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Ruth Judson

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Demand for U.S. Banknotes at Home and Abroad: A Post-Covid Update

Ruth Judson[1]
Board of Governors of Federal Reserve System
Division of International Finance
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Abstract

In principle, physical currency should be disappearing: payments are increasingly electronic, with new technologies emerging rapidly, and governments increasingly restrict large-denomination notes as a way to reduce crime and tax evasion. Nonetheless, demand for U.S. banknotes continues to grow, and consistently increases at times of crisis both within and outside the United States because dollar banknotes remain a desirable store of value and medium of exchange when local currency or bank deposits are inferior. Most recently, the COVID crisis resulted in historic increases in currency demand. After allowing for the effect of crises, U.S. banknote demand appears to be driven by the usual factors determining money demand, with no discernible downward trend.

In this work, I review developments in demand for U.S. currency over the past few decades with a focus on developments since early 2020. In addition, I revisit the question of international demand: I present the raw data available for measuring international banknote flows and updates on indirect methods of estimating the stock of currency held abroad. These methods continue to indicate that a large share of U.S. currency is held abroad, especially in the $100 denomination.

As shown earlier (Judson 2012, 2017), once a country or region begins using dollars, subsequent crises result in additional inflows: the dominant sources of international demand over recent decades are the countries and regions that were already heavy dollar users in the early to mid-1990s. While international demand for U.S. currency eased during the early 2000s as financial conditions improved, the abrupt return to strong international demand that began with the collapse of Lehman Brothers in 2008 has not slowed and reached new heights over 2020 and 2021. In contrast, however, the growth rate of demand for smaller denominations is slowing, perhaps indicating the first signs of declining domestic cash demand.

Keywords: Currency, banknotes, dollarization, crisis.

JEL classification: C82, E4, E49

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[1] The author is a staff economist in the Division of International Finance, Board of Governors of the Federal Reserve System, Washington, DC 20551 U.S.A. The views in this paper are solely the author's responsibility and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System or of any other person associated with the Federal Reserve System.

Contents

Demand for U.S. Banknotes at Home and Abroad: A Post-Covid Update[1]

Unlike the banknotes of most other countries, the U.S. dollar is used far beyond its borders as a medium of exchange and store of value. This international aspect of dollar banknote usage has important implications for a wide range of Federal Reserve operational considerations, including its currency production, processing, and planning, the interpretation of currency figures as part of monetary analysis, daily open market operations, management of the Federal Reserve's portfolio and balance sheet, and analysis and forecasting of the Federal Reserve's income.[2] In addition, currency exports, like other exports, figure in the U.S.balance of payments and international investment position. Finally, the role of cash in the underground economy and other illicit activities has been an increasing focus of discussion, and some countries have adjusted the mix of notes they issue based on these concerns.[3] This paper shows that the post-2008 resurgence in demand for U.S. banknotes has hardly abated and indeed the most recent crisis, the COVID pandemic, resulted in record increases banknote demand. In addition to updating all data and methods presented in Judson (2017), this paper takes a closer look at trends by denomination and poses some additional questions about the future of cash. In particular, I note that demand for smaller denominations appears to be slowing.

Direct measurement of external holdings of U.S. dollars are not available. In this paper, I present several methods for estimating stocks and flows of U.S. currency abroad from the early 1990s through the end of 2022. Despite the disparate methods and data sources, the data consistently indicate several trends. First, international demand for U.S. currency increased steadily over the 1990s and into the early 2000s, a period that coincided with the fall of the Berlin Wall, the collapse of the Soviet Union, and periodic

[1] This work would have been impossible without the generous assistance of, and thought-provoking discussions over many years with Joann Freddo, Eileen Goodman and Elliot Shuke (FRB-New York); Brian Lawler and Frank Warnock (Board); and especially Dick Porter (Board and FRB Chicago), who first introduced me to this topic and was the originator of most of the methods used in this work. All errors and omissions are mine.

[2] Until late 2008, Federal Reserve notes, the dominant form of currency, were the primary liability on the Federal Reserve's balance sheet. As a result, currency demand was a primary consideration in the conduct of daily open market operations as well as in longer-range planning related to the Federal Reserve's System Open Market Account portfolio. After late 2008, deposits of depository institutions (of which reserve balances are the vast majority) increased significantly and now exceed currency as a liability on the Federal Reserve's balance sheet. Appendix Figure 2 illustrates the major components of the Federal Reserve's balance sheet since 2003.

[3] For example, India had a surprise recall of its highest-denomination notes in late 2016. The 500 euro note will be phased out after 2018.

economic and political crises in several Latin American countriesfa. Second, international demand for dollars began to stabilize or decline around the time of the introduction of the cash euro in 2002.[4] This decline coincided with economic and political stabilization and financial modernization in many economies in and around the euro zone and the former Soviet Union and continued until late 2008, when the global financial crisis sparked renewed demand for U.S. banknotes that has shown no sign of abating.

Section 1 reviews the available data sources, with a focus on their strengths and weaknesses for use in answering questions about the shares of banknotes held in the United States and abroad. Section 2 presents an overview of currency demand over the past several decades and some stylized facts about the composition of U.S. currency levels and changes over time, with a focus on the years just before and after the COVID pandemic. Section 3 builds on these stylized facts and presents simple and direct estimates of stocks and flows of U.S. currency abroad. Section 4 presents updated indirect estimates of stocks and flows of U.S. currency held abroad; these estimates are based on the data sources from Section 1 as well as additional information.[5] Section 5 presents estimates of a very simple currency demand equation for the United States, from which estimates of the impact of international demand on currency growth can be derived. Section 6 summarizes and compares the estimates of overseas holdings of U.S. currency from the range of methods presented in sections 3 through 5. The methods and data presented in sections 1 through 6 are largely unchanged from those presented in Judson (2012, 2017, and 2018) but the time series are now extended by five years or more. Section 7 reviews developments in denominations other than $100s and provides further detail on developments since the onset of the COVID pandemic in 2020. Section 8 concludes with some general observations and directions for further work.

1 Data: An Overview

1.1 Total Currency in Circulation

1.1.1 Public Data

In general, the aggregate quantity of genuine currency in circulation is relatively easy to measure: it is physical, and it is produced, transported, and issued under very secure

[4] The euro currency was introduced as a unit of account in 1999; the physical currency was introduced in 2002.

[5] It is not possible to apply the "biometric" or "fish" method as in U.S. Treasury (2006) to the most recent design of U.S. banknotes because of a change in the way the notes are introduced.

conditions.[6] Official currency statistics for the United States are reported by the Treasury and Federal Reserve, which collaborate to produce data on currency in circulation, generally defined as Federal Reserve notes, Treasury currency, and coin held outside of the vaults of the Federal Reserve and the Treasury.[7] Figures on total currency in circulation are reported weekly on the Federal Reserve's H.4.1 and H.6 Statistical Releases; the quarterly *Treasury Bulletin* provides additional detail on denominations of banknotes and coin in circulation.

1.1.2 Internal Data

The Federal Reserve's internal accounting and production processes require close monitoring of currency production, processing, and movements; as a result, more frequent and detailed data are available internally for Federal Reserve notes, which constitute the vast majority of currency in circulation ($2.26 trillion of the $2.31 trillion total as of the end of 2022).[8] In particular, accounting data provide daily updates by denomination on the quantity of Federal Reserve notes outstanding (that is, carried on the books of each Federal Reserve Bank), and in the custody of each Federal Reserve Bank. In addition, processing data provide daily and monthly totals of Federal Reserve note movements between each Federal Reserve office and circulation by denomination.[9] As shown in section 3, these data and simplifying assumptions about domestic and international movements of banknotes can be exploited to obtain estimates of stocks and flows of U.S. currency abroad.

1.2 Data on Cross-Border Flows of U.S. Currency

Movements of currency across U.S. borders cannot be precisely measured for several reasons. First, there is no legal requirement or mechanism to monitor movements of $10,000 or less, and many individuals cross U.S. borders each year.[10] The net movements of currency across U.S. borders through such nonbanking channels are

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[6] The quantity of counterfeit currency in circulation at any point is not known, but estimates suggest that circulating counterfeits are extremely small relative to genuine currency, on the order of one to three in 10,000 (Judson and Porter (2010)). Updated estimates are forthcoming and are almost surely lower.

[7] Appendix Table 1 provides a list of sources of currency data along with a description of the different definitions of currency.

[8] H.4.1 Statistical Release, tables 1 and 6. http://www.federalreserve.gov/releases/h41/20221229/.

[9] The locations and boundaries of the twelve Federal Reserve districts were set when the Federal Reserve was established in 1913. Within each district, cash processing occurs at one or more cash offices. The number and location of these offices varies over time. Processing data are reported separately for each office.

[10] In 2022, about 187 million passengers arrived and departed on international flights at U.S. airports and nearly 200 million border crossings occurred by land (Bureau of Transportation Statistics, 2023).

potentially significant. Indeed, as noted in U.S. Treasury (2006), customs reporting for Mexico indicates substantial cash flows from the United States to Mexico in the hands of tourists and migrants; such flows, since they typically occur in amounts of less than $10,000 and through nonbanking channels, are not captured in U.S. data. Second, even when there is a legal requirement to report currency flows, mechanisms are not always in place to capture the data and reporters might not comply with requirements. Despite these challenges, informative measurements do exist.

The Federal Reserve provides currency on demand to all account holders, including those who provide banknotes to international customers. Many of these institutions, including most of the largest wholesale banknote dealers, report monthly the value and ultimate source or destination country of their receipts and payments of U.S. currency. While not all banks that deal in the international shipment of banknotes provide these reports, the banknote shipping business is highly concentrated and this dataset currently captures the vast majority of banknote shipments that cross U.S. borders through commercial banking channels.

This dataset, which is maintained by the Federal Reserve Bank of New York (FRBNY) begins in the late 1980s and covers virtually every country in the world. The quality of the data varies across time as the set of reporting dealers has evolved; for all practical purposes, the dataset begins in the early 1990s. For example, consider a shipment bound for Russia via Germany. The immediate source or destination of the shipment can be identified by the location of the counterparty. Thus, for a nonreporting dealer, the dataset would only indicate a shipment to Germany, but a reporting dealer would provide the ultimate destination, Russia. Conversely, consider a shipment from Cambodia back to the United States via Hong Kong. Data from a nonreporting dealer would indicate an inflow of dollars to the United States from Hong Kong, but data from reporting dealer would indicate the ultimate source of shipment as Cambodia. The level of detail in the reporting has generally improved over time as more dealers have begun to report. However, this trend has reversed in some cases in recent years as reporting banknote dealers have left the market and as other nonreporting dealers begin providing banknote shipment services to the departing reporter's customers. As a result, since 2014 the country dimension of this shipment dataset has become substantially less informative.

Two additional shortcomings of this dataset are that it covers only banknote flows to and from the United States, and that it only covers flows through the banking system. First, the dataset does not cover U.S. banknote flows among other countries, which can be

substantial, especially in areas where large volumes of cross-border trade are conducted in cash.[11] The absence of such information complicates any estimation of regional or country-level holdings outside the United States, but does not affect aggregate measurements of commercial bank currency shipment flows into and out of the United States. However, banknote flows through nonbank channels can also be significant, and observations gathered in the course of the joint U.S. Treasury – Federal Reserve International Currency Awareness Program indicate that several countries receive dollar inflows through nonbank channels such as tourists or migrant workers but return the currency to the United States through banking channels.[12] As a result of these shortcomings and complications, the country-level data must be interpreted with care and with an understanding of the institutional arrangements in place through time.[13]

2 Stylized Facts about U.S. Currency in Circulation

2.1 Overall Currency Growth Has Been Strong

The death of cash has often been predicted, and it would seem that demand for currency should grow somewhat more slowly than income given the general increase in the variety of payment media as well as increasing use noncash means of payment.[14] However, U.S. currency in circulation has grown at an average rate of about 7 percent annually over the past few decades, about two percentage points more rapidly than U.S. nominal GDP. Since 2008, the gap has been greater: annual currency growth has remained around 7 percent even though GDP growth has averaged less than 3 percent.[15]

[11] Refer to U.S. Treasury (2006) for examples of such flows.

[12] This phenomenon is addressed in more detail in the discussion of the flow data.

[13] In principle, the most obvious direct source of information on U.S. currency flows across U.S. borders should be the Currency and Monetary Instrument Reports (CMIRs), which are compiled by the U.S. Customs Service. Individuals and firms making almost any shipment of more than $10,000 in cash across a U.S. border are required to file CMIRs, so these reports should be quite comprehensive and informative. However, as noted in Treasury (2006) and in Judson (2012, 2017), CMIRs are neither accurate nor thorough measures of large cash shipments outside the banking sector, and hence we do not use the CMIR data in this study. For researchers who do not have access to the shipment data, or for certain countries and time periods, the CMIR data can provide useful insights. Refer, for example, to Feige (1996, 2012) for analysis of the U.S. economy and to Kamin and Ericsson (2003) for analysis of dollarization in Argentina. For the latter analysis, CMIR data were both available over a longer time period and more reliable than usual because of the patterns of dollar flows to Argentina.

[14] Refer to BIS (2016).

[15] On a Q4-to-Q4 basis, over 1989-2022, currency growth averaged 7 percent and nominal GDP growth averaged 4.8 percent.

2.2 Overall U.S. Currency Movements are Dominated by $100s

In value terms, the driving force over this period has generally been growth in the $100 denomination, as can be seen in Figures 1A and 1B.[16] Figure 1A presents annual end-year data on U.S. currency in circulation by denomination from 1989 to 2022. At the end of 2022, U.S. currency in circulation totaled about $2.2 trillion, of which $1.8 trillion, or 82 percent, was in the $100 denomination.[17] Figure 1B presents annual growth rates for the same items, on a fourth-quarter-to-fourth-quarter basis. The overall growth of currency, the solid black line, moves closely with, though generally more slowly than, the growth of $100 notes, the dashed purple line. The correlation of overall currency growth with $100s over this period is over 0.9; correlations with the other denominations are generally decreasing in the denomination.

