2001 were

- Depository Institution Check Study[7]—Survey of the number, value, and collection sources of checks paid in March and April 2001 from a stratified random sample of insured commercial banks, credit unions, and savings institutions in the United States
- Check Sample Study[8]—Survey of a random sample of individual checks submitted for collection by a stratified random sample of depository institutions during 2000
- Electronic Payment Instruments Study[9]—Survey of the number and value of retail electronic payments originated in the United States in 2000 through the universe of electronic payment networks, card issuers, and third-party processors.

Only the first of the three surveys is analyzed in detail in this paper, although results of the other two are discussed.

3.1.1 Survey and sample design

In the Depository Institution Check Study, the surveyed depository institutions were instructed to report only those checks paid on behalf of their own customers and to exclude checks that they collected on behalf of other depository institutions. To account for checks written on money market and other accounts at brokerages, respondents were instructed to include the checks they settled on behalf of those nondepository institutions in their reported figures.

[7]Global Concepts, Inc. and Westat, Inc. were retained by the Federal Reserve Bank of Atlanta to assist with the survey design, estimation, and data collection. The survey was designed by a team of staff members from the Federal Reserve System, Global, and Westat. Data collection and initial estimation was performed by Global and Westat in consultation with Federal Reserve staff.

[8]Global Concepts, Inc. and Westat, Inc. were also retained to assist with this survey. Global and Westat designed the survey, collected the data, and performed the estimation in consultation with Federal Reserve staff members.

[9]Dove Consulting was retained by the Federal Reserve Bank of Atlanta to assist with the survey design, estimation, and data collection. The survey was designed by a team of staff members from the Federal Reserve System and Dove Consulting. Dove consulting, in consultation with Federal Reserve staff members, performed the data collection and produced the estimates for the number and value of electronic payments reported in this paper.

The population of depository institutions from which the sample was drawn encompassed commercial banks (including branches of foreign banks), credit unions, and savings institutions. Depository institution subsidiaries of multibank holding companies were treated as a single institution. Depository institutions in the population that had transaction deposits at the close of business on September 30, 2000 (June 30, 2000, for credit unions), were grouped by type—commercial bank, credit union, or savings institution—and stratified by value of transaction deposits (excluding the transaction deposits of other banks and the U.S. government), as reported to federal depository institution regulators.

The sampling procedure was designed to achieve 95 percent confidence intervals no larger than ± 5 percent of the size of the estimates of total number and value of checks paid. Six strata were defined for commercial banks, five for credit unions, and three for savings institutions. The boundaries of the strata and the probability of selection for institutions in each stratum were set to maximize the precision of the estimates of the number and value of checks. Because transaction deposits are concentrated in the largest institutions, the probability of an institution's being sampled increased with the value of its transaction deposits, although the probability of selection was the same for all the institutions in a given stratum.

Using the assumption of a response rate of 65 percent or greater, 2,365 depository institutions were sampled. The probability of selection for the largest 533 commercial banks, 104 credit unions, and 40 savings institutions was 100 percent. There were 1,256 valid responses for the number and value of checks; 1,011 valid responses for the share of on-us checks; and 1,036 valid responses for the number of returned checks. For the total number and value of checks, the overall response rate was about 53 percent. In part because response rates were higher for strata with larger depository institutions, the desired precision was achieved for the estimate of check number; it was not, however, for the estimate of check value.

The approach to sampling was to stratify the population of each type of DI by size, then produce separate estimates of the total for the population within the stratum using the institutions sampled from the same stratum. For each institution type, the population was sorted and divided into several strata according to the value of a measure of size called public checkable deposits (PCD). The boundaries and sampling rates for each stratum were selected based on PCD following a procedure designed to contribute to minimizing the standard error of the estimates (Lavalee and Hidiroglou, 1988). At the sampling stage, the population of charters for the 1979 and 1995 samples were stratified by total deposits rather than PCD.

In general, PCD is the value of transaction deposits, excluding deposits of other DIs and the federal government. Deposits of other DIs are generally compensating balances for correspondent services, and institutions were instructed not to report checks paid on behalf of their DI customers, because reporting such checks would result in double counting. The known number of federal

government checks and postal money orders are paid by the Federal Reserve Banks and are not paid on deposits held at private DIs. Thus, PCD is a measure of the type of deposits against which most checks are written. Given the different ways that each institution type reports its deposits, the PCD definition was not perfectly consistent between different DI types, but does not present a problem as the estimates for these types are produced independently.

After strata boundaries were chosen, balanced random samples without replacement were taken from the strata populations. The probability of selection was greater for DIs in strata with larger PCD values, and the largest DIs were selected with certainty. A similar approach was used for the 1979 and 1995 studies. Such an approach can help to increase the precision of estimates for a given sample size when a population is highly skewed, as is the case for depository institutions.

Another reason for stratifying the population according to the size of PCD at the estimation stage was because the average value of checks, the intensity with which the customers of depository institutions used checks, and the tendency to sweep temporarily unused deposits out of transaction accounts was expected to vary across different size groups, but be fairly similar within groups.

3.1.2 Estimation

To improve the accuracy of the estimates, the strata used for estimation were updated using PCD information for the population of depository institutions with transaction deposits at the close of business on March 31, 2001 (December 31, 2000, for credit unions) (14,696 institutions). For the final estimation, commercial banks were grouped into seven strata, credit unions into six, and savings institutions into four.

Check figures were annualized by summing the figures for March and April 2001 and multiplying by six. For simplicity, these annualized figures were assumed valid for 2000, an assumption supported by data on Federal Reserve check collections: The number of checks collected by the Federal Reserve Banks, which may track total checks for short intervals, declined slightly but was relatively flat between 2000 and 2001. The annualization factor implied by the number of checks collected by the Reserve Banks in March and April would have been slightly smaller than six because check collection volume in March and April tends to be higher than in other months.

Ratio Estimates Estimates of the number and value of checks were based on separate ratio estimators for each stratum using transaction deposits as the covariate. (Within a stratum, the amount of transaction deposits was highly correlated with the number and value of checks reported by the responding institutions.) The estimate of total number (or value) of checks paid by depository institutions was equal to the sum of the estimates for the strata. Data on the number (or value) of U.S. Treasury checks and postal money orders paid in 2000 were added to that estimate to obtain the estimated total for 2000 (See Table 1).

Since the original study estimates were reported, some correction of the data was possible, in part because depository institutions are given the opportunity to correct errors in quarterly reports filed with the Federal Reserve. This allowed an update of the PCD values reported by the institutions for March 31, 2001. New strata boundaries were chosen based on the corrected data according to the first iteration of an approximately optimal algorithm due to Dalenius and Hodges, Jr. (1959), using PCD of the population. (The method is referred to as cum$\sqrt{f}$ by Cochran (1977).)

To further reduce the variance of the total estimate, the lower boundary of the stratum with the largest DIs was adjusted to obtain a certainty stratum of the largest institutions. Such judgemental choices are appropriate in light of the fact that the allocation to boundaries is approximate, and assumes that sampling rate objectives are met. In any case, given that the minimum variance estimator is preferred, judgement exercised solely for the purpose of increasing the precision of the estimate is appropriate and common, in practice. The 33 largest banks that end up representing only themselves in the adjusted cum$\sqrt{f}$ allocation are unlikely to be representative of banks of smaller size. The new estimates are reported in Table 2.

The value estimate changed the most. In fact, the estimated value dropped by almost \$0.5 trillion (1.2 percent) while the standard error was reduced by half. In the original estimate, the 95 percent confidence interval was $\pm\$2.5$ trillion while in the new estimate the confidence interval is $\pm\$1.2$ trillion. The drop in the corresponding 95 percent confidence intervals for the number of checks was not as dramatic, dropping from ± 1.6 billion to ± 1.2 billion. Recall, however, that these confidence intervals do not account for mistakes, or errors in reporting. While much effort was invested in identifying, verifying, and editing possible problems in the data, it is still important to note that if a very large DI miscounted, the mistake could be in the billions of checks or trillions of dollars.

The average value of a check for each stratum was estimated as the ratio of the estimated total value of checks to the estimated total number. For each estimated average, an asymptotic standard error was computed according to the following formula for the standard error of a ratio of two correlated random variables from Kendall and Stewart (1977). For two random variables, a and b,the variance of the ratio a/b is

$$\text{var}(a/b) = \left\{\frac{E(a)}{E(b)}\right\}^2 \left\{\frac{\text{var}(a)}{E^2(a)} + \frac{\text{var}(b)}{E^2(b)} - \frac{2\text{cov}(a,b)}{E(a)E(b)}\right\}.$$

The variances in the formula were simply the estimated variances of value and number, respectively. The covariance between value and number for each stratum was estimated using a rearrangement of the formula for the variance of a sum of two random variables, i.e. $\text{Cov}(a,b) = (\text{Var}(a+b) - \text{Var}(a) - \text{Var}(b))/2$. Each of the three variances on the right hand side were produced from separate ratio estimation procedures according to the formula in Equation 13. Notice that the

confidence interval for the average value of a check is estimated with more precision than either the total number or total value.

Linear Regression Estimates Linear regression estimates (not reported) were also estimated and compared to the ratio estimates. In practice, the parameters β_h are estimated on data trimmed of outliers. Then the total is estimated according to the formula in Equation 14. As stated above, the linear regression estimators are equivalent to the ratio estimators when the constant in the linear regression is equal to zero. The hypothesis that the fitted constant in the linear regressions were equal to zero could not be rejected. In addition, the estimated totals based on the linear regressions in each stratum were practically identical to their ratio estimator counterparts.

While the regression estimator resulted in virtually identical totals and standard errors, the fit of some of the regressions was not particularly high for some strata, although overall the fit was quite acceptable for a cross-section. The cross-sectional variation of PCD explained less than one-quarter of the variation in the total number of checks for some strata of intermediately sized commercial banks.[10]

The ratio estimator studied above and linear regression estimator is best when y and x are highly correlated and $\sigma^2(y_i) = \sigma^2 * x_i$. That is, the variance of the number and value of checks should be proportional to the value of PCD. Scatterplots of the number of checks paid to the value of PCD appear consistent with this assumption. Figures 2, 3, and 4 show scatterplots by stratum along with the corresponding fitted regression lines. The size of each dot in the plots correspond to the value of checks paid by each DI relative to other members of the stratum. In general, banks of larger size in terms of the number of checks are also larger in terms of value. On the other hand, the scatterplots show that banks exhibit considerable diversity, reflecting different mixes of consumer and business customers. Interestingly, the very largest banks have smaller average value than the second to largest banks, reflecting either a greater focus on consumers than the not-so-large, more regional banks, or revealing a boundary where larger business payments at these banks are transferred electronically. Aside from this anomaly, the average value of a check gets smaller as the size of a DI becomes smaller.

