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Construction of an Estimated Domestic Monetary Base Using New Estimates of Foreign Holdings of U.S. Currency

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Richard G. Anderson and Robert H. Rasche*

1. *A Method to Measure Currency Exports*

Economic theory suggests that the long-run price level in a monetary economy is determined by the size of its monetary base. Most models assume that this quantity is the domestically held monetary base. For the United States, however, it is well known that a significant part of the increase in the U.S. monetary base during the last several decades has been exports of currency.[1] Modeling linkages between the U.S. price level and the monetary base therefore requires a partition of the U.S. monetary base into its domestic and foreign-held components.

No direct data are available on the amount of U.S. currency held abroad. Anecdotal information suggests that large sums of one, 50 and 100 dollar Federal Reserve notes are in continual foreign circulation. In a recent study, Porter and Judson (1996) examine eleven different methods for estimating the net outflow of currency from the U.S. into foreign circulation during 1977-95 and provide estimates of the stock of U.S. currency held abroad. Their outflow estimates, although the best published data, are not particularly useful for constructing a domestic monetary base time series because the estimates are: a) not available before 1977, b) only for annual net outflows and c) difficult to update on a real time basis.[2]

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[1] The Deutsche Bundesbank has faced similar distortions to the growth of its monetary base. See Deutsche Bundesbank (1995).

[2] In correspondence, Richard Porter notes that some of their methods can (and are) being applied to obtain quarterly estimates such as now appear in the Board's Flow of Funds accounts (see the following footnote).

Porter and Judson further assume that at the end of 1995 about 55 percent of the total stock of U.S. currency held by the nonbank public was held abroad, 44 percent of which was in the form of 100 dollar Federal Reserve notes (Porter and Judson, 1996, p. 895-6; Table 5). Unfortunately there is no way to determine the accuracy or degree of precision of measurement associated with this benchmark. Porter and Judson's methods and estimates are discussed more fully in the appendix.[3]

Feige (1994, 1996) has also constructed estimates of the fraction of U.S. currency held abroad. In his method which is most similar to ours, he assumes that the net outflows of 100 dollar Federal Reserve notes from the New York City cash office are exported and remain in circulation outside of the U.S. Feige's method is discussed more fully in the appendix.

In this paper, we present an alternative method based on Federal Reserve currency processing data for estimating the amount of U.S. currency that circulates abroad. Although similar in spirit to the methods of Porter and Judson and of Feige, our method is independent of theirs. In our method, we partition the net outflow of 50 and 100 dollar Federal Reserve notes from all Federal Reserve cash offices into a portion that remains in domestic circulation and a portion that is exported into "permanent" foreign circulation.[4] We estimate that at the end of 1995 approximately 53 percent of the U.S. currency held by the nonbank public was held abroad, about the same proportion as that obtained by the Porter-Judson median-flow method.[5] Our method is superior, however, because it furnishes monthly time-series estimates of both the flow of U.S. currency to foreign circulation and the outstanding stock of foreign-held U.S. currency, conditional on our assumed initial benchmark stocks in 1965 and 1969.

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[3] In addition to analyses of the stance of monetary policy, foreign holdings of U.S. currency also are prominent in estimates of the net international investment position of the United States. See Bach (1997), Scholl (1997), and *Flow of Funds Accounts of the United States*, Table F.204.

[4] Our method seeks to estimate the share of U.S. currency that tends to remain abroad, either as a medium of exchange or as a store of value. Our method is robust to routine inflows and outflows of small-denomination currency; see the discussion of our Assumptions 1 and 2.

In our method the fundamental data are the number of pieces of currency of each denomination put into circulation (E_t = emissions) and received from circulation (R_t = receipts) each month by Federal Reserve cash offices.[6] By definition, these flows into and out of circulation are related to the amount of currency in circulation of a particular denomination, C_t, by the identity:

$$(1) \qquad \Delta C_t \equiv E_t - R_t.$$

Currency of a particular denomination put into circulation (E_t) either circulates domestically (E_t^D) or is exported and circulates abroad (E_t^F).

To estimate the stock of currency held outside of the country, some identifying assumptions are necessary:

- First, that currency once exported tends to stay abroad and hence has been permanently removed from domestic circulation. This allows us to assume that currency received from circulation by Federal Reserve Banks and their branches reflects (almost) exclusively domestic circulation, that is $R_t = R_t^D$.
- Second, that small denomination notes -- ones, fives and tens – carried abroad tend to circulate into and out of the U.S. and hence into and out of Federal Reserve cash offices in a manner similar to internal domestic circulation of the same denomination notes.
- Third, that the emissions and receipts patterns of smaller denomination notes at Federal Reserve cash offices are a good measure of the unobservable emissions and receipts patterns of the larger denomination notes that are in domestic circulation. In particular, for reasons examined below, we rely on the patterns for the emissions/receipts ratio of ten dollar notes at

[5] We also estimate that 100-dollar notes accounted for about 44 of these 53 percentage points, similar to Porter-Judson and to Feige (1994, p. 128).

[6] The Federal Reserve ships and receives currency at 37 cash offices nationwide. Data for these offices are available on Federal Reserve electronic data bases beginning January, 1974. Historical data back to January, 1958 are available on archieval microfilm. Our estimates utilize both these forms of data

the New York City cash office to construct our estimates of the foreign circulation of larger denomination notes.

Assumption 1: Currency Abroad Tends to Stay Abroad

Anecdotal evidence suggests that much U.S. currency held abroad is infrequently repatriated to the United States. Although some currency enters and leaves the U.S. each day with businessmen and tourists, and some currency certainly is returned to the United States when foreign stocks exceed desired levels, U.S. currency abroad acts as both a store of wealth and medium of exchange. Surges in currency exports have tended to be correlated with increases in economic and/or political instability and, because of its dual role as a medium of exchange and store of value, currency may be retained abroad as a hedge against future instability even after the immediate crisis subsides. Phrased somewhat differently, once households and firms are induced by political and economic instability or by transactions needs to allocate some part of their portfolio to U.S. currency, that share perhaps tends to change slowly.

The assumption that exported currency tends to remain abroad may be relaxed without significantly affecting our analysis.[7] An alternative (and equivalent) identifying assumption is to specify that there is a permanent and transitory component to foreign circulation. Currency held *permanently* abroad, by definition, never returns to Federal Reserve cash offices. Assume that currency held abroad temporarily returns to the Federal Reserve cash offices with the same transit time as currency in domestic circulation or, alternatively, that the ratio of the currency temporarily abroad to currency in domestic circulation is constant. Receipts of currency at Federal Reserve cash offices then reflect the sum of currency in domestic circulation plus currency temporarily abroad, and the methodology developed here gives a measure of currency that is permanently outside of the country.