2.3 Crises Are Reflected in Aggregate U.S. Currency Data

Figure 1B begins to reveal some general patterns in overall currency demand. In particular, currency growth was quite strong in the early 1990s, which coincided with the fall of the Berlin Wall and the collapse of the Soviet Union. After a brief lull in the mid-1990s, currency growth picked up again in the late 1990s, driven by crisis in Argentina in 1997 and then concern about Y2K in 1998 and 1999. Following a dip in currency demand in 2000, which largely reflected the return early in 2000 of precautionary stocks accumulated late in 1999, demand was boosted in the early 2000s by the events of September 11, which, judging by outsized commercial bank shipments, led to strong overseas demand for currency in the short run and, in the longer run, the apparent accumulation of precautionary stocks at home and abroad. Demand then slowed over the mid- to late-2000s until the sharp reversal seen in late 2008.[18] More formally, Banegas, Judson, Sims, and Stebunovs (2015) show that there was a strong correlation between international demand for U.S. dollars and indexes of economic and political uncertainty over 2000-2014. Growth stabilized or slowed from 2010 to 2019, then skyrocketed in 2020.

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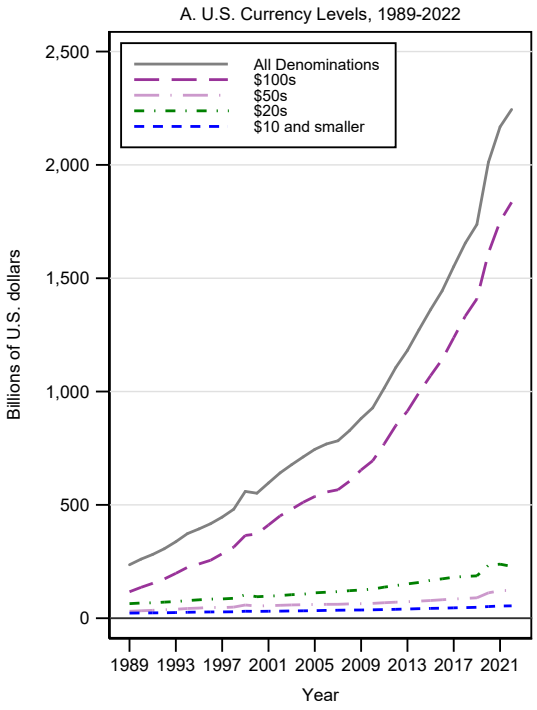
[16] In piece terms, however, U.S. currency is dominated by smaller denominations. As of the end of 2022, $1s were 26% of notes in circulation, $2s to $10s were 13%, $20s were 22 percent, $50s were 5% and $100s were 34%. Appendix Figures 1A and 1B provide a breakdown of U.S. and Canadian currency by denomination in both value and piece terms.

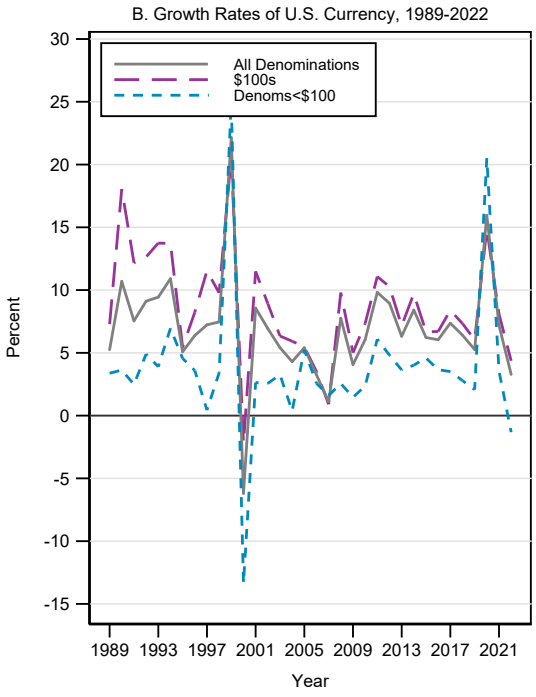
[17] These figures are from the Treasury Bulletin: https://fiscal.treasury.gov/files/reports-statements/treasury-bulletin/b2022-4.pdf .

[18] Hellerstein and Ryan (2011) find systematic relationships between currency shipments and inflation and other factors.

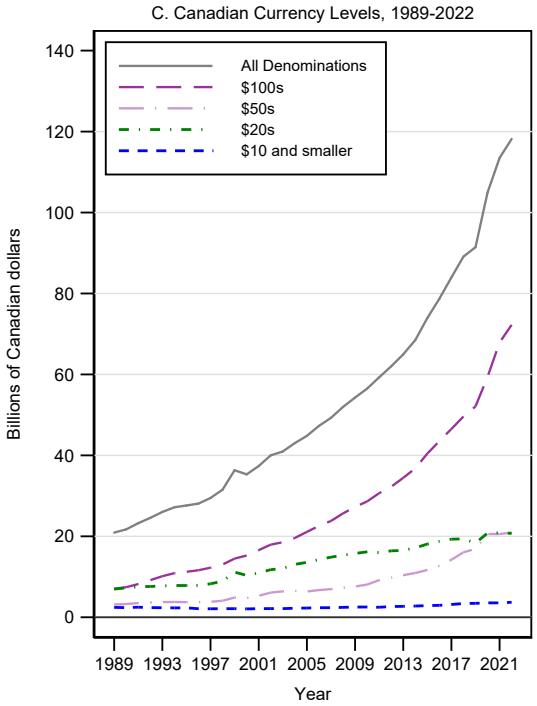
Figure 1. Levels and Growth Rates of Currency in Circulation for U.S. and Canada



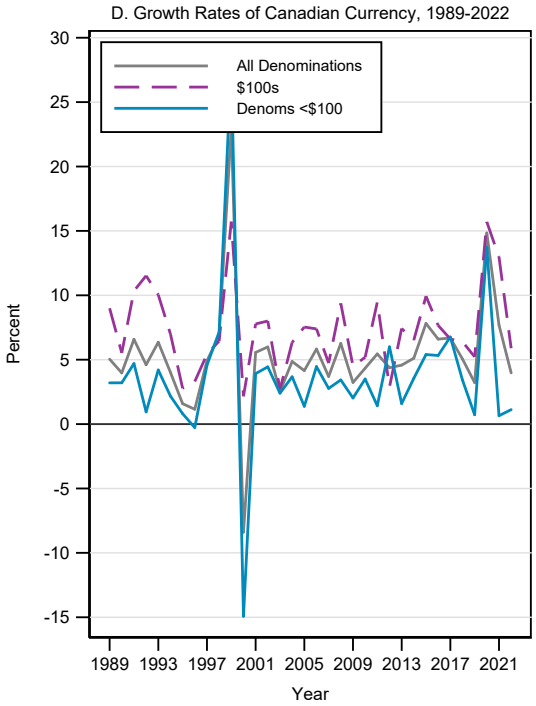
Note: Average of Sept. and Dec. currency in circulation.
Source: U.S. Treasury.



Note: Annual growth rates of fourth-quarter averages
(average of end-September and end-December levels).
Source: U.S. Treasury.



Note: Average of Sept. and Dec. currency in circulation.
Source: Bank of Canada.



Note: Annual growth rates of fourth-quarter averages.
Source: Bank of Canada.

2.4 Canadian Patterns of Currency Demand Are Likely Similar to U.S. Domestic Currency Demand

One might look to Canada for evidence of what U.S. currency demand would look like without a foreign component. Canada has similar income levels, payments technologies, holiday patterns, and GDP growth rates to those in the United States, but little Canadian currency is believed to circulate externally. Figures 1C and 1D display Canadian currency in circulation by denomination in levels and growth rates from 1989 to 2016. As can be seen in Figure 1C, $100s are also prevalent in Canada, though less dramatically than in the U.S., accounting for 61 percent of Canadian currency in circulation at the end of 2022.[19] Overall currency growth rates for Canada are, not surprisingly, driven less strongly by $100s and more strongly by $20s and $50s, the primary transaction denominations in Canada.

2.5 U.S. and Canadian Currency Growth Relative to Income Diverged Beginning in the 1980s

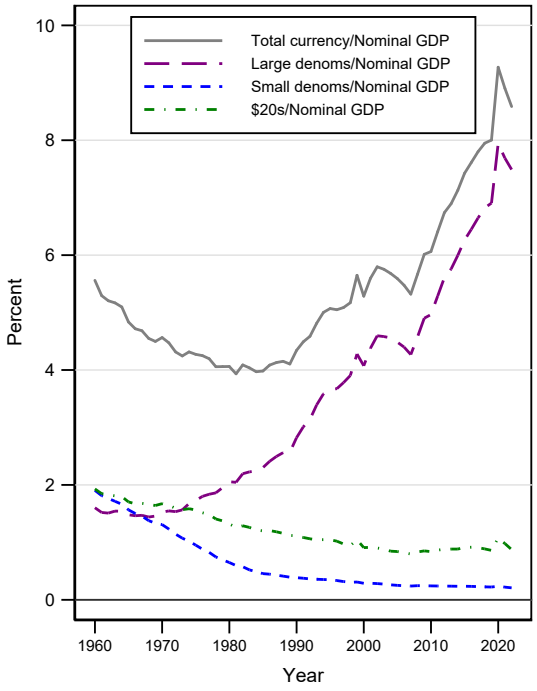
As noted earlier, U.S. currency growth has been strong even relative to nominal GDP. Figure 2 displays the ratios of total currency to nominal GDP for the United States and Canada over the past half-century. Ordinary theories of money demand would predict that the ratio of income to currency, or velocity (the *inverse* of the ratio shown here) should vary positively with the opportunity cost of holding money. That is, in terms of these charts, higher opportunity cost would be associated with *lower* demand for currency relative to income. As cashless payments become more common and, presumably, more cost-effective, one might expect that, abstracting from movements in market interest rates, demand for currency relative to income should decline. Indeed, that pattern prevailed in the United States until about 1985, and in Canada generally for the period. The upturn in the U.S. ratio of currency to nominal GDP beginning in 1989 is thus anomalous and is consistent with substantial and growing external use of U.S. currency.

In the next section, I present a very simple estimate of overseas demand for U.S. currency based on these patterns and the assumption that patterns of domestic demand for currency are the same in the United States and Canada. I then juxtapose these estimates with direct measurements of cross-border currency flows.

[19] Both the United States and Canada have notes of denominations above $100 in circulation, but in both cases, these notes have not been issued to circulation for some time.

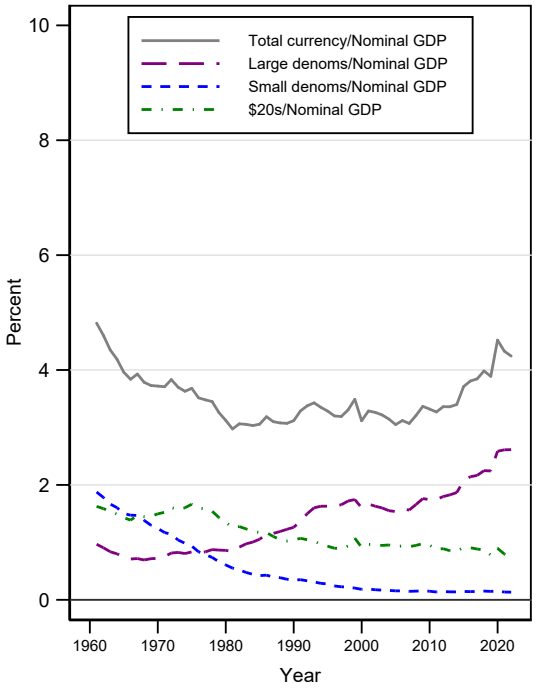
Figure 2. U.S. and Canadian Currency to GDP Ratios and GDP Growth Rates

A. U.S. Currency to GDP Ratios, 1960-2022



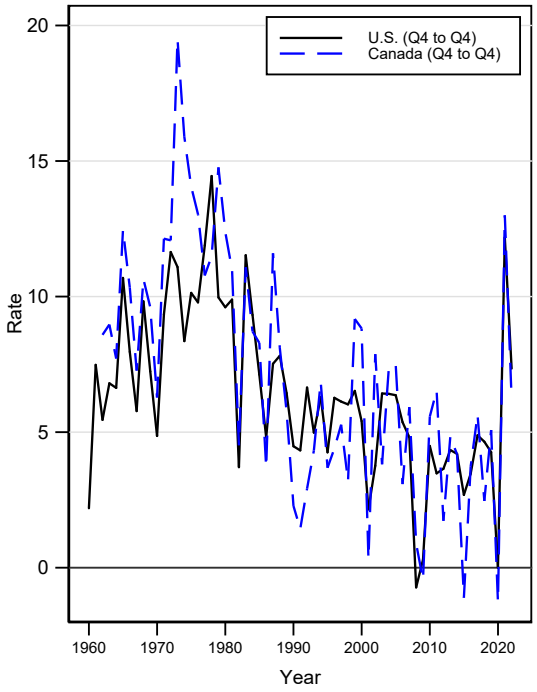
Source: U.S Treasury; Bureau of Economic Analysis via Haver.

B. Canadian Currency to GDP Ratios, 1961-2022



Source: Bank of Canada; Statistics Canada via Haver.

C. Canada and U.S. Nominal GDP Growth, 1960-2022



Source: Bureau of Economic Analyis and Statistics Canada via Haver.