Nonparametric estimates While the linear assumption is convenient and likely reasonably close to the true model, it is worth studying the data more closely to see how nonparametric model performs relative to the ratio estimator. The first step will be to explore the univariate empirical distributions of PCD. One of the defining characteristics of the population of DIs is the highly-skewed nature of the distribution of common measures of size such as assets, PCD, and total deposits.

[10] The relatively poor fit of the regressions for this class of DI also suggests that other covariates might be considered. The CALL reports provide an impressive number of balance sheet and income statement related candidates, allowing for a multivariate linear regression estimate of the population totals. Such models could be explored in the future.

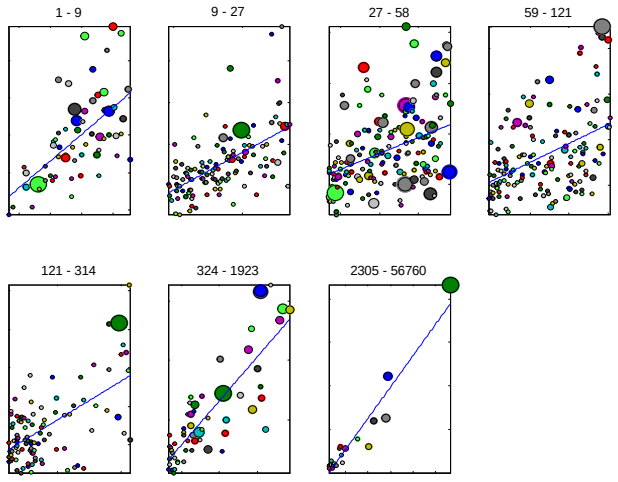


Figure 2: Scatter plots of the data used to estimate the number of checks and value of checks paid by commercial banks Each plot corresponds to one of the strata used for estimation. The vertical axis is the number of checks, and the horizontal axis is the value of public checkable deposits, where the range on the horizontal axis (in $1 millions) is printed above each plot. The line is the fitted line for the regression of the number of checks on the value of public checkable deposits and a constant. The size of the dots in each scatter plot represent the relative value of checks paid by the institutions within the strata.

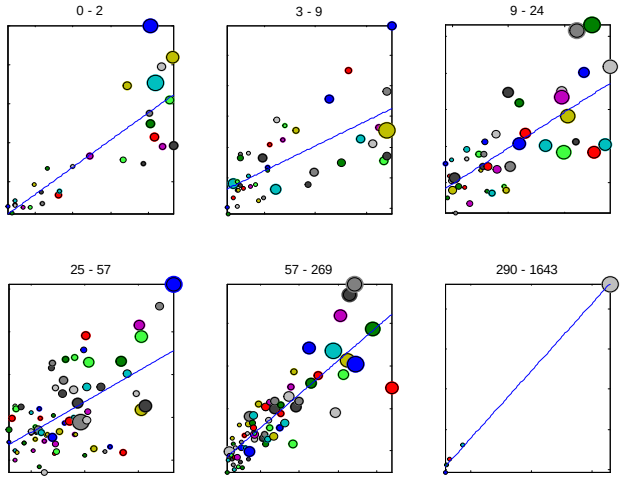


Figure 3: Scatter plots of the data used to estimate the number of checks and value of checks paid by credit unions Each plot corresponds to one of the strata used for estimation. The vertical axis is the number of checks, and the horizontal axis is the value of public checkable deposits, where the range on the horizontal axis (in $1 millions) is printed above each plot. The line is the fitted line for the regression of the number of checks on the value of public checkable deposits and a constant. The size of the dots in each scatter plot represent the relative value of checks paid by the institutions within the strata.

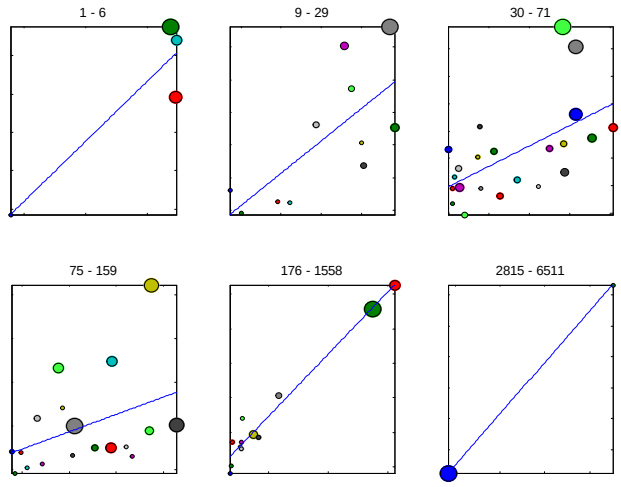


Figure 4: Scatter plots of the data used to estimate the number of checks and value of checks paid by savings institutions. Each plot corresponds to one of the strata used for estimation. The vertical axis is the number of checks, and the horizontal axis is the value of public checkable deposits, where the range on the horizontal axis (in $1 millions) is printed above each plot. The line is the fitted line for the regression of the number of checks on the value of public checkable deposits and a constant. The size of the dots in each scatter plot represent the relative value of checks paid by the institutions within the strata.

While there are approximately 15 thousand DIs in the United States with nonzero PCD, most of the assets, deposits, and PCD are controlled by a small number of very large institutions. As a result, the median-sized DI tends to be much smaller than the DI of average size. The skewness in part is related to the fact that these measures are bounded below by zero.

One common parametric approach to modeling data with this property is to transform it using the natural logarithm and fit the transformed data to a normal distribution. In that case, the data are assumed to be lognormally distributed. Under the lognormal assumption, the mean and variance of the untransformed data are

$$E(X) = e^{\mu+\frac{\sigma^2}{2}} \tag{22}$$

$$var(X) = e^{2\mu}(e^{2\sigma^2} - e^{\sigma^2}) \tag{23}$$

where X is the untransformed variable and μ, σ are the mean and standard deviation of $\ln(X)$. As will be seen below, the lognormal distribution is too restrictive as skewness and kurtosis of the distributions are not necessarily well represented by the lognormal model.

There are other reasons to transform the data. The skewness of the distributions make the display of the data on a common, linear scale difficult. In addition, production of the empirical

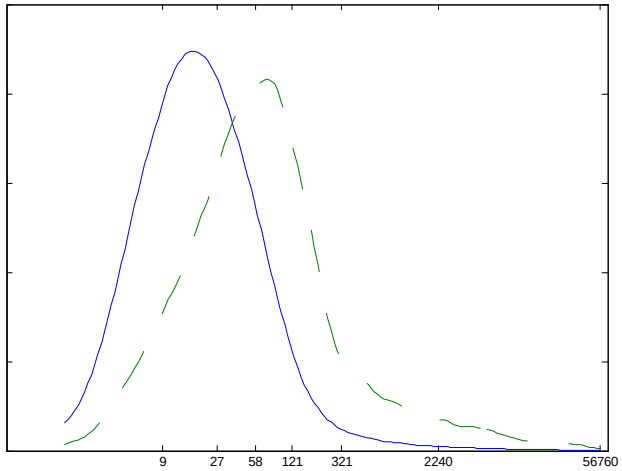


Figure 5: Density of commercial bank PCD. The solid blue line is for the population, and the dashed red line is for the sample. The numbers on the horizontal axis correspond to the upper bounds of the strata for the ratio estimates.

distributions using a common bandwidth for a kernel over the range of the untransformed data is problematic when the data are highly skewed. Suppose $Z = e^X$, the probability function of X is f and the probability function of Z is g. When f is continuous, and the transformation function and its inverse are continuously differentiable and monotonically increasing as with the natural logarithm, then for a given z of Z,

$$g(z) = \frac{f(ln(z))}{z}. \tag{24}$$

This shows that if the distribution of X is approximately symmetrical then the distribution of Z will be highly skewed to the right.

In the original study, larger institutions were deliberately oversampled, muting the skewness of the sample relative to the population. Sampling frequency thus increases with size resulting in skewing the transformed sample data to the left (Figures 5, 6, and 7).

Nadaraya-Watson regressions were estimated for the number of paid checks. In the present paper, K is the Epanechnikov kernel and h is chosen according to a formula known as Silverman's rule of thumb, which approximates the bandwidth that minimizes the integrated mean squared error of the $\hat{m}(x)$'s. Pointwise confidence intervals are based on the estimated asymptotic variance of $\hat{m}_h(x)$ which depends on $\hat{\sigma}^2(x)$, $\hat{f^S}_h(x)$ and a correction for the finite population. Unlike the linear regressions reported above, NW estimates use all of the sample data including outliers.

Unlike the linear regressions, NW estimates use all of the sample data including outliers. The nonparametric regressions of the natural log of the number of checks against the natural log of

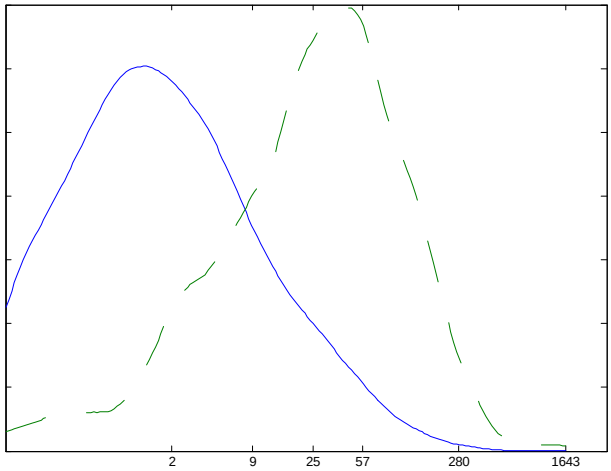


Figure 6: Density of credit union PCD. The solid blue line is for the population, and the dashed red line is for the sample. The numbers on the horizontal axis correspond to the upper bounds of the strata for the ratio estimates.

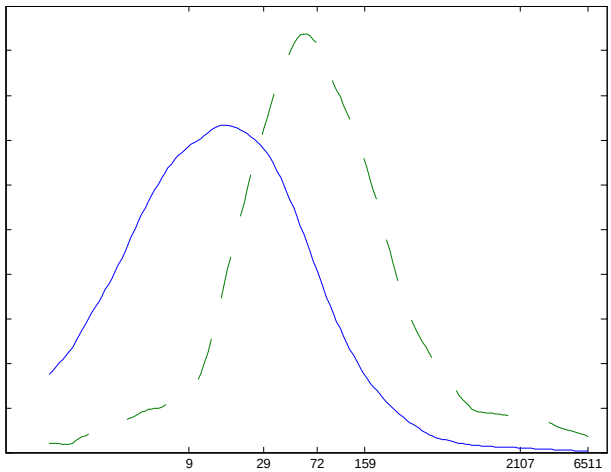


Figure 7: Density of savings institution PCD. The solid blue line is for the population, and the dashed red line is for the sample. The numbers on the horizontal axis correspond to the upper bounds of the strata for the ratio estimates.