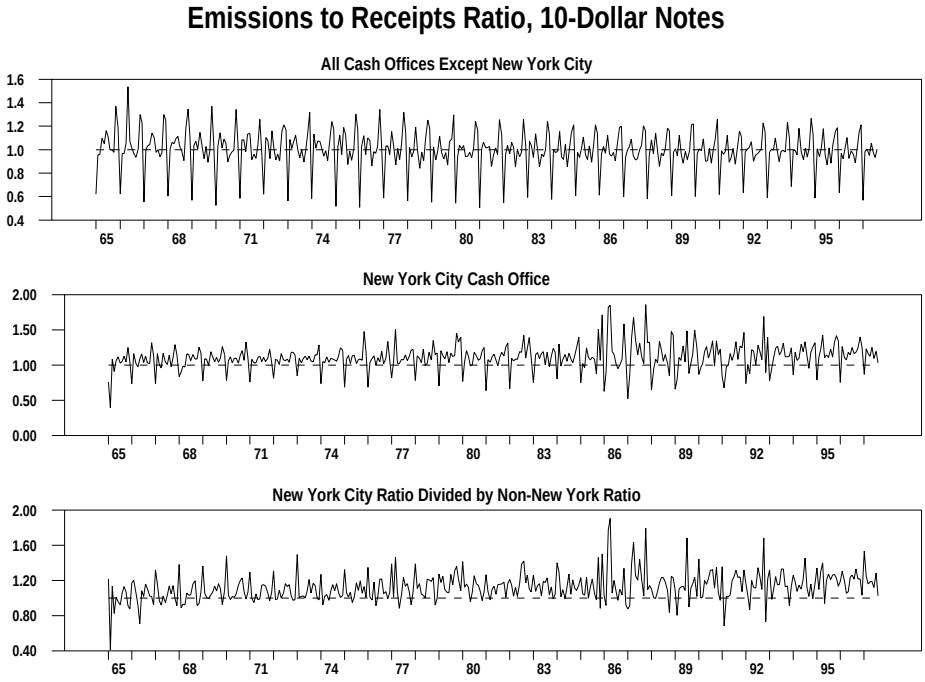
[7] We of course do not mean that precisely the same paper notes stay abroad (although many perhaps do), but rather that the aggregate value held abroad tends to be stable.

Assumption 2: Common Circulation Pattern for Small Denomination Notes

Our assumption 2 implies that, through time, Federal Reserve cash office emissions of small denomination notes should be approximately equal to receipts (adjusted for growth of the economy) and that the seasonal variation in the quantity of these notes in circulation should vary relatively little; that is, that the pattern of Federal Reserve cash office currency processing activity for small denomination notes should be uncorrelated with both the level and growth rate of foreign-held U.S. currency. We have examined the ratios of emissions to receipts for one, five, ten and twenty dollar Federal Reserve notes.[8] The first three display the stable patterns suggested by assumption 2. The ratio of emissions, E_t, to receipts R_t, for ten dollar notes at the New York City cash office and at all other Federal Reserve cash offices are shown in Figure 1 for 1965-July, 1997. The data are monthly, not seasonally adjusted. The time series of the ratio at the New York City office and at all other cash offices have two distinct characteristics: 1) a strong but remarkably constant seasonal pattern and 2) no distinct trend.

[8] These ratios are shown in appendix Tables A.7 and A.8.

Figure 1



It is also evident that the mean of the ratio of emissions to returns at the New York City cash office (=1.11) is about ten percent higher than for the ratio at the aggregate of all other cash offices (=0.999). Because the average ratio for the offices other than New York City is not significantly different from 1.0, all growth in the outstanding stock of ten dollar Federal Reserve notes in circulation has come from the New York City office. There is somewhat more irregularity in the New York City office series in the late 1980s, as is evident in the ratio of the New York City office series to the aggregate series from all other cash offices, shown in the bottom part of Figure 1.

Assumption 3: The Domestic Circulation of Large Denomination Notes

Our third identifying assumption is that the emissions/receipts patterns at Federal Reserve cash offices of large denomination (50 and 100 dollar) notes in domestic circulation can be measured by the emissions/receipts pattern of smaller denomination notes. We believe that it is reasonable to assume that large denomination notes in domestic circulation will pass through

the Federal Reserve in the same fashion as smaller denomination notes (i.e. ones, fives and tens). Since there are no data on the separate domestic circulation of large denomination notes, this assumption is not testable.[9]

The analysis below that separates domestic and foreign circulation is based on the patterns of (E_t/R_t) for ten-dollar notes at the New York City cash office. This ratio generates a conservative estimate of the share of currency going to foreign circulation because it allows for more secular growth in the domestic circulation of large denomination notes than would be suggested by the nationwide ratio for all cash offices (recall that data for all other cash offices shows no secular growth in the outstanding stock of 10 dollar Federal Reserve notes).[10]

Specifically, for large denomination Federal Reserve notes in domestic circulation, let the ratio of emissions to receipts be denoted as:

$$(2) \qquad \mu_{Lt} = \frac{E_t^{DL}}{R_t^{DL}}$$

where E_t^{DL} are emissions to domestic circulation and R_t^{DL} are receipts from domestic circulation. Our estimator $\hat{\mu}_{Lt}$ is the ratio of emissions (E_t^S) to receipts (R_t^S) of 10 dollar denomination notes at the New York City cash office:

[9] Some readers have objected to this assumption on the grounds that the domestic velocity of circulation (turnover rate) of large denomination notes is likely much smaller than for small denomination notes. This is a misinterpretation. Our method relies on the ratio of emissions to receipts of notes at Federal Reserve cash offices, and not at all on the ratios of emissions and/or receipts of notes to the outstanding numbers of notes or to measures of aggregate economic activity. The appropriateness of our method is independent of differences by denomination in the velocity of circulation of domestically held currency. One other reader has objected by asserting that banks tend to return small denomination notes to the Federal Reserve for processing more frequently that large denomination notes, perhaps because newly issued small denomination notes deteriorate in circulation more rapidly than large denomination notes. This objection also is a misinterpretation. Even if the proportion of notes that banks return to the Federal Reserve differs by denomination (and it likely does), our results—which depend on the ratios of Federal Reserve cash office shipments to receipts by denomination—would be affected only if the tendency for banks to return notes to the Federal Reserve has changed differentially by denomination through time. We doubt that this has occurred.

[10] The sensitivity of our estimates to possible changes in the domestic demand for and use of 100-dollar notes, beyond what is captured in the New York City cash office data for 10 dollar notes, is a topic for further research.