3 Simple Estimates of Stocks and Flows of U.S. Currency Held Abroad

3.1 Two Estimates Based on Money Demand and Comparisons with Canada

3.1.1 A Very Simple Estimate

Taken together, the difference between the patterns seen for the United States and for Canada in Figures 3 and 4 suggest a simple estimate of the share of U.S. currency abroad. As noted above, and as displayed in Figure 5, U.S. and Canadian nominal GDP growth rates have been similar over this period. The observed U.S. ratio of currency to nominal GDP is the sum of domestic and foreign demand. If we assume that the Canadian ratio of currency to nominal GDP is the same as its U.S. counterpart for domestic demand, then the foreign share of U.S. demand can be estimated as follows. Define

$$(1) \quad CURRGDP_{Canada} = \frac{CURR_{Canada}}{GDP_{Canada}}$$

$$(2) \quad CURRGDP_{USA} = \frac{CURR_{USA}}{GDP_{USA}} = \frac{CURR_{USADom}}{GDP_{USA}} + \frac{CURR_{USAFor}}{GDP_{USA}}$$
$$= CURRGDP_{USA\_Dom} + CURRGDP_{USA\_For}$$

Replacing CURRGDP_{USA_Dom} with CURRGDP_{Canada}in the equation above, it is then possible to solve for CURRUSA_For / CURRUSA_Tot as

$$(3) \quad ForShare_{VerySimple} \equiv \frac{CurrUSA_{For}}{CurrUSA_{Total}} = 1 - (\frac{CurrGDP_{Canada}}{CurrGDP_{USA}})$$

3.1.2 A Simple Estimate

The approach above carries with it the assumption that Canadian and U.S. domestic demand for currency are the same at the same point in time. However, the level of Canadian per capita income, while similar to that of the United States, has generally been a bit lower. Thus, an alternative assumption would be that Canadian and U.S. domestic demands for currency relative to income are the same at the same levels of per capita income. In order to construct an estimate of the share of U.S. currency abroad using this assumption, we proceed as follows. First we regress the ratio of Canadian currency to GDP on the log and level of Canadian per capita GDP, denoted GDPC:

$$(4) \quad CURRGDP_{Canada} = \alpha_{Canada} + \beta_1 lnGDPC_{Canada} + \beta_2 GDPC_{Canada} + \varepsilon_t$$

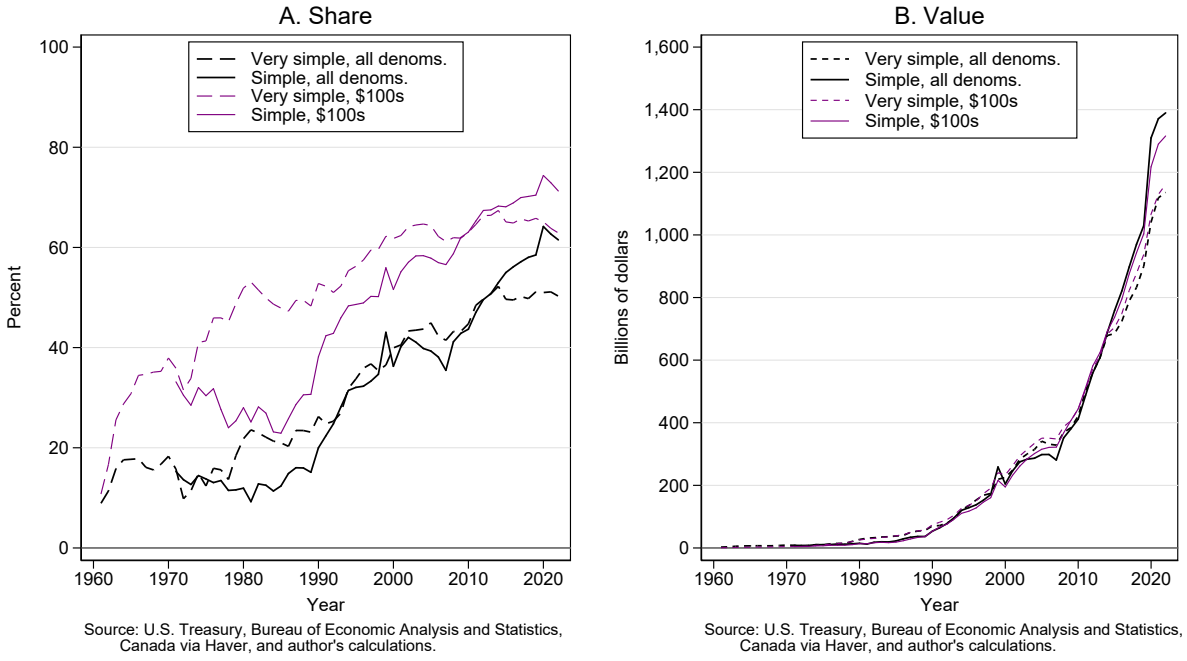
To be sure, this specification is a very simple reduced form based on the chart shown; it effectively assumes a log-linear structure for demand for currency as a function of income and assumes no other factors. We then construct the estimated domestic share of U.S currency for a given level of GDPC as

$$(5) \quad \widehat{CURRGDP_{USADom}} = \alpha_{Canada} + \beta ln(GDPC_{USA} * X_{CanUS})$$

where X_{CanUS} is the U.S.-Canadian dollar exchange rate. The simple estimate is then constructed as before, replacing CURRGDP_{USADom} with $\widehat{CURRGDP_{USADom}}$ rather than CurrGPD_{Can} in Equation 2 and rearranging to solve for CURR_{USAFor} / CURR_{USATot}, which gives

$$(6) \quad ForShare_{Simple} \equiv \frac{CurrUSA_{For}}{CurrUSA_{Total}} = 1 - \left(\frac{\widehat{CurrGDP_{USADom}}}{CurrGDP_{US}}\right)$$

Figure 3. Simple Estimates of U.S. Currency Abroad



These two estimates of U.S. currency abroad are displayed in Figure 3. The GDP-based estimates, the solid lines, suggest that about 60 percent of all U.S. currency, and about 70 percent of $100s, were held abroad as of the end of 2022, for a total value of about $1.4 trillion. Over the past two decades, these estimates point to a sharp runup in external demand for U.S. currency beginning in the late 1980s, a brief pop in 1999, a decline

beginning in 2003, and a resurgence in 2008 that continued through 2022, all patterns consistent with the overall growth of U.S. currency. Notably, the increase in the estimated share of U.S. banknotes abroad increased in 2022 but, unlike previous episodes, that increase reversed by the end of 2022.

3.2 Measurements of Cross-Border Flows of U.S. Currency

We now turn to the information provided by direct measurements of currency flows. Figures 4 and 5 display annual data on the primary measurements of cross-border currency flows in dollars, the international commercial bank shipment data described in Section 1.2. Beginning with Figure 4A, the solid black line indicates net commercial bank shipments and the dashed blue line indicates the total change in currency in circulation each year.[20] Focusing only on the solid black and blue dashed lines, several features of the data stand out. First, reflecting the strong influence that international demand has on overall U.S. currency demand, the two series generally move in parallel, though the gap widens in the early 2000s and narrows in the most recent years. Second, the spike up in 1999 and down in 2000 seen in total currency in circulation, the blue dashed line, is absent in the shipment flows. This feature of the data reflects the fact that a large share of the runup in holdings of currency immediately prior to the century date change (that is, in the final weeks of 1999) was held in commercial bank vaults and was then returned to the Federal Reserve early in 2000. Thus, while the currency was technically "in circulation" in the sense that it was held outside the Federal Reserve, the bulk of it never went to bank customers.[21]

While U.S. currency is used in, and is shipped to and from, many countries, a few areas stand out because of their size and their appetite for dollars in times of crisis. In Figure 4B, the dashed red line indicates net commercial bank shipments to the two leading markets in this category, the former Soviet Union and Argentina. For all but the first and last few years of the period shown, or from about 1995 to 2008, these shipments more than fully accounted for all net commercial bank shipments. This phenomenon might also have been the case in the early part of the sample, but reporting in that period was not as detailed. As a result, shipments recorded with a destination of Europe might well have been sent to the former Soviet Union. In the early 2000s, net shipments to these

[20] Net commercial bank shipments are defined as shipments out of the United States to other countries (exports) less shipments from other countries into the United States (imports).

[21] For many internal calculations, we typically smooth through this spike because of its extremely transitory and peculiar nature. The currency component of the money stock excludes currency held in the vaults of depository institutions. We would ordinarily prefer to use this currency component measurement, but data are not available by denomination on that basis.

markets declined as the financial conditions stabilized and as the need to use cash for saving and transactions has faded. In the years since 2008, though, global conditions as well as crisis and political uncertainty in these regions appears to have coincided with an upswing in demand for dollars.[22]

Figure 4C displays a proxy for commercial bank shipments based on currency processing data, the solid gray line. Commercial bank shipments are reported on a confidential basis, and monthly data are not always available on a consistent schedule. In order to have data for operational and publication purposes, Federal Reserve Board staff developed this proxy, which is the sum of net payments of $100 notes from three Federal Reserve offices known to handle substantial volumes of deposits and withdrawals sent from or to international destinations: New York, Los Angeles, and Miami.[23] This proxy is based on two assumptions, which differ from the true net shipments series in two offsetting ways. The first assumption, which likely results in an overestimate, is that all payments and receipts at these offices are to or from international counterparties and that all payments and receipts at other offices are to or from domestic entities; in fact, every Federal Reserve office serves domestic and international customers. The second assumption, which would generally result in an underestimate, is that only $100s are sent to or received from international destinations. This proxy moved very closely with the total shipments data in the 1990s, but was considerably higher than shipments over most of the 2000s, perhaps suggesting that domestic demand for $100s was stronger in that period.

The two dashed series in Figure 4C indicate two alternative series. As noted above, one shortcoming of the shipment dataset is that it captures only cross-border flows carried through commercial banking, or "wholesale" channels. However, as reported in U.S. Treasury (2006), many countries receive large dollar flows through nonbank, or "retail" channels and return dollars to the United States through banking channels. In the commercial bank shipment data, this phenomenon emerges in the form of persistent negative net shipment figures. That is, the shipment figures indicate large flows of dollars out of the foreign country into the United States and much smaller flows in the opposite direction.

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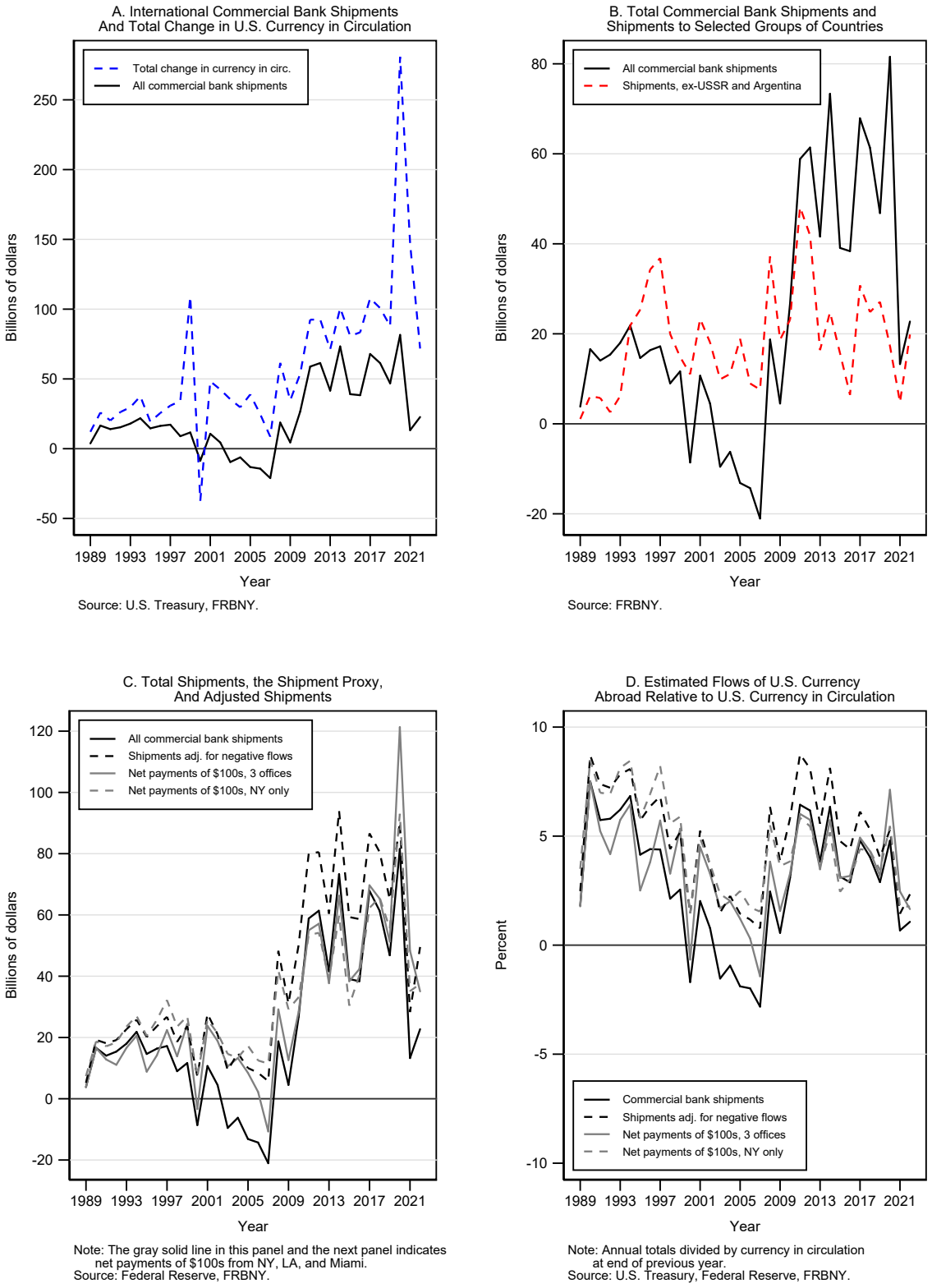
[22] See Banegas et al. (2015) for analysis of the significance internal and external economic and political crisis for currency demand at the global and country level.