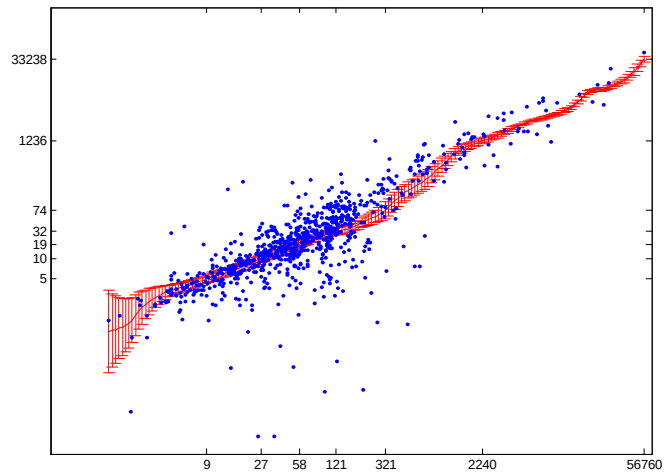


Figure 8: Nadaraya-Watson regression of the natural log of the number of checks against the natural log of PCD for commercial banks. The vertical axis indicates the number of checks paid and the horizontal axis corresponds to the upper boundaries of the strata used for the ratio estimator. The data points are represented as blue dots, and estimated 95 percent confidence bounds are shown in red.

PCD show that the data are not well-described by a single linear function, but could be reasonably described by a judiciously selected piecewise linear function such as the ratio estimator or linear regression estimator (Figures 8, 9, and 10).[11] For a few short intervals, monotonicity of the estimated function $\hat{m}(x)$ is violated, but the estimated confidence intervals tend to be wider at these locations on the curve, and the confidence intervals envelop a monotonically increasing function.

For the non-parametric estimate of the total number of paid checks, Y_i is defined as the number of checks paid by institution i but X_i is defined as the log of PCD in order to allow the selection of a common h for q discrete locations spanning the data described above.[12] While the number of checks could have been logged as well as in the NW regressions reported above, doing so would have introduced additional complications having to do with the need to transform expectations of the logged variable into expectations of the actual variable and the fact that the sum of natural logs is not equal to the natural log of a sum. As shown above, if the logged data are normally distributed, the expectation and variance of the actual variable are simple functions of the two moments that describe the distribution. When the assumption of normality is relaxed, the transformation is not so straightforward. The intuition provided by the result for the log-normal distribution, however, is that if the dependent variable is transformed by the natural logarithm, the expectation of the actual

[11] While the value of paid checks is also of interest, for this paper I concentrate on the number of paid checks because, for policy reasons, it is typically viewed as the more critical estimate relative to value of paid checks.

[12] A more general kernel estimate that allows the width of h to vary with the value of PCD rather than logging PCD is another way to deal with the skewness of the distribution, and may be attempted in the future.

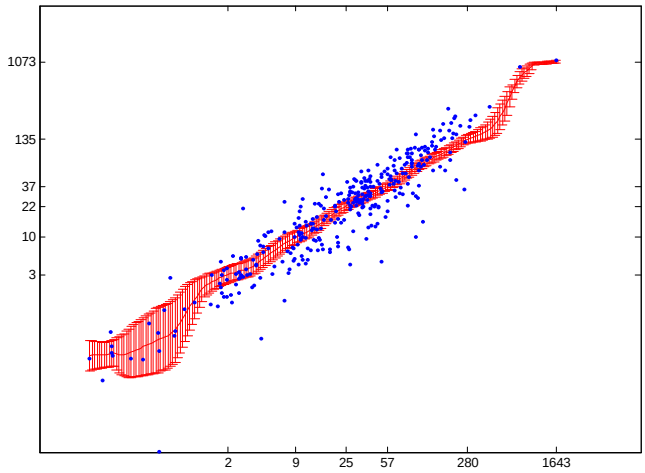


Figure 9: Nadaraya-Watson regression of the natural log of the number of checks against the natural log of PCD for credit unions. The vertical axis indicates the number of checks paid and the horizontal axis corresponds to the upper boundaries of the strata used for the ratio estimator.The data points are represented as blue dots, and estimated 95 percent confidence bounds are shown in red.

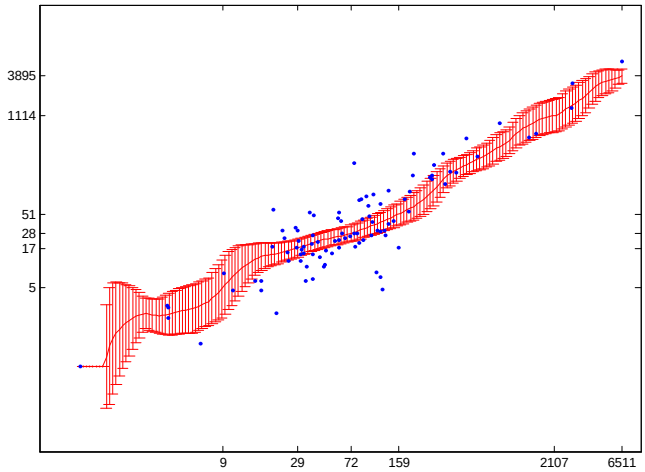


Figure 10: Nadaraya-Watson regression of the natural log of the number of checks against the natural log of PCD for savings institutions. The vertical axis indicates the number of checks paid and the horizontal axis corresponds to the upper boundaries of the strata used for the ratio estimator.The data points are represented as blue dots, and estimated 95 percent confidence bounds are shown in red.

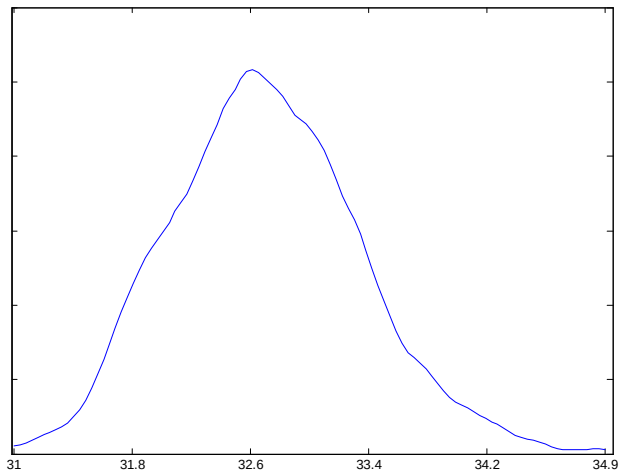


Figure 11: Bootstrap distribution of the nonparametric estimate for the total number of checks paid by commercial banks.

variable will be biased downward but the bias decreases with the variance and thus with the size of the sample.[13]

Estimation of Equation 21 for each institution type shows that the nonparametric estimation is quite close to the linear estimates with PCD as covariate (Table 3). (Another estimate which treated the entire population as an uncertainty group (not reported here) was very close to the reported estimates.) The point estimates of the number of checks paid by commercial banks and savings institutions are extremely close to the estimates using the linear techniques presented previously. The nonparametric estimate for credit unions is larger by about 0.5 billion or about 10 percent.

Bootstrapped standard errors and confidence intervals were specified to take account of the finite population, but did not take advantage of the dependency produced by the stratified sampling except for the separation into uncertainty and certainty strata. Accounting for that dependency would have made the bootstrapped standard errors smaller. Nonetheless, the estimated standard errors from the bootstrap are roughly equal to those from the linear models. The separate estimation of the certainty groups was done primarily to correct for the finite population in the bootstrap computations. The confidence intervals and means from the bootstrap show that the estimates could be roughly described by a normal distribution with mean $\hat{Y}^{np}$ and standard deviation s^{np} although the distributions are very modestly skewed to the right (Figures 11, 12, and 13).

[13] The implications of such specification issues may also be explored later.

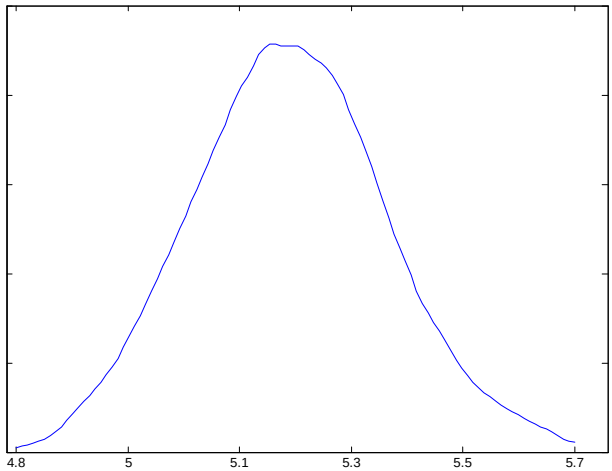


Figure 12: Bootstrap distribution of the nonparametric estimate for the total number of checks paid by credit unions.

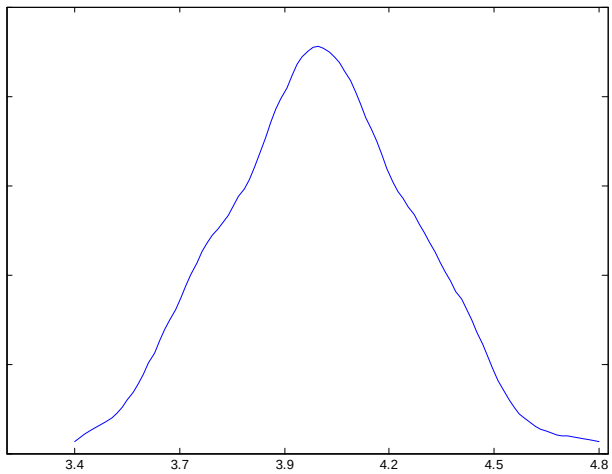


Figure 13: Bootstrap distribution of the nonparametric estimate for the total number of checks paid by savings institutions.

3.1.3 Estimation of the Number and Value of Checks Paid by Location of Deposits

Although the survey of depository institutions was not explicitly designed to facilitate a comparison of check use by geographic region, sufficient responses were received to make such a comparison possible. For each of four regions—Northeast, South, Midwest, and West—separate estimates of the number and value of checks paid were made for single-region institutions (those having deposits in only one region) and multi-region institutions (those having deposits in more than one region). For multi-region commercial banks and savings institutions, checks and transaction deposits were allocated to regions according to the proportion of the institution's total deposits in each of the regions. The allocation method assumed that within these institutions, the ratios of transaction deposits to total deposits, check number to transaction deposits, and check value to transaction deposits were constant. Information on the location of deposits at credit unions and branches of foreign banks was unavailable, and data for these institutions were assigned to the state in which the head office of the depository institution was located. Except for several of the largest credit unions (about ten), most of these institutions operate within the boundaries of a single state.