(3) $$\hat{\mu}_{Lt} = \mu_{St} = \frac{E_t^S}{R_t^S},$$

Recall from assumption 2 that $R_t^L = R_t^D$, that is receipts of large denomination notes from (permanent) foreign circulation are zero by assumption. An estimate of emissions of large denomination notes to domestic circulation is:

(4) $$\hat{E}_t^{DL} = \hat{\mu}_{Lt} R_t^L$$

or: (5) $$\frac{\hat{E}_t^{DL}}{E_t^L} = \hat{\mu}_{Lt}\left(\frac{R_t^L}{E_t^L}\right).$$

Since $E_t^L = \hat{E}_t^{DL} + \hat{E}_t^{FL}$,

(6) $$E_t^L = \hat{\mu}_{Lt} R_t^L + \hat{E}_t^{FL}$$

and estimated emissions to permanent foreign circulation are:

(7) $$\hat{E}_t^{FL} = E_t^L - \hat{\mu}_{Lt} R_t^L$$

or: (8) $$\frac{\hat{E}_t^{FL}}{E_t^L} = 1 - \hat{\mu}_{Lt}\left(\frac{R_t^L}{E_t^L}\right).$$

Both E_t^{DL} and E_t^{FL} are emissions, and hence necessarily are > 0. Since R_t^L is receipts, it is also necessarily > 0. The factor μ_{St} is > 0, since the ratio $\frac{E_t^S}{R_t^S}$ is a positive number.

By (5) it is guaranteed that the estimated gross emissions (shipments) of large denomination notes to domestic circulation is positive, $\hat{E}_t^{DL} > 0$. This is, of course, reasonable: *true* gross shipments, E_t^{DL}, cannot be negative. However, since the estimated foreign shipments, $\hat{E}_t^{FL}$, is computed as the difference between two positive numbers, there is no guarantee that it will be nonnegative. We regard negative values of $\hat{E}_t^{FL}$ as a reflecting either data errors or specification errors in our model. Estimated foreign gross shipments will be negative, $\hat{E}_t^{FL} < 0$,

when the ratio $\frac{\hat{E}_t^{DL}}{E_t^L} > 1.0$, that is, when estimated emissions to domestic circulation exceed total emissions of large denomination notes. Because $E_t^{FL} < 0$ is not feasible (actual gross shipments of currency are always nonnegative), we regard values of $\hat{E}_t^{FL} < 0$ as inadmissible and impose the restriction in our method that $\frac{\hat{E}_t^{DL}}{E_t} \leq 1$ or equivalently $\hat{E}_t^{FL} \geq 0$.

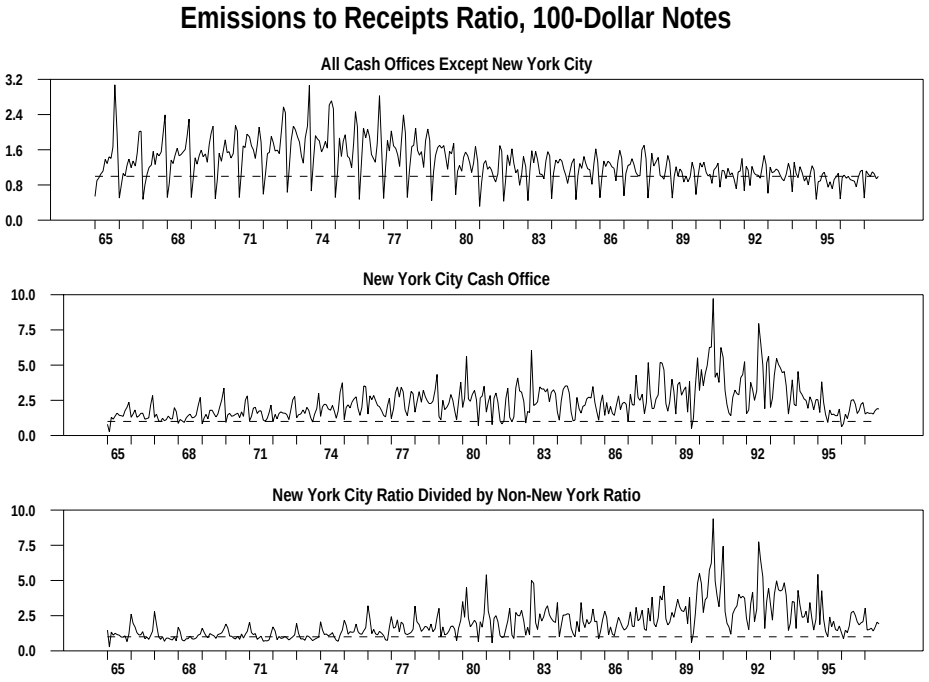
The most likely cause of $\hat{E}_t^{FL} < 0$ is that, contrary to our assumptions, some receipts of large denomination notes at Federal Reserve cash offices came from foreign circulation: Recall that $\hat{E}_t^{FL} = E_t^L - \hat{\mu}_{Lt}\hat{R}_t^{DL}$, that $\hat{R}_t^{DL} = R_t^L - \hat{R}_t^{FL}$, and that $\hat{R}_t^{FL} = 0$ for all t by assumption. Even if $\hat{E}_t^{FL} > \hat{R}_t^{FL}$ for all *t*, such that the stock of large denomination U.S. currency held abroad never decreases (which is consistent with both Porter and Judson's (1996) estimates and anecdotal evidence), some large denomination notes received at the cash offices might have come from abroad, that is, $\hat{R}_t^{FL} > 0$. As with most foreign currency transactions, such foreign receipts, if any, are not observable and hence inevitably remain as estimation error. Finally, note that $\hat{E}_t^{FL} < 0$ should occur less frequently for notes that are more heavily in demand abroad—that is, for notes where the assumption $\hat{R}_t^{FL} = 0$ is true for more values of *t* (or at least $\hat{R}_t^{FL}$ is very small)— and should occur more frequently for notes that are less heavily (or decreasingly) in demand abroad; in what follows, this is exactly the relative pattern we find for 100 and 50 dollar notes, respectively.

2. *Estimated Exports of Federal Reserve Notes*

A. 100 Dollar Notes

The monthly ratios of emissions to receipts at the New York City cash office and all other cash offices for 100 dollar Federal Reserve notes are plotted in Figure 2.