[23] The Federal Reserve System has 12 regional Banks, whose locations are fixed. Many Federal Reserve Banks also have one or more branches, whose number and location can change over time as operational needs dictate. The Miami office is a branch of the Federal Reserve Bank of Atlanta and the Los Angeles office is a branch of the Federal Reserve Bank of San Francisco.

Figure 4. Shipments of U.S. Currency Abroad



For some such countries, the net commercial bank shipments figures are likely accurate and reflect dollar banknote inflows from third countries. For example, if tourists from Country A routinely carry dollars to Country B and the residents of Country B have little other use for dollars, the dollars might be shipped from Country B to the United States. All other factors equal, this pattern would result in negative net shipments figures, and shipments figures summed across Country A and Country B would give an accurate indicate of flows into and out of the United States. For some countries, however, it is likely that dollars arrived in the country from the United States through nonbank channels. In such cases, the commercial banknote flows would not give an accurate indication of net flows to and from the United States.

The first alternative series imposes a very rough adjustment for this phenomenon as follows. First, a group of countries known to have significant tourism or significant populations of immigrants or migrant workers in the United States is identified. Second, a group of countries whose total net shipments is substantial and negative is identified. Third, for each year and for each country in both groups, the assumption is imposed that total net currency shipments to these countries, including the observed net commercial bank "wholesale" flows and nonbank "retail" flows, were zero.

As with the shipments proxy, this approach embodies two assumptions. First, this approach implicitly assigns a value of zero for net currency flows to these countries. This assumption could be erroneous in either direction: actual net flows could be positive or negative. Second, this approach assumes that other countries' flows in aggregate are accurately measured by net commercial bank shipments. The blue dashed line shown here displays an adjustment that imposes this assumption for about a dozen countries. While this approach is admittedly crude, it is suggestive of the magnitude of flows that could be occurring through nonbank, or "retail" channels. Ideally, we could refine this measure by constructing series of "retail" (nonbank channel) banknote flows from the United States to other countries. While this type of data is not available universally, it has at times been collected by some countries, including Mexico.[24] This measure, the dashed black line, also generally tracks the shipments proxy for most of

[24] Mexico is the largest single contributor to this adjustment, and it was the case of Mexico that inspired this approach. In the 1990s, Mexico collected customs data on cash imports from all travelers with no lower bound on the reporting threshold. This reporting is, of course, subject to the same problems of underreporting as other customs data, but the magnitudes were substantial and of a magnitude similar to reported commercial bank inflows. More recent customs reporting requires only declaration of amounts above $10,000. Regardless, Mexican statistics on tourism flows indicate substantial volumes of people and revenue, though the form of the revenue (cash, credit card, or other) is not specified. Refer to Banco de Mexico (2012).

the sample. To the extent that this adjustment it useful, it is probably more applicable for cumulative, or stock estimates, than it is for flow estimates, because the nonbank flows likely occur at different times than the measured banking-channel flows back to the United States. For example, currency might be brought from the United States to another country through nonbanking channels over time and then return quickly in the event of a regulatory or other political or economic change.

Finally, the dashed gray line is an adjusted shipment proxy series. Along the lines of the adjusted commercial bank series, this series includes only payments of $100s from the Federal Reserve Bank of New York, which are generally positive, and omits payments from the Miami and Los Angeles cash offices, which are generally negative and might reflect reflows of currency that moved across U.S. borders through nonbank channels.

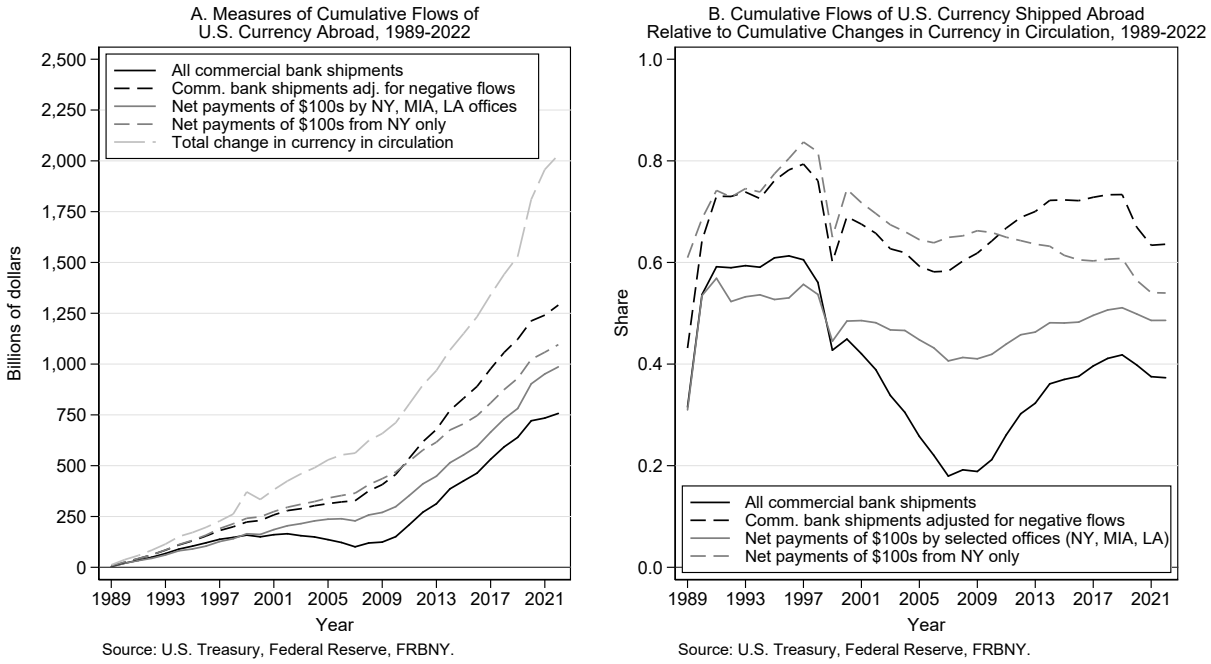
Figures 4A through 4C display nominal values, which can be misleading even in a period with relatively low inflation. Figure 4D, therefore, displays all of the same series as in Figures 4A through 4C, but scaled by the stock of currency in circulation at the end of the previous year, or the approximate percentage-point contribution to currency growth that would be implied by each of these measures. While the measures certainly vary, they generally point to strong contributions from foreign demand in the early to mid-1990s, a slowing in the mid-2000s, and a resurgence beginning in 2008, a sharp increase in 2020, and partial unwinding in 2021 and 2022.

3.3 Using Cross-Border Flow Estimates to Construct Estimates of the Stock of U.S. Currency Abroad

While tracking movements in currency in circulation is the major object of operational interest, having an estimate of the stock of U.S. currency abroad is also important for various analytical and operational questions faced by the Federal Reserve. Figures 5A and 5B chart the stocks of currency in circulation implied by the flow measures presented earlier. In Figure 5A, each line represents the cumulative change in the item since the end of 1988, when currency in circulation was about $230 billion. As indicated by the thicker gray dashed line, total U.S. currency in circulation worldwide has increased by about $2 trillion since 1990. The most direct measurement, commercial bank shipments, the solid black line, suggests that about $750 billion has moved abroad since 1989, which would put the total at between $750 billion and $1 trillion, depending on the assumed initial value. The shipments proxy, the solid gray line, suggests that about $1 trillion moved abroad over the period, putting the total at $1 trillion to $1.2

trillion.[25] Finally, the adjusted shipments and proxy figures, the dashed black and gray lines respectively, suggest that $1.1 trillion to $1.25 trillion moved abroad over the period, putting the total at $1.1 trillion to $1.5 trillion. These ranges are, of course, large, though the simple method proposed above in Section 3.1 produces an estimate very close to the center of the range.

Figure 5. Shipments and Proxies for Flows of U.S. Currency Abroad



Finally, Figure 5B displays the cumulative flow measurement and estimates as a share of the cumulative increase in currency in circulation at each point in time. Again, the estimates are disparate, but indicate some common trends, including a strong role for international demand in the 1990s, a waning role in the early 2000s, a resurgence that began in 2008 and shows signs of stabilizing but not waning. As in other measurements, a pronounced increase can be seen in 2020 but more recent years show a return to the trend of the past decade.

[25] The proxy is the only measurement available before 1988. It indicates that $40 billion moved abroad over the period from 1974 to 1989; during that time, currency in circulation increased by about $180 billion.

4 Indirect Estimates of the Share of U.S. Currency: The Seasonal Method

Earlier work on estimates of the stock of currency abroad has developed and provided estimates from two methods, known as the seasonal method and the biometric method.[26] Updates to these methods continue to indicate that a substantial share of U.S. currency is abroad, but technical factors and shifting patterns of currency demand have made their use more challenging.

In particular, this paper does not present estimates based on the biometric ("fish") method because current banknote distribution practice does not allow use of one of the critical assumptions. In particular, the biometric method relies on the assumption that, when a new banknote series is issued, all banknotes issued are of that series. However, for the issuance of 2003-series $20s, $50s, and $100s, older designs co-circulated for a time, and so it is not currently feasible to produce these estimates for the current design.

4.1 The Seasonal Method: Key Assumptions

The seasonal method extracts an estimate of the share of U.S. currency abroad by working from four key assumptions. First, we assume that the seasonal pattern in domestic demand for U.S. dollars is similar to the seasonal pattern of demand within Canada for Canadian dollars (similar holidays, vacations, customs, and denominations). More specifically, we assume that the seasonal amplitude, or the percentage difference between the seasonal peak and seasonal trough, is similar for U.S.domestic and total Canadian currency demand.[27] Second, we assume that foreign demand for U.S. dollars has no significant seasonal pattern, or, correspondingly, that the seasonal amplitude for the foreign component of demand for U.S. dollars is zero. Third, we assume that circulation of Canadian dollars outside of Canada is negligible, so that the demand for Canadian dollars can be attributed solely to domestic demand. Finally, we assume that U.S. currency is not used to a substantial degree inside Canada.

4.2 Model

Based on these assumptions, we can express the seasonal model as follows:

Define:

[26] Refer to Porter and Judson (1996), Judson and Porter (2001), U.S. Treasury (2006).

[27] Of course, Canadian and U.S. holidays are not identical: to give just two examples, Canada observes Thanksgiving in October and the U.S. observes it in November, and Canada's holidays include the day after Easter and the day after Christmas while these days are not generally holidays in the United States. Nonetheless, the broad outlines of holidays are very similar, especially at a monthly frequency.

S_i^j = seasonal amplitude for country i, component j

β_t = fraction of currency held abroad at time t

The overall seasonal amplitude in U.S. currency, ${S_{US}}^T$, can be expressed as a weighted sum of domestic (d) and foreign (f) components:

(S1) $S^T_{US,t} = \beta_t S^f_{US,t} + (1-\beta) S^d_{US,t}$

We cannot separately identify ${S^f}_{US,t}$ and ${S^d}_{US,t}$ but, using the assumptions above, we replace ${S^f}_{US,t}$ with 0 and ${S^d}_{US,t}$ with ${S^T}_{Can,t}$ to obtain:

(S2) $S^T_{US,t} = \beta_t * 0 + (1-\beta) S^T_{Can,t}$

Or, solving for β_t:

(S3) ${}_t = 1 - \frac{S^T_{US,t}}{S^T_{Can,t}}$

4.3 Application and Estimates

We estimate the share of all currency abroad and the share of $100s abroad using X-13 ARIMA to obtain seasonal factors for U.S. and Canadian currency in circulation. Once the seasonal factors are estimated, the seasonal amplitude must be calculated.

In earlier estimates using this method, the peak month was December and the trough month was February of the following year. However, it seems that seasonal factor patterns have changed in the past several years, as illustrated in Figures 6A and 6B. December remains the clear peak, though its relative magnitude has declined precipitously. The monthly trough for U.S. currency in circulation has varied over time, with January consistently near the trough. Since this method requires that the same "peak" and "trough" months be chosen, I use December and January.

Because of these shifts over time, I propose two approaches to measuring the seasonal amplitude. For each, I report results using X13-ARIMA. The first approach estimates the annual amplitude as the difference between the seasonal factor for December of one year and January of the next year. These estimates are associated with the year in which December falls and are shown in Figures 6C and 6D as the "annual" estimate, the solid

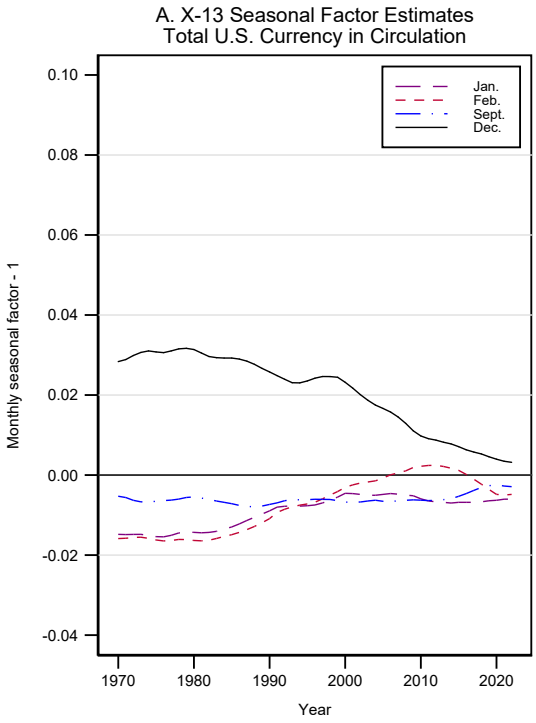
lines. A second approach is to estimate the seasonal amplitude each month as the difference between the maximum and minimum seasonal factors over the most recent twelve months, and then to estimate the monthly share of currency abroad as the trailing average of the estimates for the past twelve months. The estimates from this approach are shown in Figures 6C and 6D as the "monthly" short-dashed lines.