To produce the regional estimates, institutions were stratified first by region and then by type and size. For each region, the strata were constructed by separating institutions into multi-region and single-region, type, and size categories, with strata boundaries selected according to an approximation to Neyman allocation. New ratio estimators were produced using these strata, following the procedure described in the preceding section (Table 4).

About 138 institutions had branches in more than one of the four regions. (These institutions paid about 40 percent of all checks and accounted for just over 40 percent of transaction deposits.) For each of these multi-region institutions, prior to estimation, transaction deposits and check data (number and value of checks) were allocated to regions in proportion to the location of their total deposits. Allocating transaction deposits according to total deposits assumes that, for the institutions in the sample, transaction deposits and checks are in the same proportion to total deposits for every region. This allocation method appears reasonable for the construction of an aggregate regional estimate but may not hold true for some institutions. Whether large regional differentials in this proportion for some very large institutions would weaken or strengthen the apparent regional differences reported here is unclear. Estimates of urban and rural check use were constructed using a method similar to that used to construct estimates by region. Urban areas were defined as metropolitan statistical areas (MSAs) and New England county metropolitan statistical areas (NECMAs), and rural areas as all other areas.

3.2 1995 Data

The 1995 data were collected in a survey conducted by Board staff in 1996 for a report to the Congress on funds availability and check fraud (*Report to Congress on Funds Availability Schedules and Check Fraud at Depository Institutions*, 1996). The estimate of number of checks paid was based on the sum of two figures requested in the survey questionnaire: number of checks paid during 1995 that had been received from other institutions and number of checks paid during 1995 that were on-us checks. Thus, the survey provided information on checks paid by a random sample of depository institutions. The definition of the amount of transaction deposits was the same as that used for the 2000 estimates. Unlike the 2000 estimate, the population in this study was defined as individually chartered depository institutions.

For the estimation of the number of checks paid, the population of depository institutions was stratified using the value of transaction deposits in December 1995, with optimal strata boundaries set using adjusted cum$\sqrt{f}$ as described above for the 2001 data. Seven strata were defined for commercial banks, three for credit unions, and three for savings institutions. The estimate of the total number of checks paid by depository institutions was equal to the sum of separate ratio estimates for the strata. The number of U.S. Treasury checks and postal money orders paid in 1995 was added to that estimate to obtain the estimate of the total for 1995 (Table 5).

3.3 1979 Data

The 1979 data were collected in a survey conducted in that year by the Federal Reserve Bank of Atlanta and cosponsored by the Reserve Bank, the American Bankers Association, and the Bank Administration Institute (*A Quantitative Description of the Check Collection System*, 1980). The estimates of the number and value of checks for 1979 were produced from separate ratio estimates of the total number of checks reported by a stratified sample of 343 banks.

4 Trends in Payment Activity

In the United States, most noncash payments are made using checks, credit cards, debit cards, and the electronic payment system called the automated clearinghouse (ACH)—collectively referred to as retail noncash payments. Consumers, businesses, and government entities made about 71.5 billion retail noncash payments in 2000 (Table 6). The total value of these payments was about $46.6 trillion, approximately four and three-fourths times U.S. gross domestic product (GDP) for that year. According to these estimates, checks were the predominant type of retail noncash payment, accounting for 59.5 percent of these payments by number. By comparison, checks constituted 85.7 percent of retail noncash payments in 1979.

Although the number of check payments increased from 1979 to 2000, the number of checks as a share of retail noncash payments declined about 26 percent. Growth in overall economic activity and population led to a general growth in payments, including cash payments, between 1979 and 2000. Such factors as technological change and increased availability and acceptability of alternatives to cash influenced the proportion of payments made with retail noncash instruments.

From 1979 to 2000, the sum of the number of checks and retail electronic payments grew approximately 3 percent a year, about the same as the rate of growth of real GDP. Hence, both the number of retail noncash payments and the amount of economic output roughly doubled over the period. Over the same period, the number of households increased from 78.8 million to 105.5 million, for an annual rate of growth of almost 1.5 percent.

While a comparison of growth in the number and value of payments to various measures of economic activity is useful, the ratios of total number (or value) of payments are not necessarily stable over time. A general increase in payments, an increase in the number of households with checking accounts, or the replacement of some cash payments by noncash payment alternatives could each have contributed in varying amounts to the growth in retail noncash payments leading up to the mid-1990s. (The proportion of households without a checking account fell from 18.7 percent in 1989 to 13.2 percent in 1998 (Kennickell et al., 2000).) In addition, changes in business payment practices, different types of credit arrangements, trends in vertical integration or disintegration of supply chains, and other activities could result in the elimination of some payments, and the replacement of multiple payments with single payments (or the reverse).

About 9.2 billion more retail electronic payments were made in 1995 than in 1979. The number of checks also rose considerably over the period. In fact, about 16.7 billion more checks were paid in 1995. However, the number of checks paid as a share of all retail noncash payments declined, from 85.7 percent to 77.1 percent. The decline in the number of checks as a share of retail noncash payments continued over the period 1995 to 2000, and the number of checks paid declined as well, from an estimated 49.5 billion in 1995 to 42.5 billion in 2000. (In comparison, the annual number of electronic payments increased 14.2 billion over the period.)

Whether the number of checks paid in nearby years was higher or lower than in 1995 is unknown. However, these estimates suggest that the number of checks paid peaked during the mid-1990s. The apparent decline in the number of checks paid between 1995 and 2000 was likely not driven by a change in the general level of economic activity. Both years were part of an economic expansion that began in the early 1990s and peaked in March 2001 (according to the National Bureau of Economic Research), and spending by consumers and businesses, which make the predominant number of payments in the economy, increased during the period.

Instead, the decline in check use appears to have been related to increased use of electronic payments by consumers and businesses. Although the number of checks paid appears to have

declined during the latter part of the period, the number increased on net from 1979 to 2000. The value of checks paid, however, decreased—from an estimated $50.7 trillion in 1979 to $39.3 trillion in 2000 (both in 2000 dollars; Table 7).

The declines in overall check value and related measures (the estimated average value of a check, for example, declined from $1,544 in 1979 to $925 in 2000) provide supporting evidence that electronic payments have replaced checks for at least some types of transactions. In addition, most large-value payments for settlement of financial market transactions that were once made by check are now made electronically, many using the large-value funds transfer systems (such as Fedwire and CHIPS). Such payments are discussed separately because they are not considered retail noncash payments.

4.1 Trends in Total Transaction Deposits

Not only do checks appear to have peaked in the mid-1990's, the total value of PCD held at depository institutions peaked in 1994 (Figure 14). The fact that PCD peaked at about the same time that checks are estimated to have peaked, at first glance, would appear to be more than a coincidence. In fact, one major phenomenon having little connection with the propensity to write checks is at least partially responsible for a decline in total PCD. Sweep programs, which tend to reduce the amount of the checkable deposits at depository institutions that use them, were adopted increasingly during this period.

Generally, depository institutions use two types of sweep programs. Wholesale sweeps, which have been offered to business customers since the 1970s, keep customers' non-earning assets low, by moving funds between non-interest-earning demand deposits, such as transaction deposits, and interest-earning money market mutual funds or other financial instruments. Retail sweeps, which first appeared in 1994, move idle funds from transaction deposit accounts to special purpose money market deposit accounts (MMDAs) and return them to transaction accounts only as needed to cover payments, limiting the number of withdrawals from the MMDAs to six per month in accordance with regulatory restrictions. This practice does not adversely affect the account holder but allows the depository institution to reduce its non-interest-earning assets. Both types of sweep programs reduce the amount of funds depository institutions must hold to meet their reserve requirements (Edwards, 1997).

The importance of check payments relative to other types of payments at individual depository institutions cannot be known precisely because data on the proportion of total payments made using checks at individual depository institutions are unavailable.[14] However, despite the confounding

[14]The 2004 Federal Reserve Payments Study, now in the field, is designed to collect data on other payments initiated from deposit accounts. Thus, the proportion of check payments relative to other payments initiated from deposit accounts could be estimated from that study.

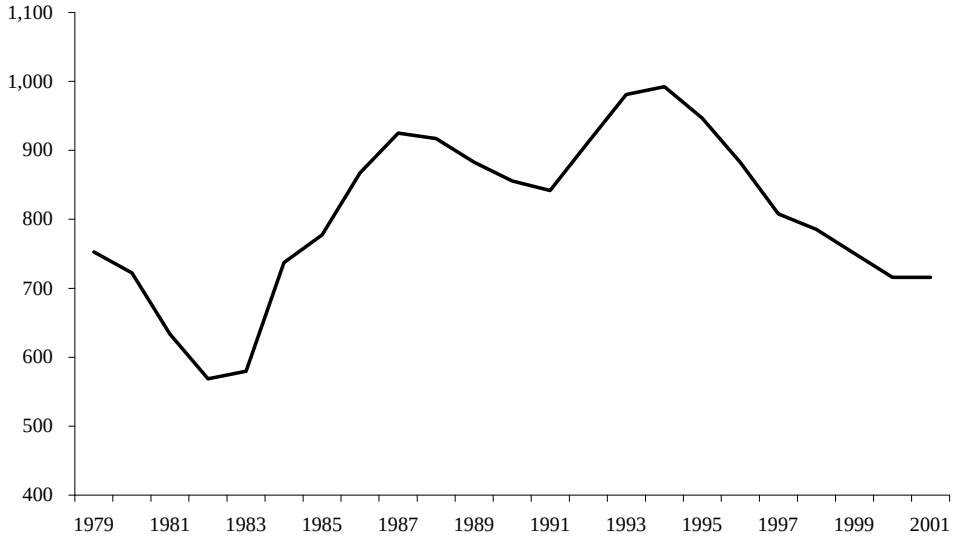


Figure 14: Total PCD from 1979-2001, all depository institutions, billions of 2000 dollars. Adjustments to historical values are made using the GDP implicit price deflator. For example, prices have roughly doubled since 1979, so that $1 in 1979 is equivalent to about $2.05 in 2000.

effects of sweep programs, trends in the number and value of checks paid in terms of the value of an institution's transaction deposits can give some indication of the importance—or intensity—of check use. Specifically, the relative intensity of check use can be approximated as the number and value of checks paid per $1,000 of transaction deposits—the number-to-deposits ratio and value-to-deposits ratio respectively. The use of sweep programs should increase the observed number-to-deposits ratio and value-to-deposits ratio, other things being equal. By value, from 1979 to 2000, the rate of aggregate payment flow via checks for a given stock of checkable deposits, however, declined more than enough to offset an increase in the value-to-deposits ratio due to sweeps.