Figure 2

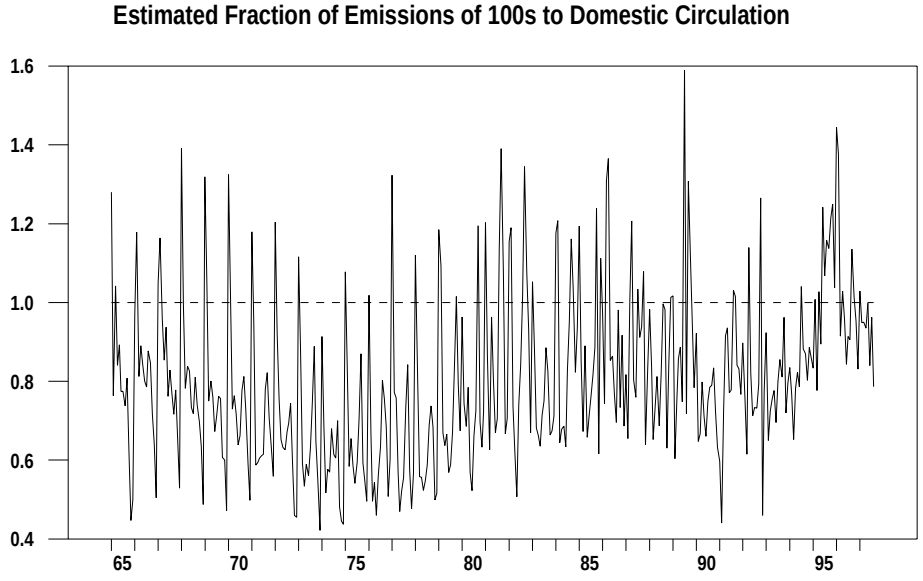


The time series for the 100 dollar notes are much different than those for the 10 dollar Federal Reserve notes (Figure 1). At both the New York City office and all other cash offices, the emissions to receipts ratio is considerably in excess of 1.0 throughout the sample period (averaging 2.37 for the New York office and 1.31 for all other offices). Such high ratios of emissions to receipts are not characteristic of the smaller (1, 5, 10 dollar) denomination notes, and the contrast between the ratios for small and large denomination notes strengthens the case for our assumption 2

Although the trends in the New York City and non-New York series are not particularly strong, there appears to be a slight positive trend in the emission/receipts ratio in the series at the New York City cash office at least prior to the 1990s, and a slight negative trend in the series at all other cash offices. Further, there is considerable volatility in the series for the New York City office in 1990 and again in 1992-3 that is not apparent in the other series. Finally, the mean of the ratio of emissions to receipts at the non-New York City cash offices is of the same order of

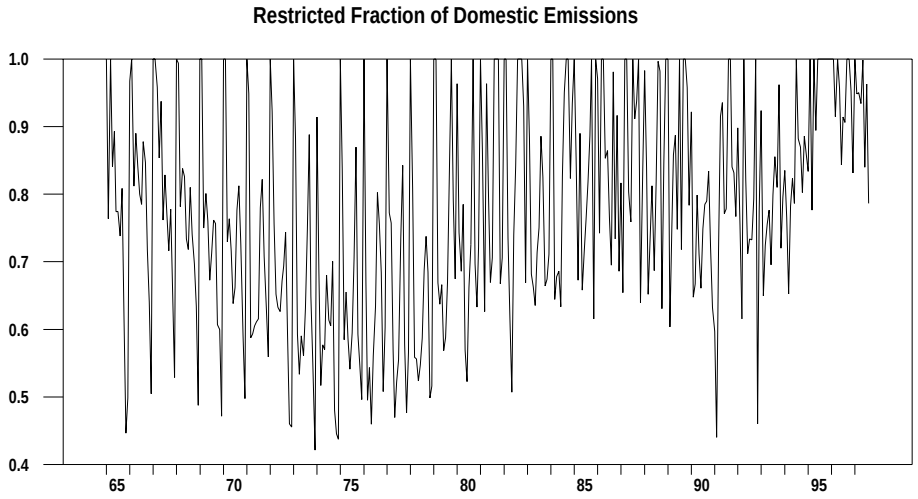
magnitude as that at the New York City office before the 1980s. These observations, along with the relatively high emissions to receipts ratio for 100 dollar notes compared with 10 dollar notes at the offices outside of New York, suggests that it is not appropriate to assume that all emissions of 100 dollar notes to foreign circulation come from the New York City office, as in Feige (1994, 1996).

Figure 3



Inadmissible occurrences of $\frac{\hat{E}_t^{DL}}{E_t^L} > 1.0$ (that is, $\hat{E}_t^{FL} < 0$) based on equation (5) appear fairly often for January observations, as indicated in Figure 3. Note that for the entire sample the frequency of occurrence is inversely related to anecdotal evidence regarding recent ebbs and flows in the export of 100 dollar notes: such exports slowed during the mid-1980s and accelerated sharply during the early 1990s. As discussed above, we impose a maximum value of 1.0 on $\frac{\hat{E}_t^{DL}}{E_t^L}$. The restricted estimates of $\frac{\hat{E}_t^{DL}}{E_t^L}$ are shown in Figure 4.

Figure 4



We have applied equation (7) to the emissions and receipts for 100 dollar Federal Reserve notes over the period from January 1965 – July 1997 using the restricted domestic emissions ratio plotted in Figure 4. Our estimates of domestic emissions and permanent foreign emissions (in dollars, not seasonally adjusted) for this denomination are plotted in Figure 5. We estimate net change in the domestic stock of 100 dollar Federal Reserve notes by subtracting total receipts of 100s at all cash offices (R_t) from the estimated domestic emissions ($\hat{E}_t^{DL}$). The estimated net change in the foreign-held stock of 100 dollar Federal Reserve notes is just the estimate of foreign emissions ($\hat{E}_t^{FL}$), since by assumption receipts at the cash offices from (permanent) foreign circulation are zero. The estimated net changes in the domestic stock of 100s, not seasonally adjusted, are shown in Figure 6.

Figure 5

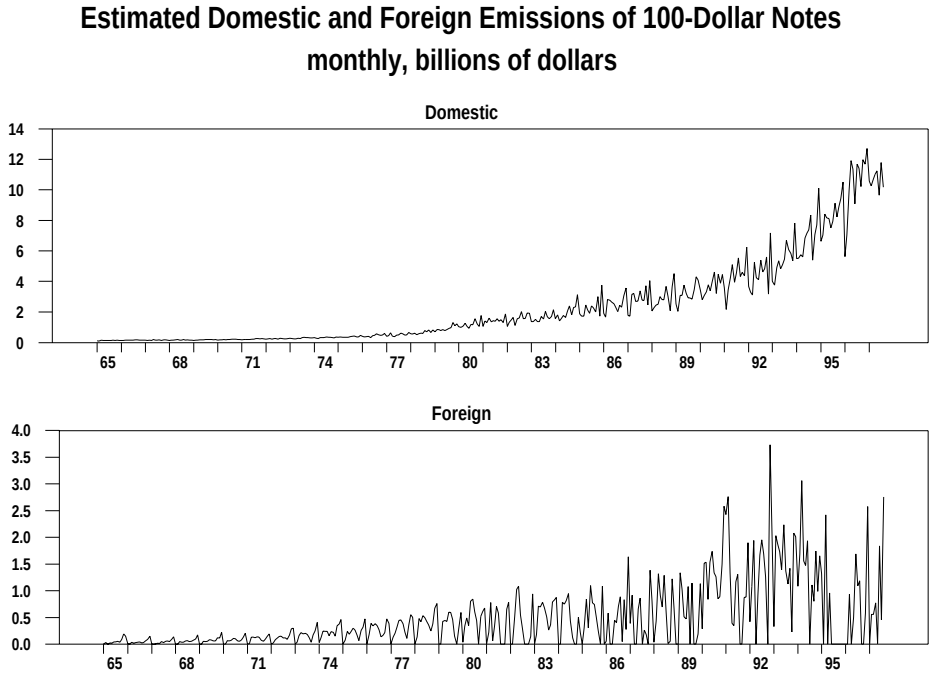
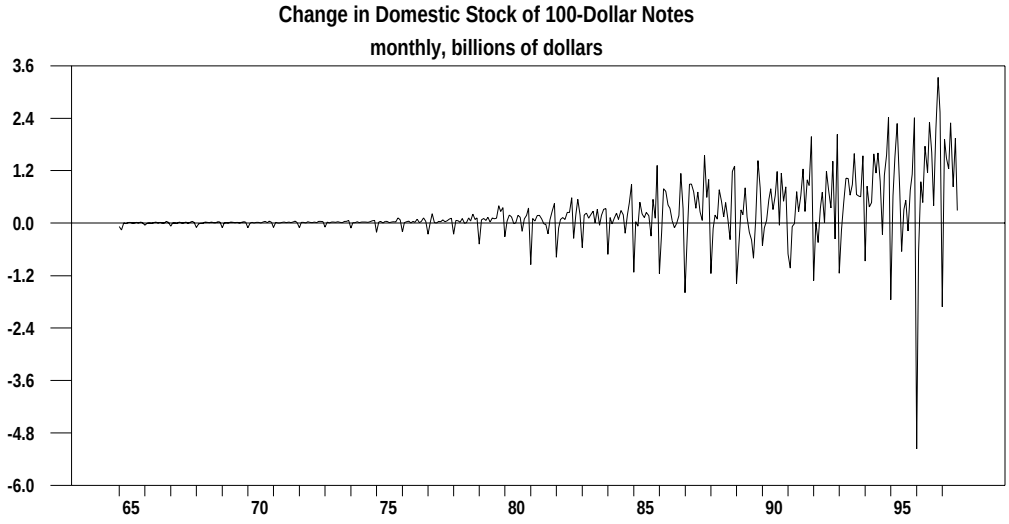