The results of the seasonal estimates for all currency abroad and for $100s through December 2022 are displayed in Figures 6C and 6D. As was the case in earlier work, these estimates are on the high end of the range. These estimates also show a quite different time series pattern relative to one another as well as relative to other flow-based measures, though the monthly measures generally indicate an upswing in the share of U.S. dollars held abroad.

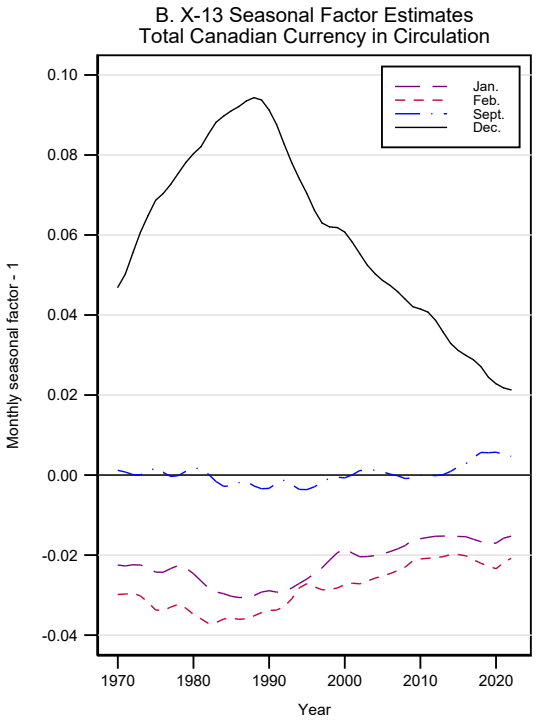
One curious feature of these results is that the estimates for $100s are lower than the estimates for currency overall despite our general impression that $100s are more prevalent in international use of U.S. currency. It is difficult to know what to make of these results, though it seems likely that it is related to the quite substantial changes in seasonal amplitudes evident in both the U.S. and Canadian data. This topic is worthy of study in its own right.

Figure 7 repeats the seasonal exercise for $20 notes, the most popular ATM currency and also a popular denomination in middle-income dollar-using countries. These estimates are being presented for the first time. It is notable that the estimated share of $20 notes held abroad is substantial–between 50 and 60 percent–though lower than the shares estimated for $100s and currency overall.

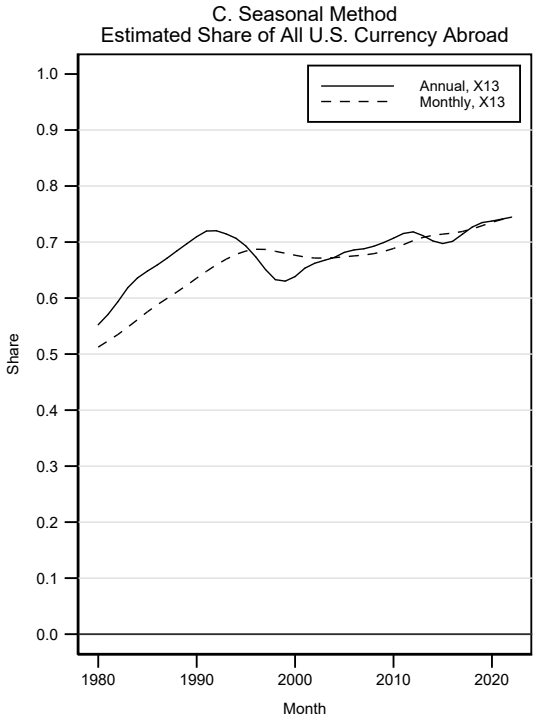
Figure 6: Seasonal Factors and Seasonal Method Estimates of U.S Currency Abroad



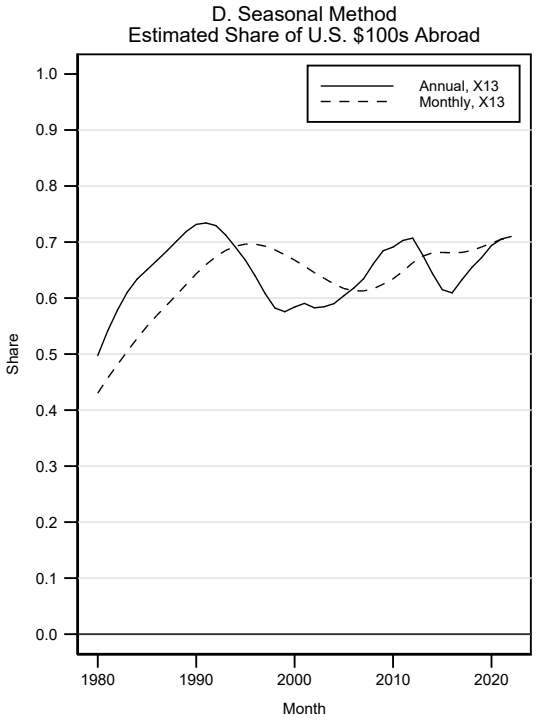
Source: U.S. Treasury, author's calculations.



Source: Bank of Canada, author's calculations.

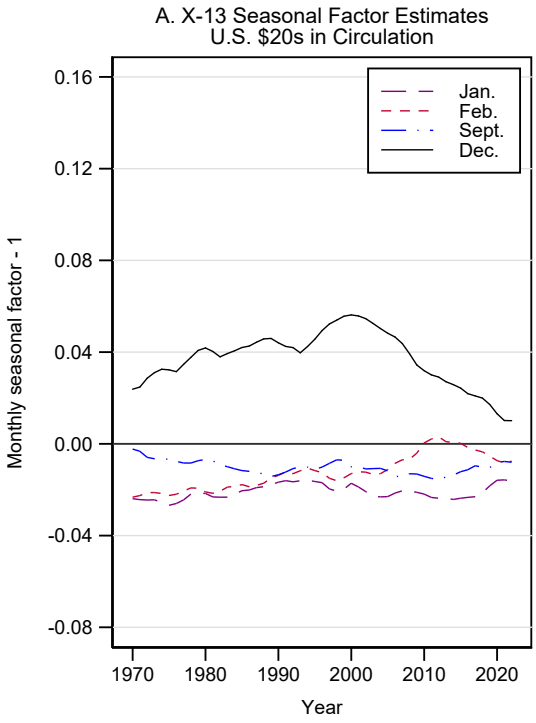


Source: U.S. Treasury, Bank of Canada, and author's calculations.

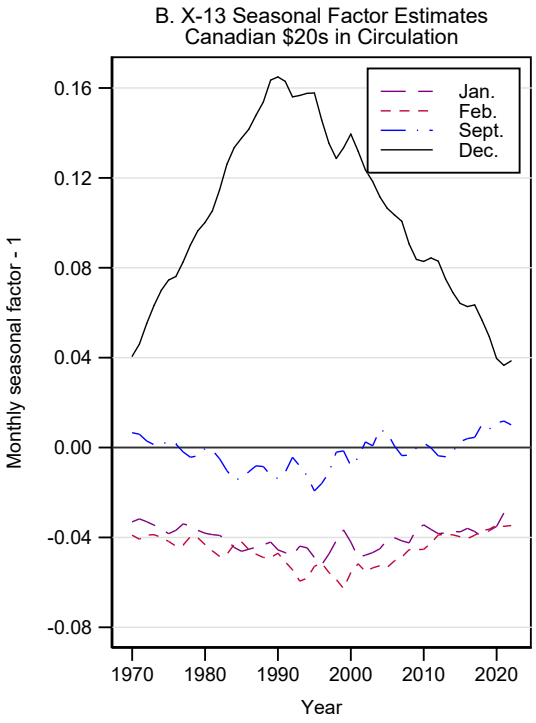


Source: U.S. Treasury, Bank of Canada, and author's calculations.

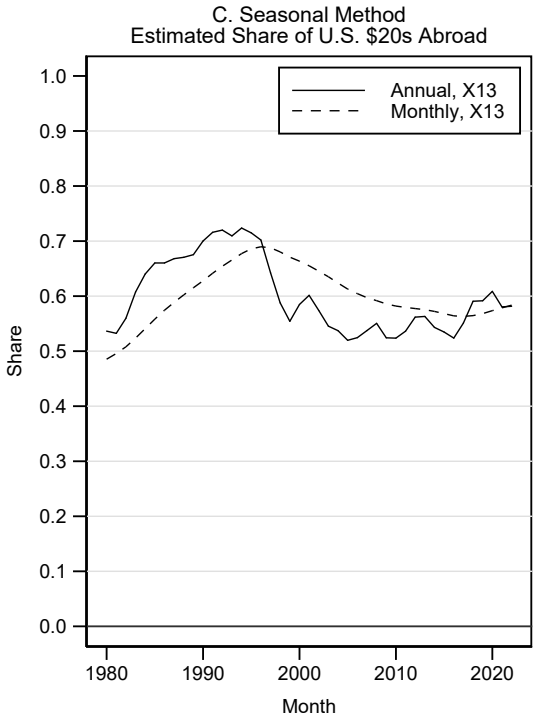
Figure 7: Seasonal Factors and Seasonal Method Estimates of U.S 20s Abroad



Source: U.S. Treasury, author's calculations.



Source: Bank of Canada, author's calculations.



Source: U.S. Treasury, Bank of Canada, and author's calculations.

5 Estimating a Currency Demand Function

Finally, we return to the idea of a currency demand function, which was briefly explored in Section 3 with reference to Canada. Here, the approach is to specify a demand function for U.S. currency that allows for foreign shipments as well as domestic factors. Our general assumption has been that currency demand consists of two components: a domestic component, which should be correlated with the typical determinants of money demand; and an international component, which is driven by routine as well as crisis-related fluctuations in foreign demand for U.S. currency.

Table 1 presents coefficient estimates for a simple error correction model for the currency component of M2 estimated quarterly beginning in 1988, a date chosen for two reasons.[28] First, 1988 marks the beginning of availability of the commercial bank shipment data as well as an apparent upshift in international demand for U.S. currency. Second, preliminary testing (not shown) indicates a distinct structural break in 1988. The regression model consists of two equations, one for the steady state and one for dynamics.

The steady state equation is

$$log(NGDP) - log(Curr) = \alpha_0 + \alpha_1(R_{short}) + \alpha_2 Trend - \varepsilon_t \tag{1}$$

The dynamic equation is

$$\begin{aligned} d(log(Curr) = \beta_0 \varepsilon_{t-1} + \beta_1 SHIP + \beta_2 (d(log(Curr))_{t-1} + \beta_3 d(log(NGDP)_{t-1} + \\ \beta_4 d(log(NGDP))_{t-4} + \beta_5 Y2K + \beta_6 COVID + \nu_t \end{aligned} \tag{2}$$

[28] As noted in Section III.B., the currency component of M2 excludes currency held in the vaults of depository institutions, or vault cash, which was one of the most volatile components of currency in circulation just before and after the century date change. Thus, this measurement of currency is more useful for longer-term analysis where the inclusion of the large and transitory swings in vault cash might be inordinately influential, such as in quarterly measurements where the periods immediately before and immediately after the century date change fall into different quarters.

Table 1: Quarterly Error Correction Regression Results

Dependent variable: Growth of seasonally adjusted currency component of M2		
Steady-state equation		
Constant	10.326*	(5.3)
$TB3M_{t-1}$	-0.026	(-0.9)
Trend	-1.362*	(-4.0)
Dynamic equation		
Error correction	-0.016+	(-1.9)
Shipments	0.425*	(5.7)
Y2K	0.007	(1.6)
Covid	-0.018*	(-4.1)
$d(\log(Curr))_{t-1}$	0.885*	(20.3)
$d(\log(NGDP))_{t-1}$	0.069+	(1.9)
Observations	140	
Adjusted R^2	0.47	
t statistics in parentheses.		
+ p <0.10, * p <0.05		

The variables are defined as follows:

NGDP: Nominal GDP, seasonally adjusted

Curr: Seasonally adjusted currency component of M2

SHIP: Two-month moving average of commercial bank shipments adjusted for negative net shipments, divided by the previous period's seasonally adjusted currency component of M2. This formulation puts shipments on the same basis as the monetary aggregate growth data, which are calculated as monthly averages.