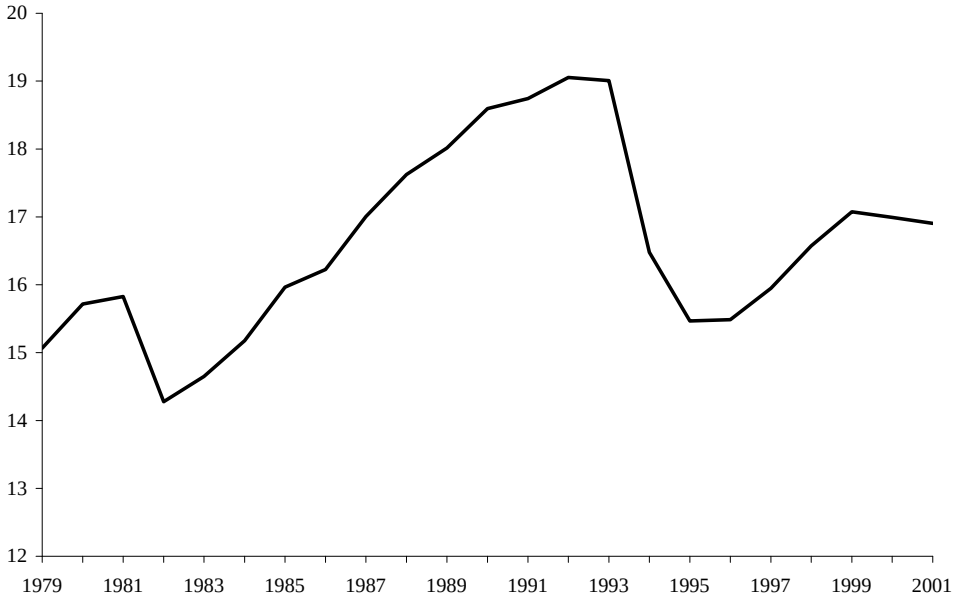
In nominal terms, retail sweeps into MMDAs are estimated by the Board of Governors to have grown from around $5 billion in early 1994 to about $400 billion in 2000, to about $575 billion in early 2004.[15] The data suggest that, after adjusting for retail sweep activity, real transaction deposits actually grew by about $115 billion from 1995 to 2000; real sweep-adjusted transaction deposits grew from about $1 trillion in 1995 to about $1.115 trillion in 2000. These adjusted aggregate PCD values suggest that the number-to-deposits ratio (checks per year, per $1000 of transaction deposits) dropped from about 49 to about 36.5, a decline of about 25 percent.

The number-to-deposits ratio was about 42.6 in 1979. Thus, before the decline, the intensity of check use, by this measure, appears to have increased during the 1980's and early 1990's. On the other hand, the intensity of check use, by number, was lower by about 17 percent for 2000 than for 1979. The value-to-deposits ratio, using the sweep-adjusted estimate of transaction deposits, was about $66 thousand per $1,000 of transaction deposits in 1979 and about $35 thousand in 2000. Checks were paid at the annual rate of about $66 per dollar of deposits in 1979 and about $35 per dollar of deposits in 2000.

Besides checks, both retail and large-value electronic payments can be initiated from checkable deposits using ACH, debit card, and ATM networks as well as other means of funds transfer, depending on the types of services offered by a depository institution. Absent an increase in the propensity to carry unused funds in transaction accounts, the declines in number-to-deposits and value-to-deposits ratios are therefore highly suggestive that check payments were being replaced by electronic payments drawn from checkable deposit accounts.

While these comparisons are highly suggestive of replacement of checks with electronic payments, other competing explanations exist. For example, an increase over time in the willingness of depositors to carry large checkable deposit balances is another possible explanation. An increase could occur, for example, if the opportunity cost of holding funds in checkable deposits declined over the period or if benefits accruing to large checkable deposits, such as the payment of interest or the waiver of fees, increased. While such explanations are possible, they do not seem as likely

[15] Data and other information on sweep programs is available at the Federal Reserve Bank of St. Louis web site (http://research.stlouisfed.org/aggreg/).



as the check replacement hypothesis.

4.2 Federal Reserve Check Clearing

The twelve Federal Reserve Banks collect checks for depository institutions by accepting checks for collection and presenting them to paying depository institutions (those on which the checks are written). In 1979, the Reserve Banks collected about 15 billion checks (4.2). At that time the Reserve Banks provided check collection and other payment services only to commercial banks that were members of the Federal Reserve System, and generally at no charge. The Monetary Control Act (MCA), implemented in 1981 changed the way the Reserve Banks offered payment services, requiring them to recover the cost of certain payment services, including check collection services, over the long run. The recovery requirement included all direct and indirect costs incurred by the Reserve Banks, as well as imputed costs that would have been incurred had the services been furnished by a private business firm, such as the taxes that would have been paid and return on capital. In addition, the MCA required the Reserve Banks to offer their services to all depository institutions, including non-member commercial banks, credit unions, and savings institutions.

In 2000, depository institutions were more likely to collect a check using the Reserve Banks when the paying bank was small, which is illustrated by the fact that, for each type of institution, the share of checks presented by the Reserve Banks decreased as the size of the bank increased. Credit unions, generally among the smallest depository institutions, received the largest share of

their check presentments from the Reserve Banks (Table **??**). The Atlanta Study found that in 1979, the share of checks presented by the Reserve Banks also decreased as the size of the bank increased. That study found that for the smallest banks–those with less than $100 million in total deposits–more than 50 percent of their checks were presented by the Reserve Banks.

The greater share of checks presented to smaller banks by the Reserve Banks is related, in part, to cost. Collecting banks generally need to present a smaller number of checks to smaller banks. The cost of delivering checks to smaller institutions may be relatively lower for the Reserve Banks than for individual banks because the Reserve Banks consolidate all the checks from many collecting banks to the paying bank each day. Alternative routes for collecting checks become more cost effective as the number of checks being presented to a single paying bank increases. Thus, collecting banks are less likely to use the Reserve Banks for the collection of checks from the larger paying banks. Similarly, the cost of presenting checks to smaller depository institutions may also be lower for correspondent banks.

In addition, regulatory differences between the Reserve Banks and private collecting banks are related to the use of Reserve Banks for check collection. For example, the Reserve Banks have a 2 p.m. presentment deadline, 6 hours later than private collecting banks, which, under same-day-settlement rules, have an 8 a.m. presentment deadline.

While the distribution of checks collected by the Reserve Banks differs from the distribution of total checks, over short intervals the trend in the number of checks collected by the Reserve Banks may roughly approximate the trend in the total number of checks. The number of checks collected by the Reserve Banks increased to a peak of 19 billion in 1992 and began to decline slightly in 1993. There was a large drop in the number of checks collected by the Reserve Banks in 1994 and 1995. This decline is generally attributed to the introduction of the same-day settlement rule, which reduced the disparities between the Reserve Banks and private collecting banks.

Other than changes in regulations, changes in the relative costs and benefits of check collection alternatives also affect the number of checks the Reserve Banks process. The number of checks collected by the Reserve Banks rose during 1997 through 1999 but has declined each year since.

Nonetheless, the share of checks presented by the Reserve Banks has remained surprisingly stable. In 1979, about 43 percent of total checks were presented by Reserve Banks, while that share was about 41 percent in 2000, a decrease of only 2 percentage points. In comparison, the estimated share of checks received from local clearinghouses was 21 percent in 1979 and 18 percent in 2000, a decline of about 3 percent.

Banks generally do not use the Reserve Banks to process checks that are on-us. Of the remaining (interbank) checks, the Reserve Banks presented approximately 57 percent in 2000. (Note that it is difficult to equate the share of checks presented by the Reserve Banks with a market share, as an unknown quantity of interbank checks could be collected by multiple intermediaries. The esti-

mate is thus most likely an upper bound.) The Reserve Banks also process returned checks. Based on the estimated total number of checks returned, the Reserve Banks appear to process about 66 percent of these checks.

4.3 Trends and Differences Across Depository Institutions

Credit unions and savings institutions generally did not offer checking accounts (or their equivalent) until the late 1970s. Since that time, transaction deposits at, and the number and value of checks paid by, these institutions have grown briskly. Despite the overall decline in the number of checks paid between 1995 and 2000, the number paid by credit unions and savings institutions continued to grow. These institutions together paid an estimated 14 percent of checks in 1995 but more than 20 percent in 2000. The 1.8 billion increase in the number of checks paid annually by these institutions, however, was more than offset by a dramatic decline of about 8.7 billion in the number paid annually by commercial banks.

These trends have at least two possible explanations. First, during the period commercial banks, especially large ones, may have more aggressively promoted the use of alternative payment instruments to the check, such as debit cards and ACH, relative to their smaller counterparts. On the other hand, credit unions, and to a lesser degree, savings institutions, have grown in number and size during the period. Thus, growth in checks at credit unions and savings institutions could simply be due to gains in the share of total payments services supplied by these types of institution to U.S. consumers and businesses.

The average value of checks paid in 2000 varied by type and size of depository institution, presumably because of the mix of business and consumer customers served by different institutions. Large commercial banks and some large savings institutions serve corporations and other businesses as well as consumers. Because large corporations tend to make larger-value payments, the average value of checks paid by depository institutions that serve them tends to be larger. Community banks (small commercial banks and savings institutions) typically serve smaller businesses and consumers, so the average value of checks they pay is smaller. Credit unions overall have the smallest average check value because they generally provide accounts only to consumers (Table 8).

In 2000, the number-to-deposits and value-to-deposits ratios appear to have varied by type and size of depository institution (Table 8). The largest commercial banks, for example, had the highest value-to-deposits ratio among all categories of depository institutions, likely reflecting the high average value of checks paid by these institutions. In contrast, these banks had a number-to-deposits ratio similar to those of the smallest banks and small savings institutions. Midsize banks had the lowest number-to-deposits ratio and a value-to-deposits ratio below the ratios for the largest

and smallest banks. These results suggest that checks may be used less intensively at midsize commercial banks than at institutions in other categories. The amount of transaction deposits held by a depository institution can be affected by both the willingness of account holders to hold idle balances and the institution's use of sweep accounts to reduce the balances their customers hold overnight in transaction accounts. The use of such deposits in measures of the relative intensity of check use may exaggerate the intensity of check use at the largest institutions because such institutions also tend to use sweep accounts most extensively.