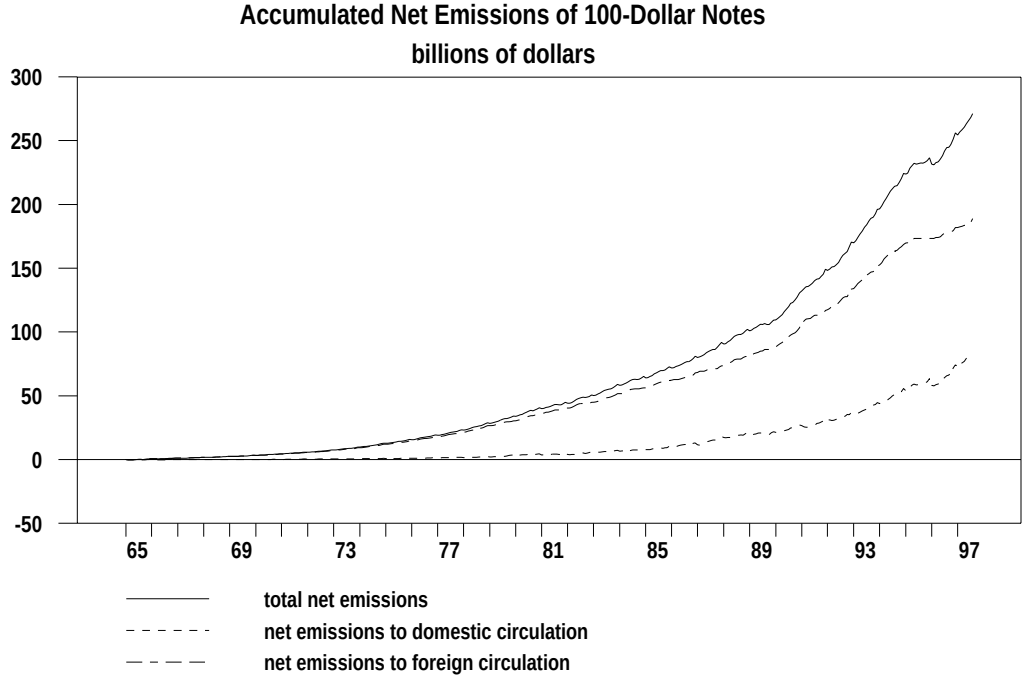
Figure 6



The accumulated net changes of 100 dollar Federal Reserve notes, not seasonally adjusted, since December 1964, along with the accumulated estimated net changes in the

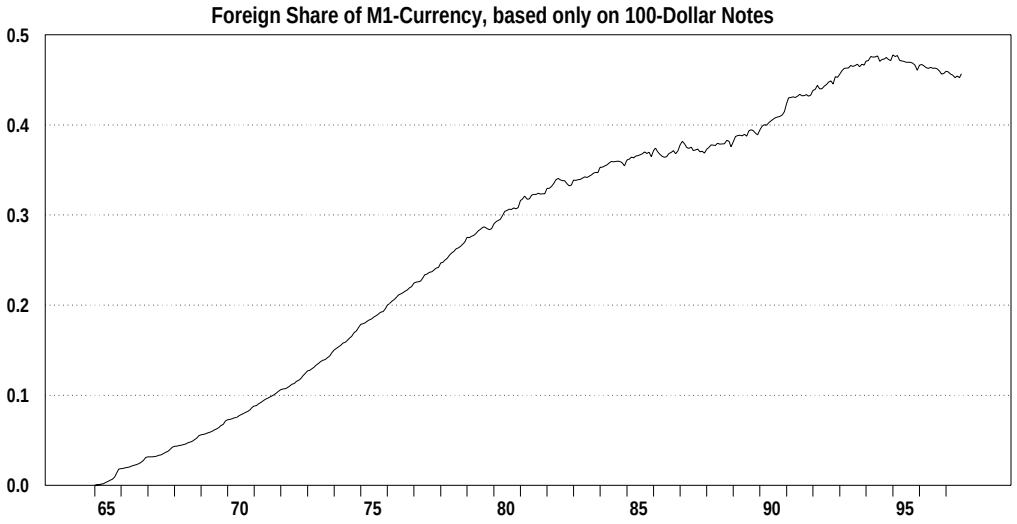
domestically held stock and the foreign- held stock, are shown in Figure 7. This figure indicates that of the 236 billion dollars of 100 dollar Federal Reserve notes that were emitted to circulation from December 1964 through December 1995, only an estimated 63 billion remained in domestic circulation, while an estimated 173 billion were exported abroad. The estimated accumulated exports of 100 dollar Federal Reserve notes as a fraction of the currency held by the nonbank public is shown in Figure 8. In 1995, foreign holdings of 100 dollar notes, by themselves, equaled about 46 percent of the aggregate currency held by the nonbank public (the currency component of M1). This estimate is constructed by benchmarking total 100 dollar Federal Reserve notes outside the United States at the end of 1964 to zero.[11]