TB3M: 3-month Treasury bill rate, a proxy for the opportunity cost of holding currency

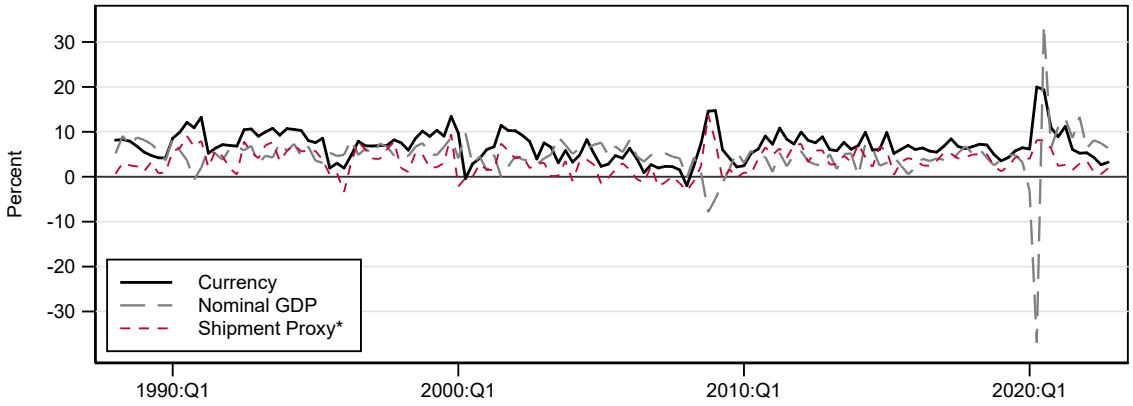
Trend: 1 for 1988:Q1 and increasing by 1 each quarter

Y2K: Dummy: 1 for 1999:Q4 and -1 for 2000:Q1

COVID: Dummy: 1 for 2020:Q2 and -1 for 2020:Q3

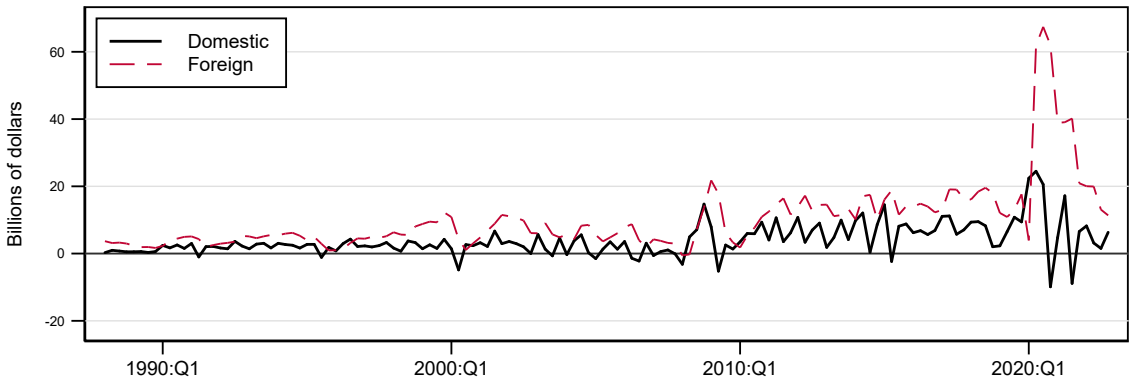
Figure 8. Currency Demand Model with Estimated International Component

A. Growth of Currency, Nominal GDP, and Proxy for Foreign Demand, 1988-2022



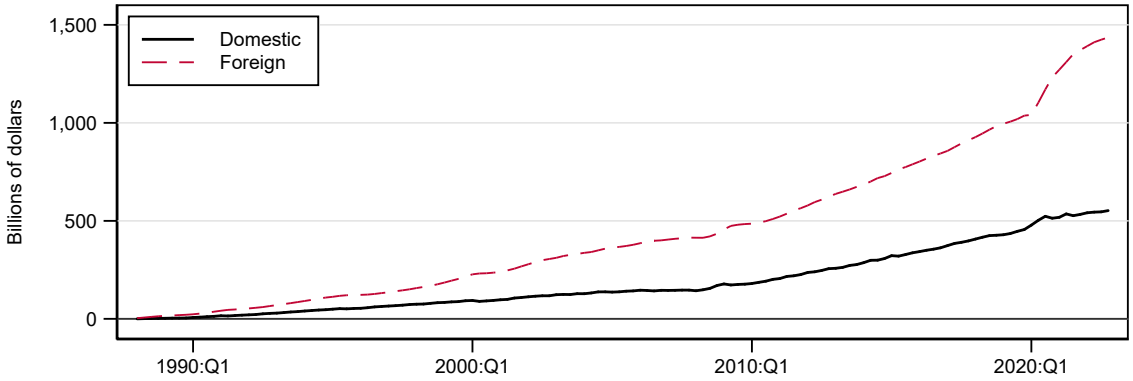
Source: U.S. Treasury, Bureau of Economic Analysis via Haver, Federal Reserve.

B. Estimated Foreign and Domestic Contributions to Currency Increases, 1988-2022



Source: U.S. Treasury, Bureau of Economic Analysis via Haver, Federal Reserve, and author's calculations.

C. Estimated Cumulative Contributions of Domestic and Foreign Factors to U.S. Currency Increases, 1988-2022



Source: U.S. Treasury, Bureau of Economic Analysis via Haver, Federal Reserve, and author's calculations.

The coefficients in the steady state equation are constrained to unitary elasticity, and the coefficients on the lagged values of log changes in currency and GDP are constrained to sum to 1. The equations are estimated by nonlinear least squares in one step by substituting for the error term in the dynamic equation. After controlling for the estimated contribution of overseas demand, the coefficients are generally of the expected sign and magnitude with the significant exception that the coefficient on the short-term interest rate is negative, albeit statistically insignificant. It is possible that this anomalous result is due to the near-zero interest rates seen for a substantial portion of the sample. The error correction coefficient is negative, shipments are strongly significant, and recent lags of currency growth and income are significant, and the time trend is negative. The Covid indicator variable is negative, likely because, as dramatic as the increase in currency demand was, the swings in GDP were even more significant.

Figure 8A displays overall currency growth, the solid black line, the proxy measurement, the short-dashed red line, and nominal GDP growth, the dashed gray line, for the regression sample period. Finally, Figures 8B and 8C display the quarterly and cumulative contributions to currency growth from foreign demand implied by the regression in Table 1. In both figures, the contributions are calculated from dynamic forecasts with residuals applied equally to the two components. As indicated by the dashed red line in Figure 8C, international shipments, as measured by the $100s proxy, are responsible for about two thirds of the growth in currency over this period.

Notably, even the highest of these estimates suggests that currency holdings by U.S. residents are significant—at least $1,000 per person—are at odds with survey work on currency holdings. The most recent Survey of Consumer Payment Choice, conducted in 2022, indicates holdings of around $400 per person (Cubides and O'Brien, 2023). Feige (1996, 2012) suggests that underground economic activity could account for this discrepancy, though underreporting, especially by individuals with large cash holdings, is also likely a substantial problem.

6 Putting It All Together: How Much U.S. Currency is Likely Held Abroad?

The preceding sections presented various methods of estimating the share or value of U.S. currency held abroad. Figure 9 combines all of these estimates on a comparable basis. For estimates based on cumulated movements, an initial value of about $120 billion, or half of currency in circulation at the end of 1988, was chosen. The upper left panel shows estimated external holdings of U.S. currency in dollar terms, with total U.S. currency in circulation, the dark gray line, shown for reference. The estimates vary

widely, from around $800 billion for the calculation based on raw commercial bank shipments to about $1.7 trillion for the seasonal method. Fewer estimation methods are available for $100s, shown in the upper right panel. The range of estimates is smaller, from about $1.2 trillion to about $1.3 trillion. The lower panels show estimated shares of U.S. currency held abroad, with the ranges similarly broad: the range of estimates is from about 40 percent to about 75 percent for all denominations and from about 60 percent to about 70 percent for $100s. While it is difficult to assign relative weights or probabilities to these varying estimates, they center in the 50 to 60 percent range for all denominations and around 65 percent for $100s.

7 Cash Demand during Covid in the U.S. and Abroad

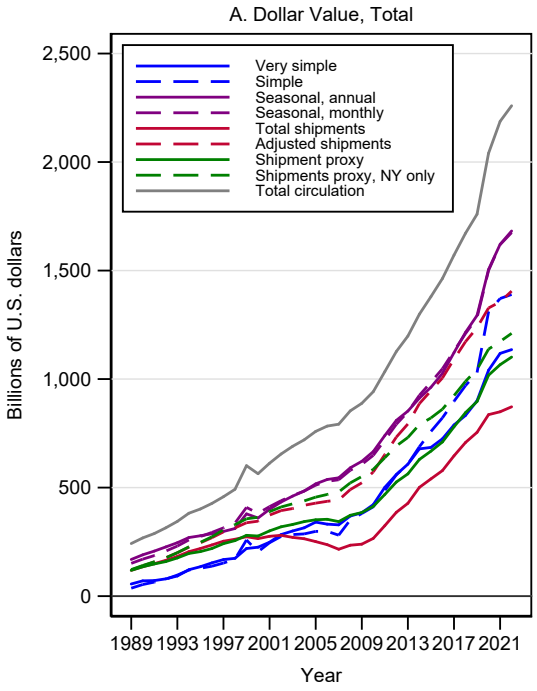
Notwithstanding a vast increase in the options for and use of electronic payments during Covid, demand for cash rose sharply in the second quarter of 2020 and remained unusually strong through 2021 in the United States as well as in other countries.

7.1 Covid: The U.S. Experience with Cash Demand

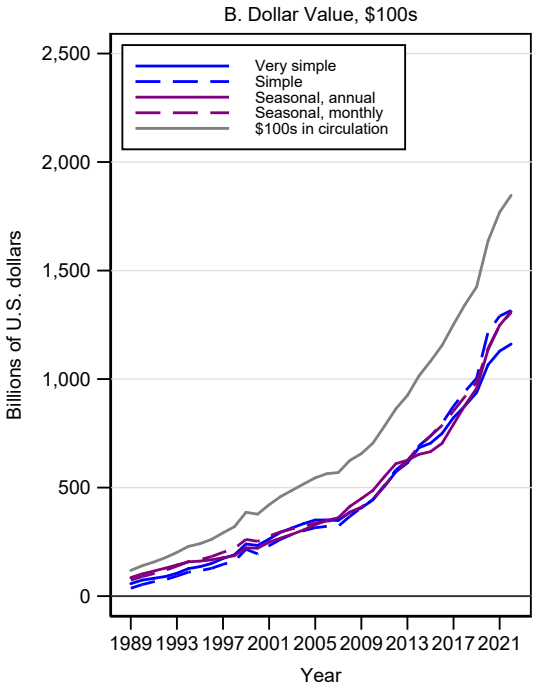
Notwithstanding a vast increase in the options for and use of electronic payments during Covid, demand for cash rose sharply in the second quarter of 2020 and remained unusually strong through 2021. Figure 10 displays average cumulative increases in currency in circulation, by week, for various years from 2003 to 2022, in dollar terms (upper panel) and growth rate terms (lower panel).[29] Over 2009 to 2019, the 11 years prior to 2020, total increases in U.S. currency in circulation over the course of a year were around $80 billion. In 2020, shown by the navy dash-dot line, cash demand was about average until March, when Covid lockdowns began. Cash demand leapt up sharply and ultimately increased over 2020 by about $280 billion, or over three times the amount seen over the prior decade. Cash demand remained unusually strong in 2021, the blue short-dash-dot line, returning to a typical range only in 2022, the purple long-dash-dot line. Notably, and as can be seen more clearly in the next section, cash demand in the first three quarters of 2023 was substantially lower even than 2009-2019, perhaps suggesting a reduction in precautionary cash holdings.

[29] Growth rates are calculated by dividing each year's cumulative increases by currency in circulation as of the last Wednesday of the prior year.

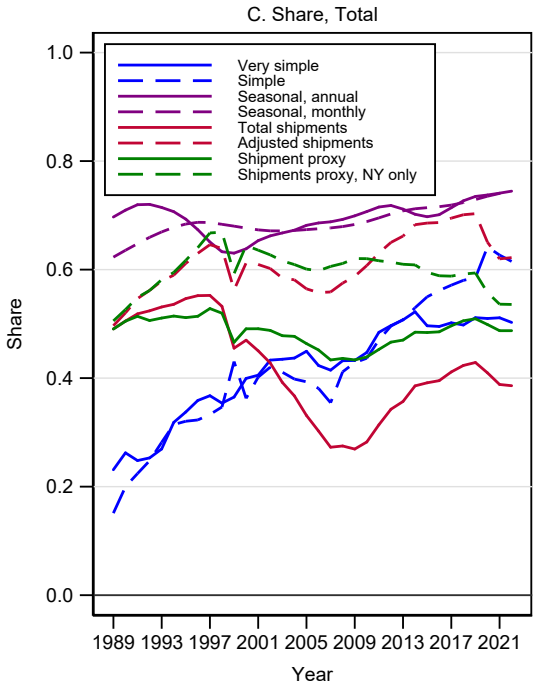
Figure 9. Estimates of U.S. Currency Held Abroad, 1989-2022



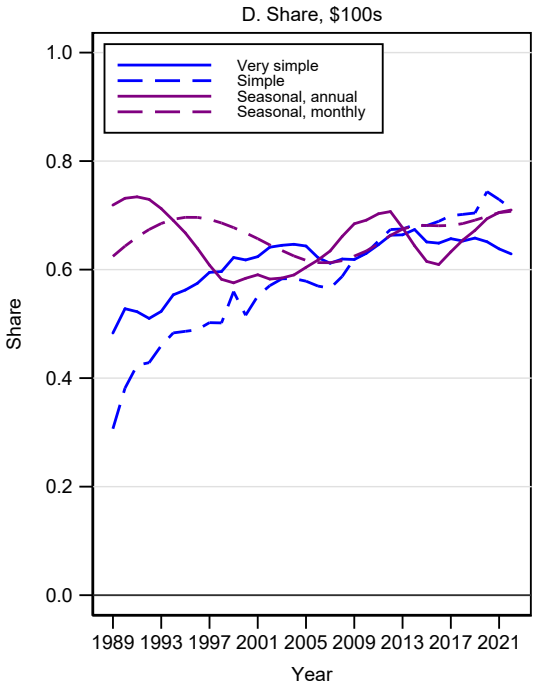
Source: U.S Treasury, Federal Reserve, FRBNY, Bank of Canada, Statistics Canada; Bureau of Economic Analysis via Haver; author's calculations.