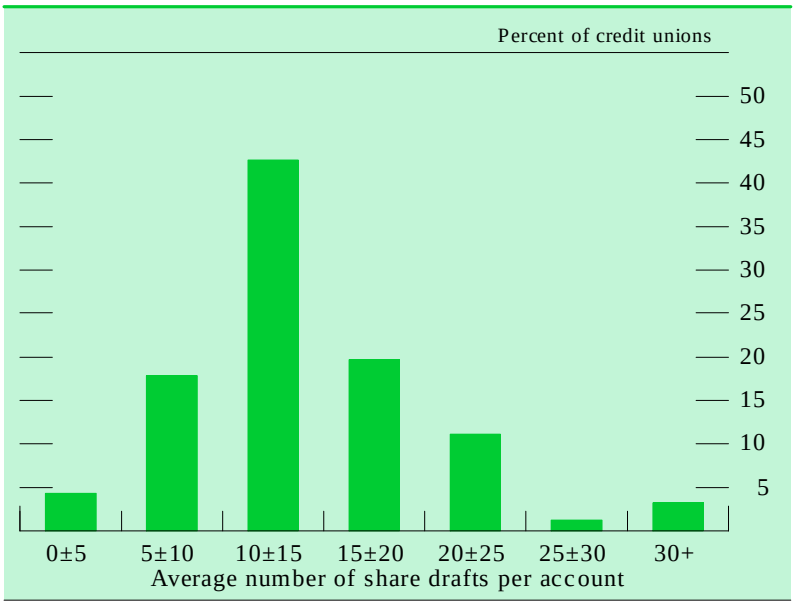
An alternative approximation that may control for various effects on transaction deposits is the number and value of checks paid per $10 thousand of assets—the number-to-assets ratio and value-to-assets ratio respectively. While the number-to-assets ratio exhibits the same general U-shaped pattern as the number-to-deposits and value-to-deposits ratios, the value-to-assets ratio for commercial banks does not. Instead, the value-to-assets ratio increases as the size category of commercial banks increases.

Whether viewed in terms of transaction deposits or assets, credit unions stand out as the type of institution at which checks are used the most intensively by number. The intensity of check use by both number and value declines as size increases, suggesting that check use is less intense at larger credit unions. Without directly measuring the number and value of all payments initiated by depository institutions, approximating the intensity of check use is difficult because of the complexity of factors affecting the data. Nevertheless, the results presented here provide preliminary evidence that the intensity of check use does vary by type and size of depository institution.

4.3.1 Number of Checks per Account at Credit Unions

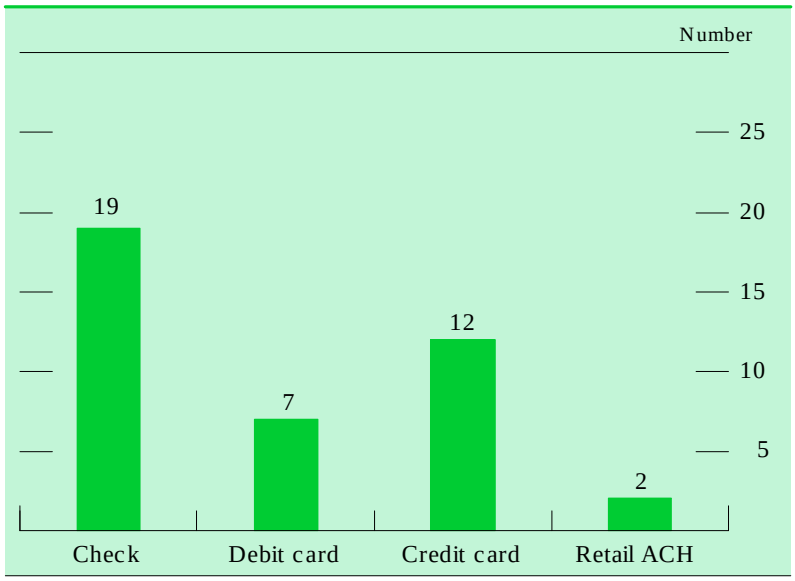
The average number of check payments per transaction account can be estimated for credit unions because data are available on the number of transaction (share draft) accounts at these institutions. Because credit unions generally do not offer business accounts, the number of checks (share drafts) paid per account is an approximation of the number of checks paid per consumer account. The average number of checks per account varies across these institutions (Figure 4.3.1). Differences in payment services offered may explain some of the variation. The monthly average number of checks paid per share draft account in 2000 (about fifteen) was somewhat lower than the monthly average number of checks estimated to have been written by households in that year (about nineteen; 4.3.1). One reason for the difference is that some households write checks on accounts at more than one institution.

2. Distribution of credit unions by average number of share drafts paid monthly per account, 2000



NOTE. Ranges may include the upper boundary but do not include the lower boundary.

3. Average number of retail noncash payments per household per month, 2000



4.3.2 "On Us" Checks

A check that is deposited in or cashed at the same depository institution on which it is drawn is referred to as an on-us check. An estimated 29 percent of checks paid in 2000 were on-us checks, about the same as in 1979. The apparent absence of an increase in the aggregate share of on-us checks is surprising in light of the consolidation of the banking industry that has occurred since 1979. When institutions merge, the probability that a check written by a customer of one of the institutions will be an on-us check for the new institution generally increases; the increase is large if the institutions that merged tended to serve customers that wrote checks to each other, though not so large if they tended to serve customers that did not. If the merger is between institutions in different geographic areas, and assuming that most checks are local, the effect of the merger on the proportion of on-us checks is small. That the share of on-us checks remained virtually unchanged from 1979 to 2000 as extensive consolidation of depository institutions both within and across regions was taking place suggests that other, behavioral changes in checkwriting offset the effects of consolidation.

One such change likely was the way account holders obtain cash: In the 1970s, account holders commonly obtained cash by cashing checks at the counter of their own banks; since then, the use of ATMs to obtain cash has increased dramatically, reducing the use of checks for this purpose. Several factors in addition to the effects of consolidation or banking concentration may affect the probability that a check paid by a particular institution is an on-us check. These include the extent of branching, the range of customers served, and the extent of business activity of account holders with non-local payment counterparties or financial institutions.

A comparison of the proportions of on-us checks paid in 2000 reveals some patterns among depository institutions of different types and sizes. Among commercial banks, the proportion of on-us checks was greater for larger institutions than for smaller institutions. Among credit unions, however, no relationship between size and proportion of on-us checks was evident; as a group, credit unions had the smallest share of on-us checks, consistent with the finding that in 2000, the share of consumer checks for which the payee was also a consumer was relatively small (23 percent). The estimated proportion of on-us checks for small savings institutions was large relative to the proportion for large savings institutions, possibly because of the types of communities the smaller institutions serve. In fact, many community banks reported a large share of on-us checks. The 1979 study also found a large share of on-us checks among community banks.

4.3.3 Returned Checks

Because an account has been closed, funds in the payer's account are insufficient, or another reason, some checks presented to a paying institution are returned unpaid to the collecting institution. An

estimated 251 million interbank (non-on-us) checks were returned in 2000, about 0.85 percent of interbank checks paid, or 8.5 checks out of every 1,000 interbank checks paid (table 4).9 This estimate is an upper bound on the number of returns, as some checks may be returned more than once, leading to some double counting.10 The estimated proportion of checks that are returned unpaid appears to vary by type and size of depository institution. Credit unions as a group had the highest return rate (10.3 checks returned for every 1,000 paid), suggesting that interbank checks written by consumers are returned more frequently than are those written by businesses. The estimated average value of a returned check in 2000 was $700.

4.3.4 Variation in Check Use by Region and Urbanization

The size and diversity of the sample of depository institutions were sufficient to estimate the number and value of checks paid in 2000 for four broad regions of the country—Northeast, South, Midwest, and West. The apparent variation among regions can be explained in part by population size and level of economic activity 4. Differences persist after controlling for those variables, however, an indication that regional differences may be associated with other factors, such as the availability of and willingness to use payment instruments other than checks. By number of checks paid per capita, the Midwest led the regions, followed by the South, West, and Northeast. By value of checks paid per capita, the Northeast led, followed by the South, Midwest, and West. Thus, no region stood out as the greatest user of checks by both number and value.

Nonetheless, some differences among regions appear to have been large. For example, the number of checks paid per capita was 27 percent higher in the Midwest than in the Northeast, and the value of checks paid per capita was 47 percent higher in the Northeast than in the West. The Northeast had the lowest number of checks per capita, the lowest number of checks per $1,000 of output, and the highest average check value. In addition, the Northeast had the lowest number-to-deposits ratio. The smallest region as measured by area and population size, the Northeast includes New York State, which is home to a significant concentration of financial and corporate activity. This activity appears to have had a large effect on checks and deposits in the region. For example, average check value for the region was more than 20 percent lower when New York State was excluded from the calculation, bringing the average value for the rest of the Northeast closer to the average values for the other regions.

Interestingly, the average check value and value-to-deposits ratio for depository institutions operating only in the Northeast (single-region institutions) were considerably lower than for institutions operating in the Northeast and at least one other region (multi-region institutions). Among single-region institutions, those in the Northeast and Midwest had the lowest average check values and value-to- deposits ratios, suggesting that these institutions were used less frequently for paying larger-value business checks. Correspondingly, the very high average check value and value-to-

deposits ratio for multi-region institutions operating in the Northeast suggest that these institutions were used more often than others for paying such larger-value business checks.

The Midwest, the region with the largest number of depository institutions per capita, had the highest number of checks per capita. The West had the smallest value of checks per capita and per $1,000 of output, possibly indicating that payers in the region, perhaps led by businesses, had a greater propensity to replace higher-value checks with electronic payments. The South had the highest value of checks per $1,000 of output and a value-to-deposits ratio similar to that for the Northeast, suggesting that checks were used by businesses more often in these two regions than in the other regions.

Almost 80 percent of checks were paid using transaction deposits located in urban areas (table 5).12 On a per capita basis, however, the number of checks paid was more than 14 percent higher in rural areas, perhaps because of lesser availability of or willingness to use electronic payment alternatives. The average value of rural checks was about 30 percent lower than that of urban checks.

4.4 Payments by Households

An estimate of the average number of check payments made monthly by a household in 2000 can be estimated from data collected in the survey on check use. Because of the nature of the data from the electronic payments survey, however, a household average for retail electronic payments cannot be estimated without making assumptions. A large proportion of credit and debit card payments are likely made by households, although businesses also use credit cards extensively, and a large proportion of ACH payments are undoubtedly made by businesses and governments. To estimate an upper bound for retail noncash electronic payments made by households, assume that households made all debit and credit card payments in 2000 and were the payers for half of all ACH payments. Under these assumptions, the average number of retail electronic payments per household per month in 2000 would have been about twenty-one, or slightly more than half the retail noncash payments per household per month in 2000.

For purposes of comparison, assume that in 1979, households made all retail electronic payments but half of all check payments. Under these assumptions, the average number of retail electronic payments per household per month would have been about six, or about one-fourth of the retail noncash payments made per household per month in 1979; check payments would have accounted for the other three-fourths (about seventeen per household per month). Although the number of checks written per household increased from 1979 to 2000 (in part because the number of households with some type of checking account increased), electronic payments per household as a proportion of retail noncash payments increased more than checks. The apparent increase

in the share of retail electronic payments suggests that consumer checks have been replaced by electronic payments to some extent. The increase in the estimated number of checks written per household per month, however, suggests that further growth in electronic payments likely will occur through the replacement of additional consumer checks.