Figure 7



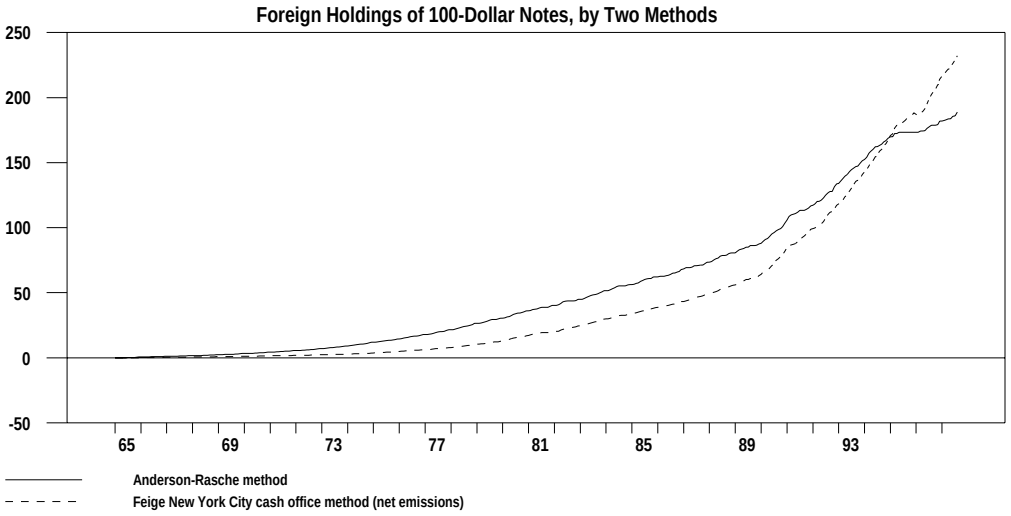
[11] Our estimate of 100 dollar notes is robust to the benchmark assumption. Since the total value of 100 dollar Federal Reserve notes in circulation in December 1964 was only $7.6 billion, even if fifty percent of the stock of such notes at that time were held abroad, which seems unlikely, the additional accumulation of estimated exports of 100s would only increase the fraction of total currency held abroad to 47 percent.

Figure 8



As indicated above, Feige (1994,1996) presents an estimated flow of currency held abroad constructed by accumulating net emissions ($E_t^{L,NYC} - R_t^{L,NYC}$) of 100 dollar Federal Reserve notes at the New York City cash office. The foreign-held stocks implied by applying his and our methods to data beginning December 1964 are compared in Figure 9. Although the trends are similar, the Feige method produces a slower accumulation of foreign holdings until the late 1980s and thereafter produces a much faster accumulation. It is noteworthy that the Feige method suggests very rapid growth of foreign holdings in 1995-6, while our method suggests that foreign holdings leveled off during this period.

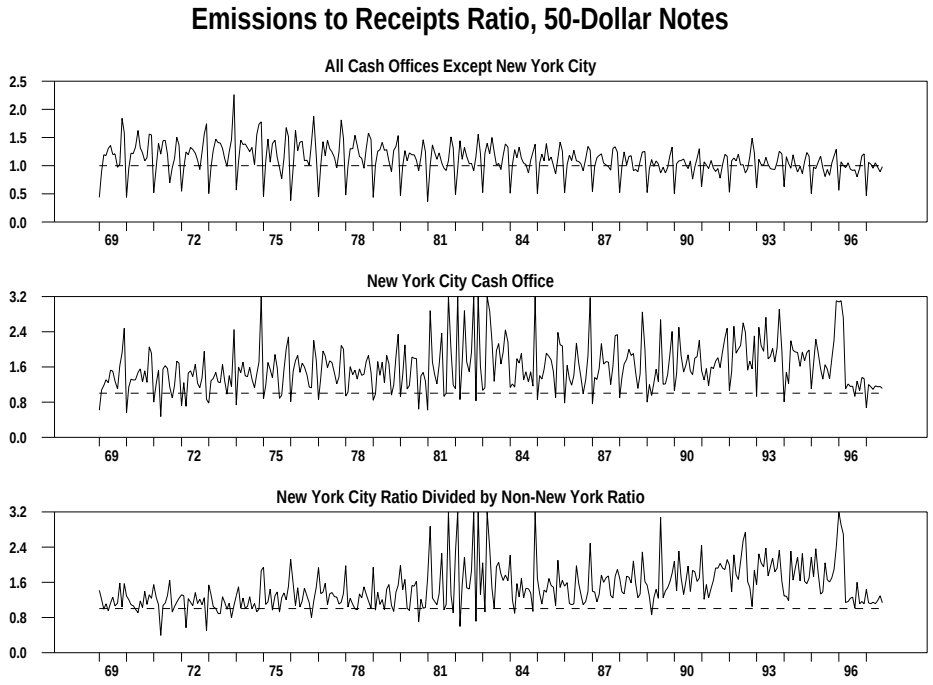
Figure 9


Foreign Holdings of 100-Dollar Notes, by Two Methods
250
200
150
100
50
0
-50
65
69
73
77
81
85
89
93
Anderson-Rasche method
Feige New York City cash office method (net emissions)

B. 50 Dollar Federal Reserve Notes

The ratios of emissions to receipts for 50 dollar Federal Reserve notes at the New York City cash office and at all other cash offices are plotted in Figure 10 for the period January 1969 – July 1997.

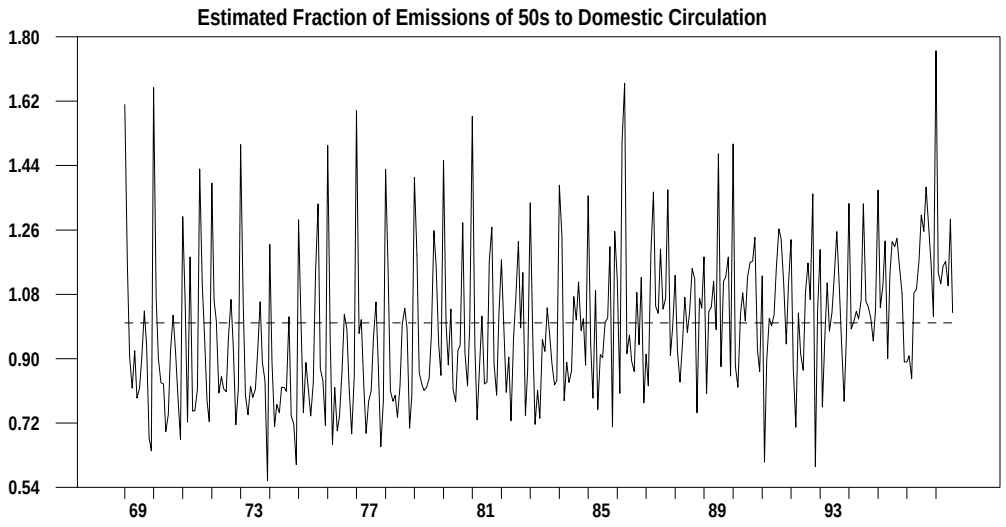
Figure 10



The first notable characteristic is that the emissions to receipts ratio is considerably in excess of 1.0 throughout the sample period at both the New York City office and all other cash offices, averaging 2.31 for the New York office and 1.11 for all other offices. The average for the New York office is almost exactly the average ratio of 2.37 for 100 dollar Federal Reserve notes at that office over the January 1965 – July 1997 period. The emissions/receipts ratio for the New York City cash office does not exhibit any trend, while the ratio at all other cash offices has a negative trend and is close to 1.0 in recent years. There is volatility in the series for the New York City office in 1981–3 that is not reflected in the other series. Finally, inadmissible