Source: U.S Treasury, Federal Reserve, FRBNY, Bank of Canada, Statistics Canada; Bureau of Economic Analysis via Haver; author's calculations.

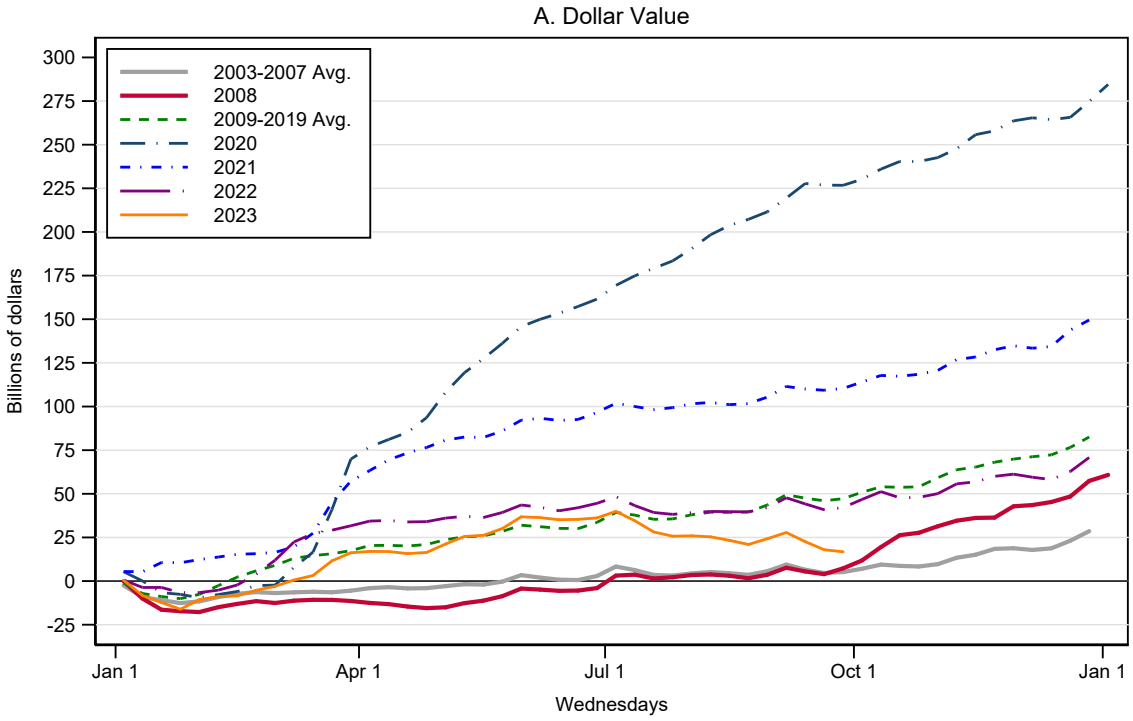


Source: U.S Treasury, Federal Reserve, FRBNY, Bank of Canada, Statistics Canada; Bureau of Economic Analysis via Haver; author's calculations.

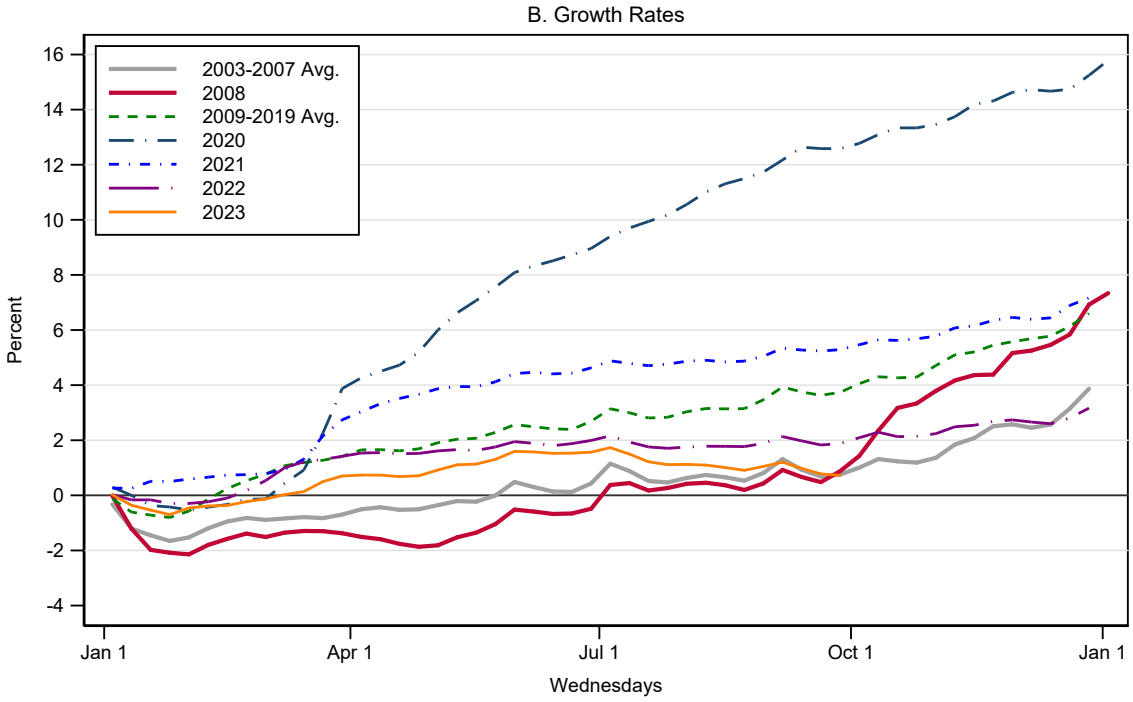


Source: U.S Treasury, Federal Reserve, FRBNY, Bank of Canada, Statistics Canada; Bureau of Economic Analysis via Haver; author's calculations.

Figure 10. Cumulative Increases in U.S. Currency in Circulation



Source: Federal Reserve H.4.1 statistical release.



Note: For growth rates, cumulative totals are divided by value for last Wednesday of prior year.
Source: Federal Reserve H.4.1 statistical release.

7.2 Covid: Demand for Cash in the United States Relative to Other Countries

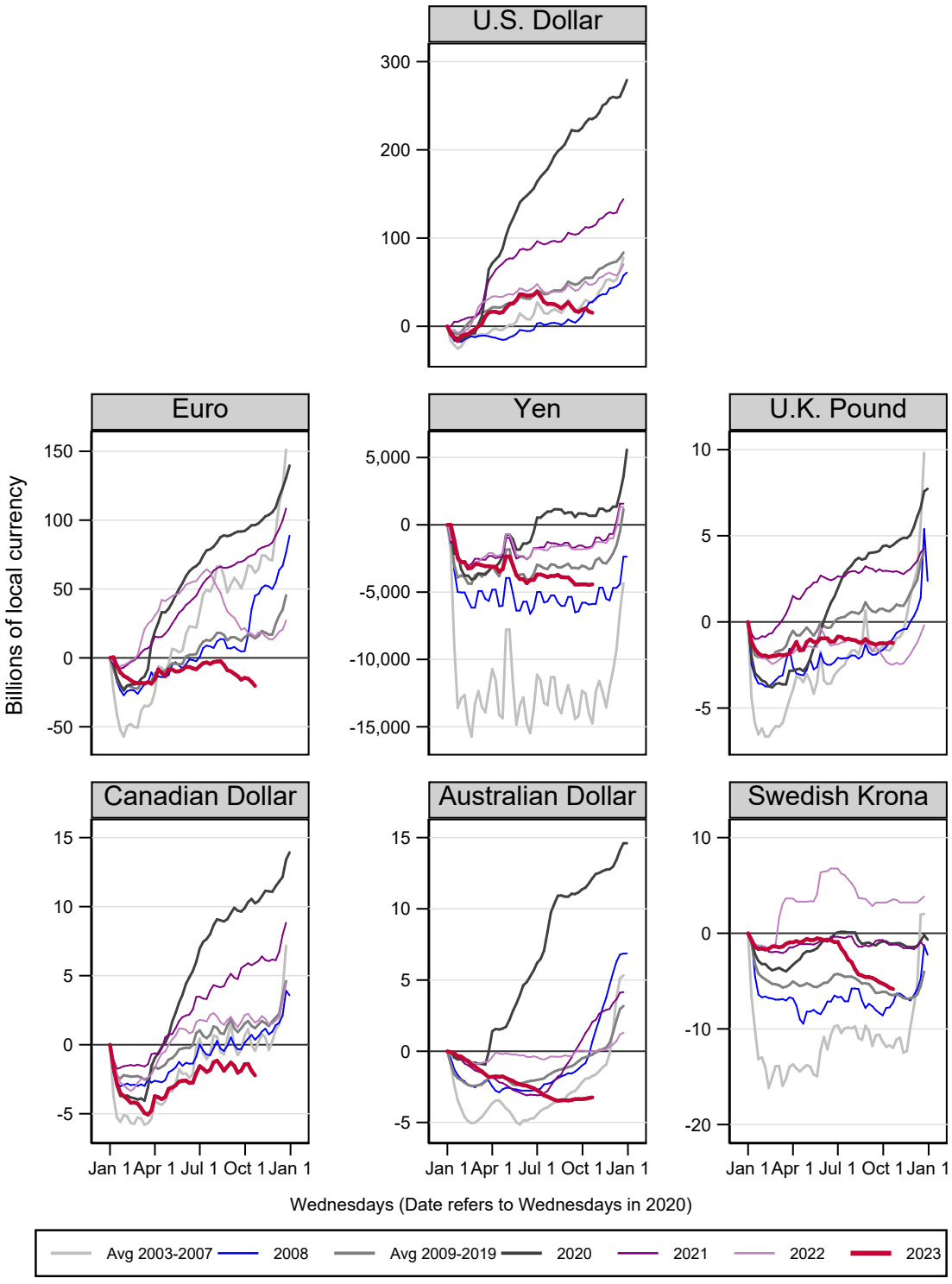
The U.S. experience with large increases in cash demand during Covid was not unique: as shown in Figure 11, increases in currency in circulation in 2020, the black lines, were the highest seen for Japan, Canada and Australia and were on a par with the strongest observations seen since 2003 for the euro ara, the U.K., and Sweden. Still, out of this group of countries and currencies, only Australia experienced an increase of the magnitude that the U.S. did. Currency demand in 2021 and 2022 generally remained strong across the board, and all countries have seen a pullback in demand over the first three quarters of 2023.

8 Down But Far From Out: Demand for U.S. Currency by Denomination

While $100s are the largest denomination by value and dominate international flows, the evolution of demand for smaller denominations in recent years deserves examination. Recall from Figure 2 that the total demand for currency and demand for large denominations ($50s and $100s) has generally increased over recent decades while the same ratio for smaller denominations has ben flat or declining.since Figure 15 displays the ratio of currency to U.S. nominal GDP from 1960 to 2016 for all currency, for $100s, for $20s, and for $10s and below. Not surprisingly, the path for total currency closely tracks that for $100s, with a steady upward path. In contrast, the path for $20s shows a slight uptick in the mid-2000s after years of steady decline, and the paths for $10s and smaller shows signs of leveling off or even declining.

Figure 12 takes a closer look at these developments by showing growth rates and growth rates scaled by GDP for all denominations, large denominations, estimated domestic demand for large denominations, and small denominations. The upper panel shows growth rates and the lower panel shows growth rates of currency divided by nominal GDP. While demand growth in dollar terms (upper panel) has been positive in nearly all cases, demand for currency relative to GDP (lower panel) has often been negative for domestically-provided large denominations and for all small denominations (the two lower panels within panel B), with the extreme years of 2008-2009 and 2020-2021 the exceptions. These developments suggest that domestic use of and demand for cash is trending down, albeit slowly, and that cash remains a popular choice in crisis episodes. Thus, while cash use seems to be diminishing relative to the size of the economy, the end of cash in the United States is probably still not imminent.

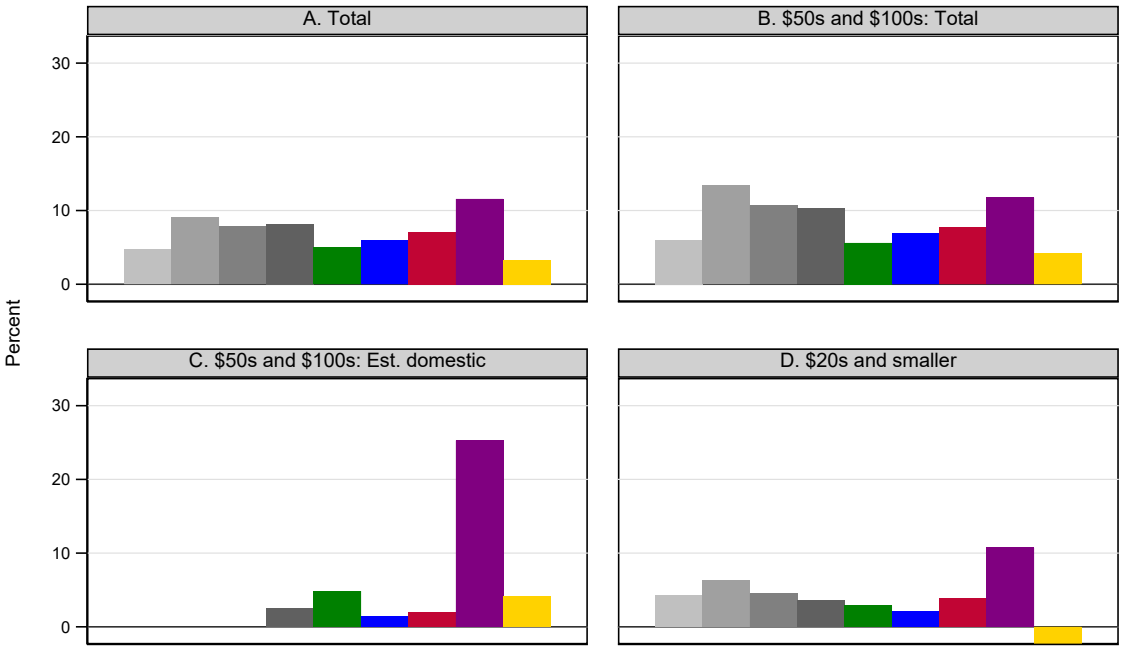
Figure 11. Cumulative Increases in Currency in Circulation in Selected Countries



Source: National statistical offices via Haver.