4.5 Payments by Businesses and Governments

The use of electronic payments by businesses and governments has also increased since 1979. Many businesses have adopted direct deposit of payroll, for example. The proportion of payroll payments made via direct deposit rather than paper check increased from close to zero in 1979 to about 50 percent in 2000. Some businesses have also begun to experiment with programs for converting checks to electronic payments at point-of-sale locations and for the processing of bill payments. In addition, a number of businesses are seeking ways to combine electronic payment processing with invoicing, which could reduce the number of check payments. The U.S. Department of the Treasury now makes most of its payments using the ACH (though federal government payments constituted only about 1.5 percent of all retail noncash payments in 2000).

4.6 Large-Value Payments

In addition to the retail payments that are the focus of this article, some very large payments, including federal government and business payments once made by check, are now made using large-value funds transfer systems. Increased use of these systems helps explain the decline in the average value of checks from $1,544 in 1979 to $925 in 2000. Relative to retail noncash payments, payments made using these systems are few in number but tend to be large in value. From 1979 to 1995, the rate of growth of large-value payments by number was similar to that for retail electronic payments. From 1995 to 2000, however, the number of retail electronic payments grew more than twice as fast as the number of payments processed by the large-value funds transfer systems. Some payments made using large-value funds transfer systems replaced some larger-value business and government payments made by check, and this switch apparently had a significant effect on the real value of check payments over time. One large scale change in business practices that motivated the replacement of some large-value checks was the switch to same-day funds for the settlement of trades between securities dealers in the U.S. equities markets in 1996.

4.7 Noncash Payments in Other Countries

A look at noncash payments in other countries provides some perspective on the use of checks and electronic payments in the United States. Compared with other industrialized economies—Japan,

the European Monetary Union (EMU), the United Kingdom, and Canada—the number of noncash payments of any type per capita is considerably higher in the United States, as is the number of check payments per capita (Figure 15). The number of electronic payments per capita is also higher in the United States, though not substantially so. Detailed data (not shown) indicate that the number of electronic payments per capita in some countries of the EMU, such as Finland, Germany, and the Netherlands, is higher than in the United States (similarly, the use of electronic payments may be greater in some regions of the United States than in others). The number of noncash payments per capita is higher in the United States than in the other economies mainly because of the more extensive use of checks. Given the very low level of noncash payments per capita in some countries, it appears likely that cash is used more extensively in these countries than in the United States. Some researchers have argued that in the 1980s and 1990s, the number of payments by cash was lower in the United States than in other countries (Hancock and Humphrey, 1998). If that is true, measures of the importance of checks as a share of noncash payments may overstate the relative use of paper-based payment instruments in the United States. Without reliable measures of cash use, however, a comprehensive comparison across countries of the extent to which electronic payments have replaced paper-based payments (mostly cash and checks) is not possible.

5 Conclusions and Future Directions

Statistical estimates indicate that the number of checks paid in the United States rose from 32.8 billion in 1979 to 49.5 billion in 1995 but declined to 42.5 billion in 2000. These three estimates suggest that the total number of checks paid per year peaked in the 1990s. Despite the apparent decline since 1995, the number of checks paid remained higher in 2000 than in 1979. The estimated value of checks paid declined from $50.7 trillion in 1979 to $39.3 trillion in 2000, suggesting that electronic payments have increasingly replaced larger-value checks. Moreover, although the real value of transaction deposits declined slightly from 1979 to 2000, the decline was not as great as the decline in the value of checks paid, a further suggestion that electronic payments originated from transaction deposits likely replaced check payments.

The number and value of checks paid vary among institutions in interesting ways. The average value of checks paid, as well as the intensity of check use, differs by type and size of institution, reflecting in part the types of customers served. Differences also exist according to geographic region. Generally, the per capita value of checks paid is highest in the Northeast, and the number of checks paid per capita is highest in the Midwest. In addition, the number of checks paid per capita apparently is greater in rural areas than in urban areas. These differences suggest that, while many businesses and consumers have converted to electronic payments in significant numbers, many others have not significantly changed their use of checks.

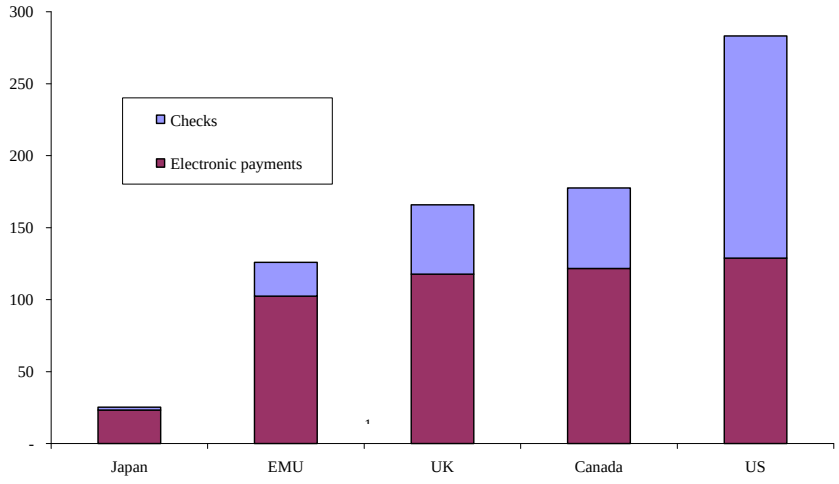


Figure 15: International comparison of electronic payments and checks per capita. Data for the United States are from 2000. Data for all other countries are from 1999. More recent data for all countries but the United States were not available when the chart was constructed.. Includes both wholesale and retail payments. EMU includes Belgium, Germany, Spain, France, Ireland, Italy, Luxemburg, Netherlands, Austria, Portugal and Finland. Sources: European Central Bank, Blue Book, and Bank for International Settlement, Statistics on payment systems in the Group of Ten countries.

In the aggregate, the trend in the intensity of check use is difficult to interpret. Changes in the use of sweep accounts over time, in particular, may affect this measure.

Checks collected through the Federal Reserve Banks peaked in the mid 1990's. The proportion of checks processed by the Reserve Banks may fluctuate over time and is not necessarily indicative of the trend in total checks. Nonetheless, this independent measure of check collection activity is consistent with the apparent rise and subsequent fledgling decline in the number of checks paid during suggested by the estimates presented in this paper.

In the late 1960s, a "checkless society" was envisioned in which bill payments would be initiated by telephone via plastic card readers on telephones, or by keying in "national transfer numbers," and point-of-sale purchases would be made with plastic debit cards (*The Checkless Society*, 1967). The vision for bill payment has not taken hold, while the vision for point-of-sale purchases is much like what we see today. While the much anticipated decline in the use of checks appears to have arrived, the data do not suggest a rapid and mass abandonment of the well-established and reliable check as a premier payment instrument.

Although the number and value of checks may have begun to decline, it appears likely that checks will continue to play a significant role in the U.S. payment system, particularly when electronic payments are not well suited for meeting consumer or business needs. New technology, however, for converting checks into electronic payments, or for collecting checks electronically while still allowing businesses and consumers to write paper checks has begun to take hold. The collection of checks via electronic images, still in its infancy, promises to allow the continued reduction of costly physical check processing without pushing costs onto consumers, businesses, and industry where conversion to another type of payment would be impractical.

While the reduction in the number of paper checks is inevitable in the long run, short run decisions by various payments system participants must still involve the weighing of the costs and benefits of different payment and processing alternatives. Given the excess capacity for paper check processing that could exist due to recent declines in check use, the speed at which checks will be replaced by electronics is still uncertain. A new survey of depository institutions by the Federal Reserve Bank of Atlanta, now under way, will attempt to help resolve some of the uncertainty concerning the rate of decline in the number of checks, and the replacement of electronic payments. That survey has an expanded questionnaire which includes the number and value of electronic payments in addition to checks. Such information will improve the ability to measure trends in the replacement of checks in the future. The survey will also improve the ability to relate the share of checks and electronic payments to other characteristics that vary across depository institutions.

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	Sampling Freq.			Est.	Number (Bil.)		Value ($Tril.)		Mean
	N	n	Freq.	Wgt.	Est.	S.E.	Est.	S.E.	Value
Commercial banks									
	2008	74	0.037	25.270	0.739	0.120	0.419	0.094	566
	2041	116	0.057	17.631	2.100	0.475	1.562	0.474	743
	1399	153	0.109	8.804	2.246	0.124	1.469	0.096	654
	846	175	0.207	4.769	2.470	0.175	1.859	0.126	753
	329	172	0.523	1.918	1.79	0.081	1.571	0.078	878
	166	113	0.681	1.152	12.772	0.538	17.307	1.139	1356
	7	7		1.000	10.900		12.363	0.000	1134
	6796	**810**			**33.016**	**0.763**	**36.549**	**1.249**	**1107**
Credit unions									
	3192	22	0.007	150.302	0.360	0.048	0.053	0.009	148
	1742	54	0.031	32.900	0.971	0.097	0.158	0.016	162
	721	78	0.108	7.735	1.012	0.071	0.185	0.006	183
	343	111	0.324	3.065	1.167	0.038	0.230	0.007	197
	104	76	0.731	1.315	1.029	0.027	0.214	0.004	208
	2	2		1.000	0.207		0.043	0.000	209
	6104	**343**			**4.745**	**0.137**	**0.883**	**0.021**	**186**
Savings institutions									
	894	18	0.020	34.302	0.707	0.172	0.202	0.027	286
	346	61	0.176	4.805	1.060	0.125	0.431	0.036	407
	36	15	0.417	2.430	1.152	0.122	0.492	0.079	427
	3	3		1.000	1.072		0.427	0.000	399
	1279	**97**			**3.991**	**0.245**	**1.552**	**0.091**	**389**
Subtotal	**14179**	**1250**			**41.751**	**0.813**	**38.984**	**1.252**	**928**
U.S. Treasury					0.262				
Postal MO					0.230				
Anomalous Banks	6	6		1.000	0.275		0.011	0.000	41
Total	**14185**	**1256**			**42.518**	**0.813**	**38.995**	**1.252**	

Table 1: Estimates for 2000 in the original published study . N is the number of depository institutions (DIs) in the population, n is the number in the sample, Freq. is the proportion of DIs in the sample, Est. Wgt. is the weight used to expand the sample to the population, and for the number, and value Est. is the point estimate and S.E. is the estimated standard error of the point estimate. The mean value of a check is the ratio of the estimated total value to the estimated total number.