values of $\frac{\hat{E}_t^{DL}}{E_t^L} > 1.0$ (that is, $\hat{E}_t^{FL} < 0$) are observed more frequently for 50s than is the case for 100s, as indicated in Figure 11. Before 1983 these observations occur mostly in January; since then the fraction of such observations during each year has been increasing. As we noted above, this increasing frequency reinforces other evidence which suggests that in recent years relatively few 50 dollar Federal Reserve notes have been exported.

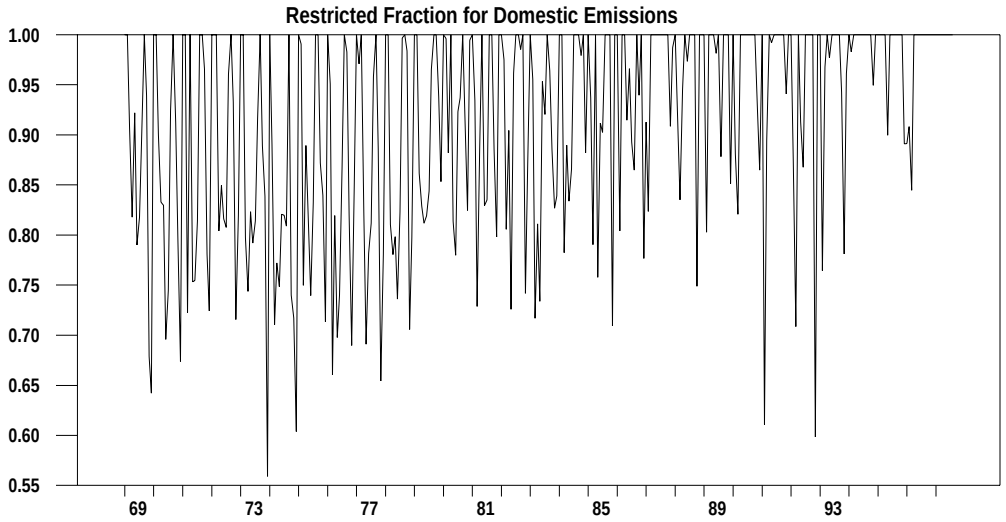
Figure 11



As discussed above, we impose a maximum value of 1.0 on $\frac{\hat{E}_t^{DL}}{E_t^L}$. We have applied equation (7) to the emissions and receipts for 50 dollar Federal Reserve notes over the period from January 1969 - August 1997 using the restricted domestic emissions ratio plotted in Figure 12.[12]

[12] Although cash office currency processing data exist on microflim for earlier years, various anomalies in the data cause us to doubt its accuracy.

Figure 12



We estimate the net change in the domestic stock of 50 dollar Federal Reserve notes by the same method we used for 100 dollar notes. The accumulated net change in aggregate, domestically held, and foreign-held stocks of 50 dollar Federal Reserve notes since December 1968 are shown in Figure 13. Of the 44.5 billion dollars of 50 dollar Federal Reserve notes that were emitted to circulation from December 1968 through December 1995, only an estimated 17.4 billion remained in domestic circulation, while an estimated 27.1 billion were exported abroad. The fraction of currency held by the nonbank public accounted for by foreign holdings of 50 dollar Federal Reserve notes is shown in Figure 14; in 1995, this is approximately 7.2 percent. This estimate is constructed by benchmarking total 50 dollar notes outside the United States at the end of 1968 to zero.[13]

[13] As with the 100 dollar Federal Reserve notes, this estimate is robust to the benchmark assumption. Since the total value of 50 Federal Reserve notes held by the public at that time was only 4.19 billion dollars, even if fifty percent of the stock of such notes at that time were held abroad, which seems unlikely, the additional accumulation of estimated exports of 50s would increase the fraction of total currency held abroad by less than one percent.

Figure 13

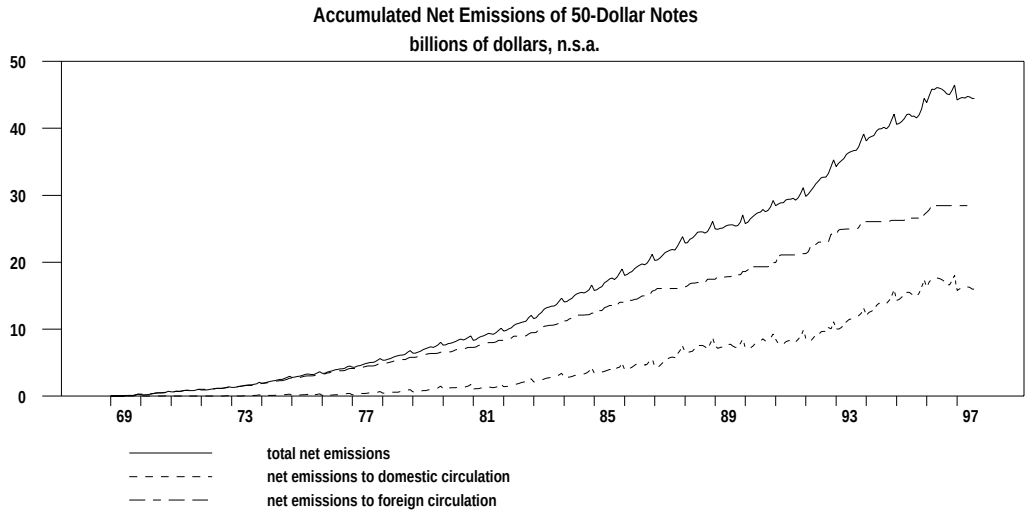
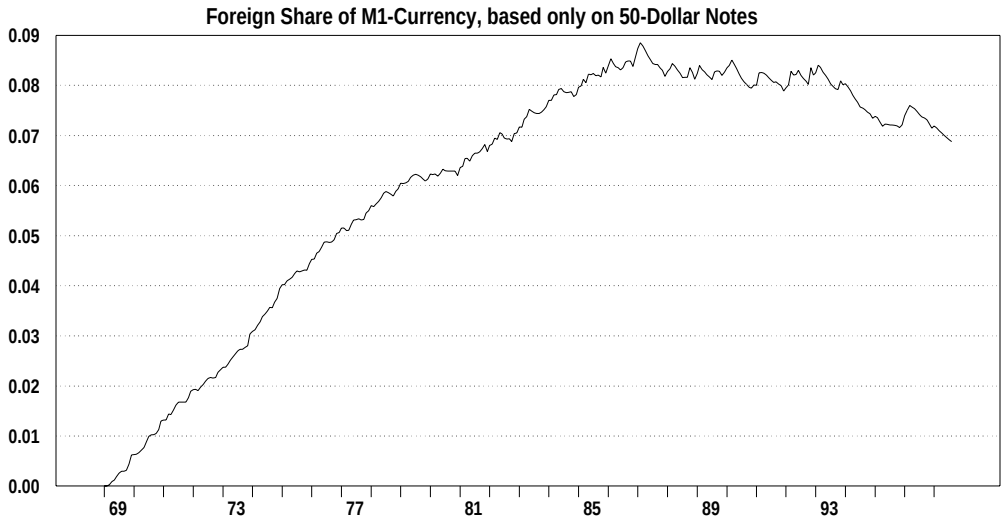