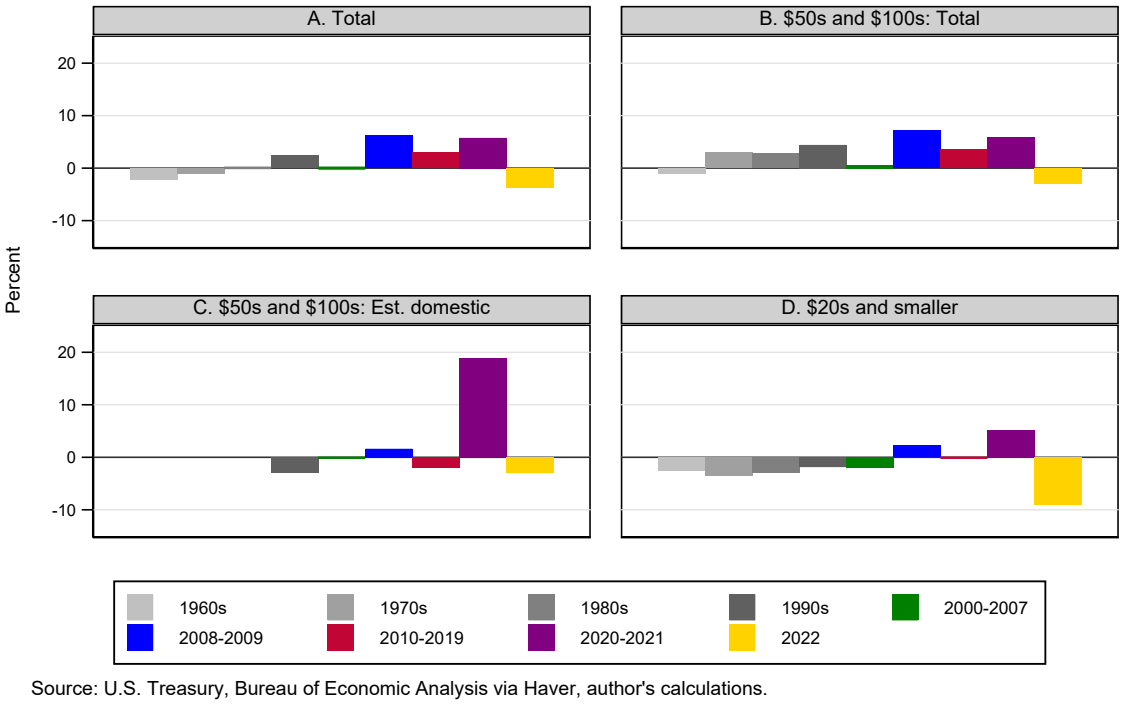
Figure 12. U.S. Currency in Circulation Growth Rates Over Time

A. Average Annual Growth in Currency in Circulation by Denomination



Source: U.S. Treasury, author's calculations.

B. Average Annual Growth in Currency in Circulation / GDP by Denomination



Source: U.S. Treasury, Bureau of Economic Analysis via Haver, author's calculations.

9 Summary, Conclusions, and Directions for Future Work

In sum, much as in earlier work, the currently available data do not allow for precise estimates of foreign holdings of U.S. currency, and the available estimates are somewhat disparate. Nonetheless, direct measurements, regression-based estimates, and indirect estimates all point to strong international demand in the 1990s, a falloff in the early 2000s, a resurgence that coincided with the collapse of Lehman Brothers that never reversed and, in the most recent years, unprecedented demand during the Covid crisis that began in early 2020. Collectively, these methods continue to suggest that half or a bit more than half of U.S. currency circulates abroad, with the share likely somewhat larger for $100 notes. For the U.S. dollar, the end of strong demand both abroad and at home seems to be far off, though, as noted, demand growth is slowing, especially for smaller denominations.

There are many promising avenues for future investigation, including the following. First, is there a good way to estimate hoarding of notes, using the biometric method or some other method based on banknote processing data? Second, if future banknote design releases allow for a revival of the biometric method, does it provide any new insights? For the seasonal method, what is the significance, if any, of the shift observed in seasonal patterns of demand for U.S. currency? For the regression-based methods, would a more rigorous and sophisticated regression framework yield more precise or very different estimates? Are there better ways to tease out the drivers of cash abroad? It is often asserted that cash is overwhelmingly used for illicit purposes, but can the forces driving licit and illicit use be identified and measured? Finally, as more and more ordinary transactions become cashless, will cash use in transactions be increasingly marginalized?

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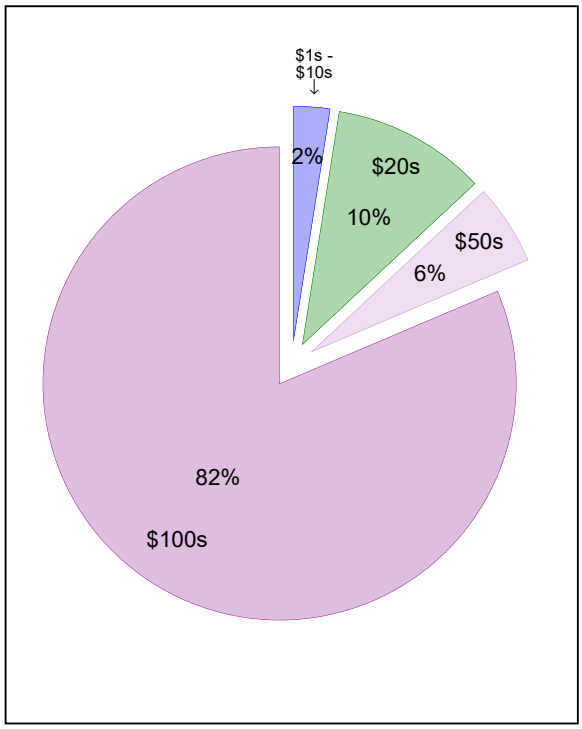
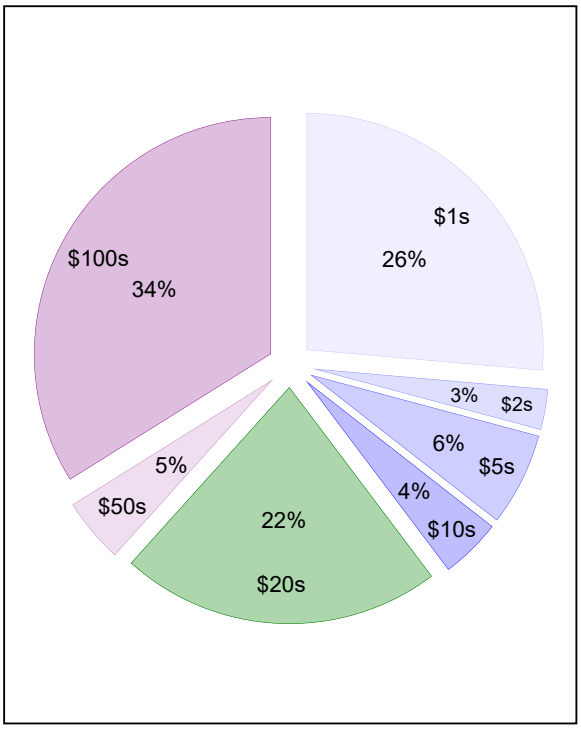
Figure A1. Denomination Shares of U.S. and Canadian Currency in Circulation
By Value and Pieces, 2022 Average

A. U.S. Shares, by Value



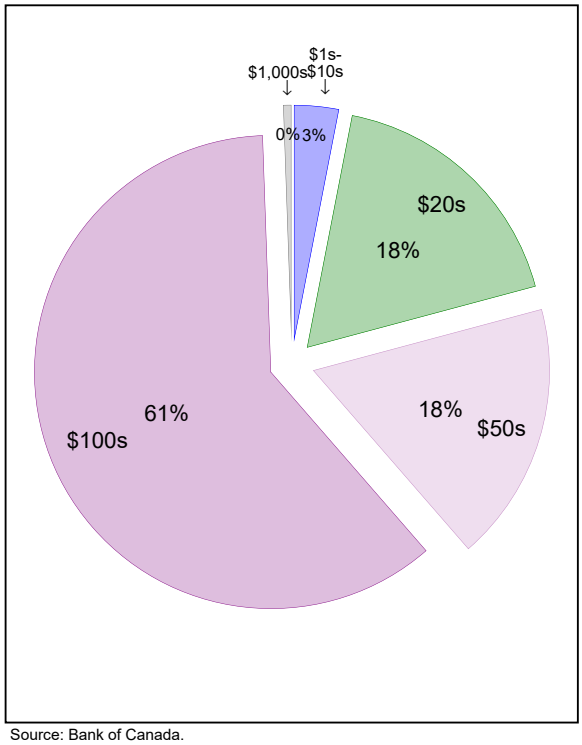
Source: U.S. Treasury.

B. U.S. Shares, Pieces



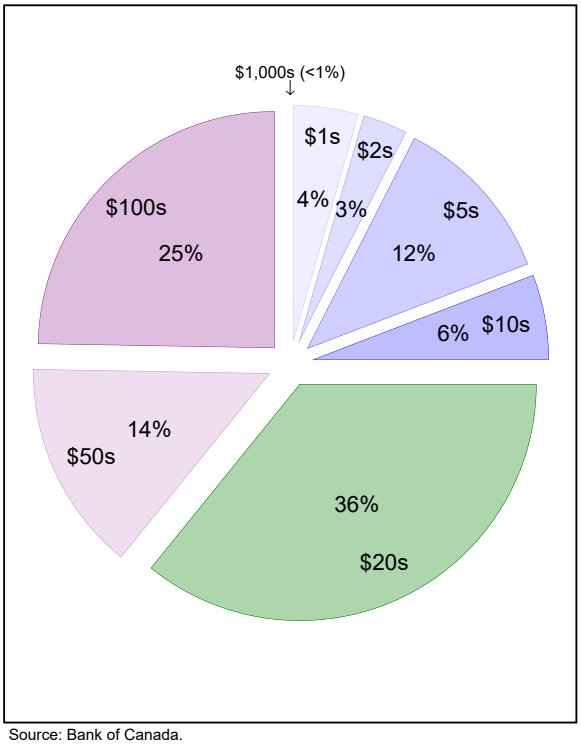
Source: U.S. Treasury.

C. Canadian Shares, by Value



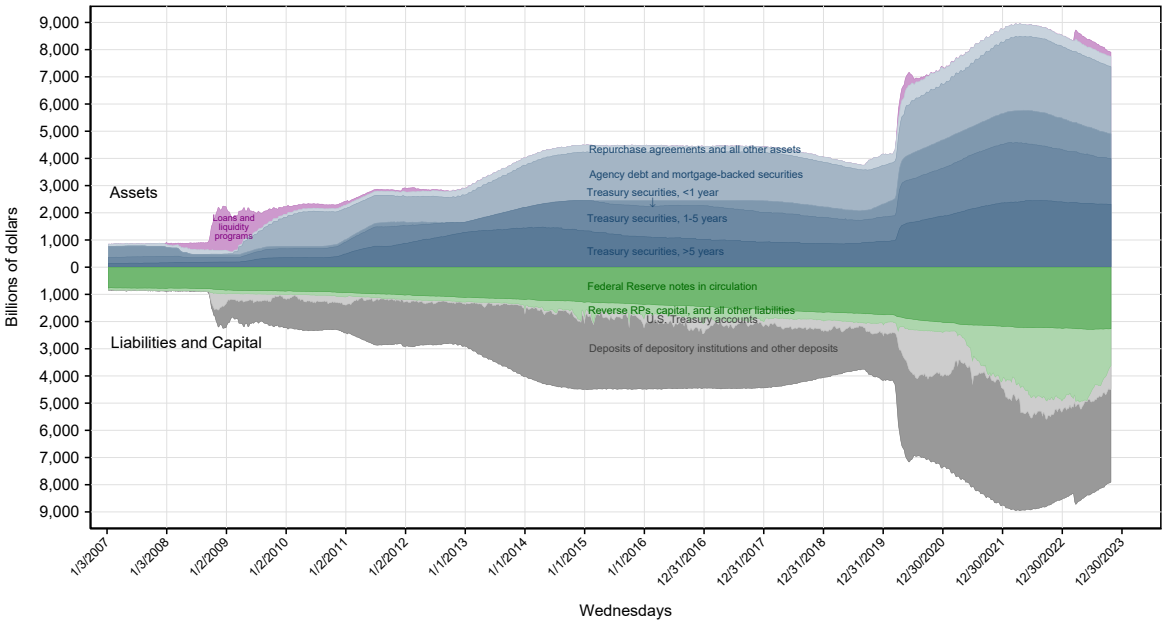
Source: Bank of Canada.

D. Canadian Shares, Pieces



Source: Bank of Canada.

Figure A2. Federal Reserve Balance Sheet 2007-2023



Source: Federal Reserve H.4.1 statistical release.