PCD ($100 Thou.)				Sampling Freq.			Est.	Number (Bil.)		Value ($Tril.)		Mean Value	
U. B.	L. B.	E(P)	E(S)	N	n	Freq.	Wgt.	Est.	S.E.	Est.	S.E.	Est.	S.E.
Commercial Banks													
9	1.3	5.2	5.5	1,918	70	0.036	25.602	0.711	0.121	0.406	0.095	571	75
27	9	16	17	2,437	144	0.059	16.304	2.519	0.451	1.771	0.448	703	75
58	27	40	42	1,395	195	0.140	6.767	2.616	0.183	1.653	0.086	632	42
121	59	80	88	672	179	0.266	3.436	2.279	0.127	1.978	0.127	868	49
321	121	181	179	224	121	0.540	1.870	1.809	0.161	1.535	0.121	849	66
2,240	324	745	806	106	67	0.632	1.462	5.267	0.246	5.249	0.296	997	62
56,760	2,305	9,852	9,852	33	33	1.000	1.000	17.994	0.000	23.490	0.000	1,305	0
				6,785	**809**			**33.194**	**0.595**	**36.083**	**0.579**	**1,087**	**14**
Credit Unions													
2.3	0.15	0.9	1.2	3,408	31	0.009	82.292	0.430	0.038	0.066	0.007	154	10
9	2.5	4.7	5	1,602	52	0.032	28.560	0.918	0.088	0.153	0.015	166	10
25	9.3	14.9	14.6	618	67	0.108	9.437	0.950	0.061	0.162	0.006	170	9
57	25	36	36	306	93	0.304	3.272	0.920	0.033	0.178	0.006	193	5
280	57	104	116	160	94	0.588	1.516	1.225	0.040	0.255	0.005	208	6
1,643	290	632	632	6	6	1.000	1.000	0.305	0.000	0.064	0.000	210	0
				6,100	**343**			**4.749**	**0.125**	**0.878**	**0.019**	**185**	**3**
Savings Institutions													
8.5	0.8	3.8	3.4	497	5	0.010	111.072	0.098	0.032	0.064	0.021	647	58
29	8.6	17	20	383	14	0.037	23.412	0.562	0.119	0.183	0.032	325	62
72	30	45	45	228	30	0.132	7.652	0.517	0.050	0.203	0.018	392	21
159	75	105	105	81	27	0.333	2.982	0.400	0.067	0.163	0.019	408	57
2,107	176	406	466	49	18	0.367	2.369	1.235	0.133	0.533	0.084	431	41
6,511	2,815	4,054	4,054	3	3	1.000	1.000	1.072	0.000	0.427	0.000	399	0
				1,241	**97**			**3.884**	**0.200**	**1.572**	**0.095**	**405**	**18**
				14,126	**1,249**			**41.827**	**0.640**	**38.533**	**0.587**		

Table 2: Estimates for 2000 using updated data and new stratification. The columns are defined as follows: PCD is public checkable deposits, for a given stratum U.B. is the upper bound, L.B. is the lower bound, E(P) is the mean for the population, and E(S) is the mean for the sample, N is the number of depository institutions (DIs) in the population, n is the number in the sample , Freq. is the proportion of DIs in the sample, Est. Wgt. is the weight used to expand the sample to the population, and for the number, value, and mean value of a check, Est. is the point estimate and S.E. is the estimated standard error of the point estimate. The mean value is the estimated total value to the estimated total number.

	Estimate		Confidence interval		
Type	Est.	S.E.	L.B.	Mean	U.B.
Commercial Banks	32.775	0.625	31.605	32.695	34.005
Credit Unions	5.247	0.144	4.948	5.224	5.523
Savings Institutions	4.090	0.250	3.557	4.038	4.523
Total	42.112	0.688	40.609	41.957	43.305

Table 3: Nonparametric estimates of the number of checks using total deposits as covariate with bootstrapped standard errors and confidence intervals. The boundaries for the 95 percent confidence intervals by type are taken to be the 25th (L.B.) and 975th (U.B.) largest value for the 1000 repetitions used for the bootstrap. The standard deviation for the total is estimated as the square root of the sum of the bootstrapped variances. The confidence boundaries for the total are estimated as plus and minus 1.96 times the estimated standard error.

Location of deposits	Number of institutions	Number Est.	Number Per capita	Number Per GDP	Number Turn. Ratio	Value Est.	Value Per capita	Value Per GDP	Value Turn Ratio	Value Mean Est.	PCD
By region											
Northeast	2,417	7.1	132.6	3.3	46.0	9.1	169.8	4,233	58,909	1,280	154
Multi-region	55	3.6			40.2	7.0			77,883	1,938	89
Single-region	2,362	3.5			54.0	2.1			32,763	606	65
South	4,841	15.3	152.8	4.7	61.9	14.6	145.8	4,467	59,096	955	247
Multi-region	92	4.9			59.6	5.7			68,824	1,155	82
Single-region	4,749	10.4			63.1	9.0			54,242	860	165
Midwest	5,396	10.8	168.4	5.0	61.6	8.0	123.9	3,683	45,362	736	176
Multi-region	94	4.1			51.9	4.4			56,387	1,086	78
Single-region	5302	6.8			69.4	3.6			36,570	527	98
West	2,182	8.8	138.5	3.7	64.1	7.3	115.5	3,102	53,437	834	137
Multi-region	72	4.2			69.1	4.0			65,235	944	61
Single-region	2,110	4.6			60.1	3.3			43,959	732	76
By urbanization											
Urban	10,173	33.3	145.3		57.6	33.0	144.2		57,215	992	578
Rural	5,970	8.7	167.0		63.8	6.0	114.0		43,575	683	137

Table 4: Number and value of checks paid by depository institutions, by location of deposits, 2000

	PCD ($100 Thou.)				Sampling Freq.			Est.	Number (Bil.)	
	U. B.	L. B.	E(P)	E(S)	N	n	Freq.	Wgt.	Est.	
Commercial Banks										
	21	1.2	9.7	9.4	6,387	272	0.043	24.231	3.215	0.131
	64	22	36	36	2,540	145	0.057	17.315	4.426	0.262
	338	64	126	160	943	69	0.073	10.749	6.469	0.602
	1,364	358	675	808	181	21	0.116	7.201	9.257	2.402
	10,667	1,407	3,210	2,999	98	17	0.173	6.169	16.470	1.422
	32,177	13,677	18,826	21,149	4	3	0.750	1.187	2.107	0.374
					10,153	**527**			**41.945**	**2.894**
Credit Unions										
	23	0.6	7.5	11.7	1,198	14	0.012	54.909	0.572	0.144
	110	25	48	50	346	28	0.081	11.853	1.004	0.131
	2,910	137	360	387	93	12	0.129	7.208	1.756	0.283
					1,637	**54**			**3.331**	**0.343**
Savings Institutions										
	10.7	1	1.9	3	5,047	10	0.002	330.654	1.711	0.234
	409	12	30	69	662	14	0.021	20.762	1.573	0.342
	1,042	1,042	1,042	1,042	1	1	1.000	1.000	0.109	0.000
					5,710	**25**			**3.393**	**0.414**
Subtotal					**17,500**	**606**			**48.669**	**2.943**
U.S. Treasury									0.460	
Postal MO									0.203	
Total									**49.332**	**2.943**

Table 5: Estimated number of checks for 1995. The columns are defined as follows: PCD is public checkable deposits, for a given stratum U.B. is the upper bound, L.B. is the lower bound, E(P) is the mean for the population, and E(S) is the mean for the sample, N is the number of depository institutions (DIs) in the population, n is the number in the sample , Freq. is the proportion of DIs in the sample, Est. Wgt. is the weight used to expand the sample to the population, and for the number of checks, Est. is the point estimate and S.E. is the estimated standard error of the point estimate. Note that the upper and lower boundaries of PCD, and number of depository institutions in the population are not directly comparable to the institutions in 2000 because the institutions in 1995 reported at the charter level, whereas in 2000 they reported at the holding company level.

Type of payment	Number (billions) 1979	1995	2000	Growth (percent, annual rate) 1979-95	1995-2000	1979-2000
Checks	32.8	49.5	42.5	2.6	-3.0	1.2
Electronic	5.5	14.7	28.9	6.3	14.6	8.2
Debit cards	0.0	1.4	8.3		41.8	
Credit cards						
General-purpose	1.5	7.8	12.3	10.9	9.5	10.5
Private-label	3.8	2.6	2.7	-2.3	0.9	-1.6
Retail ACH	0.2	2.8	5.6	19.0	15.1	18.0
Total	**38.3**	**64.2**	**71.5**	**3.3**	**2.2**	**3.0**

Table 6: Number and rate of growth of retail noncash payments, selected years. Estimates for the number of electronic payments in 2000 are from the Electronic Payment Instruments Study. Estimates for 1995 and 1979 were derived from industry sources.

	Number	Value	PCD
1979			
Commercial banks	31.4	n.a.	744
Credit unions	0.3	n.a.	4
Savings institutions	0.3	n.a.	4
All depository institutions	**32.0**	**49.6**	**752**
U.S. Treasury checks and postal money orders	0.8	1.1	...
Total	**32.8**	**50.7**	**...**
1995			
Commercial banks	42.0	n.a.	855
Credit unions	3.5	n.a.	34
Savings institutions	3.4	n.a.	64
All depository institutions	**48.9**	**n.a.**	**953**
U.S. Treasury checks and postal money orders	0.7	0.6	...
Total	**49.5**	**n.a.**	**...**
2000			
Commercial banks	33.3	36.6	602
Credit unions	4.7	0.9	51
Savings institutions	4.0	1.6	62
All depository institutions	**42.0**	**39.0**	**715**
U.S. Treasury checks and postal money orders	0.5	0.3	...
Total	**42.5**	**39.3**	**...**

Table 7: Number and value of checks paid, by type of institution, selected years

	N	Checks paid							PCD		
		Num	Val	Mean value	Percent returned	Mean value returned	Percent on-us	Percent Reserve Banks	Amount	Number deposits ratio	Value deposits ratio
Commercial banks	6,852	33.3	36.6	1,099	0.79	859	34	36	602	55	60,682
250-60,000	170	23.6	29.6	1,254	0.82	964	38	28	411	57	72,090
50-250	1,104	4.3	3.4	790	0.72	646	26	50	99	43	34,106
0-50	5,578	5.4	3.6	663	0.75	595	26	59	93	58	38,523
Credit unions	6,551	4.7	0.9	186	1.03	244	6	69	51	93	17,254
75-2,000	106	1.2	0.3	208	0.98	305	6	55	16	75	15,621
0-75	6,445	3.5	0.6	178	1.05	223	6	74	35	101	18,028
Savings institutions	1,293	4.0	1.6	389	0.99	507	18	48	62	65	25,226
200-6,500	35	2.2	0.9	413	1.22	533	14	36	30	72	29,567
0-200	1,258	1.8	0.7	360	0.67	444	22	60	31	58	20,985
All institutions	**14,696**	**42.0**	**39.0**	**928**	**0.85**	**700**	**29**	**41**	**715**	**59**	**54,522**

Table 8: Checks paid by and transaction deposits of depository institutions, by type and size of institution, 2000. The number and value of checks paid are in billions of items, and trillions of dollars, resp. The number-to-deposits ratios and value-to-deposits ratios, are in number per 1,000 dollars, and dollars per 1,000 dollars, resp.