Figure 14



C. Comparison with the Porter/Judson Estimates.

The most extensive published study of foreign holdings of U.S. currency is due to Richard Porter and Ruth Judson (1996) of the Federal Reserve Board. A comparison of our

estimates to theirs provides an essential measure of the accuracy, or reasonableness, of our estimates.[14]

Any comparison between our estimates and Porter-Judson is necessarily somewhat limited because Porter and Judson publish only total annual net outflows for the shorter time span 1977–95. To compare our monthly estimates to their annual flows, we have constructed annual exports, measured from December to December, for both 50 and 100 dollar notes. These flows, labeled "ar50" and "ar100", are shown alongside the median flow estimates published by Porter and Judson (1996, Table 6), labeled "pj", in Table 1.[15] Through 1986, our estimates of annual currency exports are always larger than the median flow estimates of Porter and Judson; in the 1990's their estimates are larger than ours. Nevertheless, the two series tend to move together quite closely. Regressing our annual net flows on a constant and the Porter-Judson median flow estimates for 1977-95 gives the result:

$$\begin{array}{l} ar = \ 3.64 + .66\ pj \\ \qquad\quad (.79)\ \ (.07) \end{array}$$

The adjusted R^2 for this regression is 0.83 and the estimated standard error of the residuals is 2.21 billion dollars. The Anderson-Rasche, Porter-Judson, and predicted flows from this regression are shown in Figure 15. Although differences in the average estimated flows are apparent, year-to-year accelerations and decelerations are quite close. The largest exception is 1994–5, where our data show a much more rapid decrease in the rate of currency exports than is shown by the Porter-Judson data.

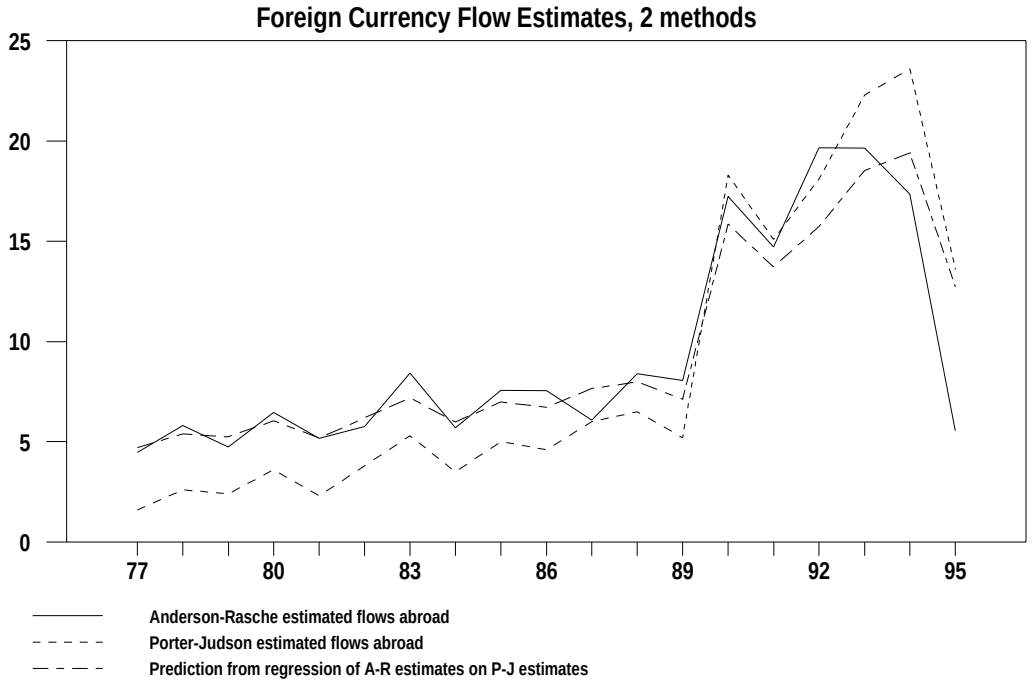
[14] Section 1 of the appendix contains a more detailed examination of the Porter-Judson method.
[15] For each year the median flow estimate is the median value of the eleven estimates constructed by Porter and Judson.

Table 1

Alternative Estimates of the Annual Increase
in Permanent Foreign Holdings of U.S. Currency
(Billions of Dollars)

Year	Porter-Judson Table 6 (pj)	100 Dollar Notes (ar100)	50 Dollar Notes (ar50)	Total Exports (ar)
1977	1.6	3.7	.8	4.5
1978	2.6	4.9	.9	5.8
1979	2.4	4.0	.7	4.7
1980	3.6	5.7	.7	6.4
1981	2.3	4.1	1.0	5.1
1982	3.8	4.6	1.2	5.8
1983	5.3	6.7	1.7	8.4
1984	3.5	4.6	1.1	5.7
1985	5.0	5.9	1.6	7.5
1986	4.6	5.9	1.7	7.6
1987	6.0	5.5	.6	6.1
1988	6.5	7.3	1.1	8.4
1989	5.7	6.9	1.2	8.1
1990	18.3	15.9	1.4	17.3
1991	15.1	13.4	1.3	14.7
1992	18.1	16.7	2.9	19.6
1993	22.3	17.8	1.8	19.6
1994	23.6	17.1	.2	17.3
1995	13.7	4.7	.8	5.5

Figure 15



The Anderson-Rasche and Porter-Judson methods also suggest similar average shares of U.S. currency held abroad in December 1995, the end of Porter and Judson's published data.

Total currency held abroad: In December 1995, Porter and Judson estimate that foreign holdings of U.S. currency were about 55 percent of the total currency held by the nonbank public; our estimates based on 50 and 100 dollar notes suggest 53.2 percent.[16] Of their 55 percent, Porter and Judson estimate that 44 percentage points was accounted for by 100 dollar Federal Reserve notes; our estimates suggest 46 percent.[17]

[16] The Porter-Judson estimate is obtained by benchmarking foreign holdings of U.S. currency in 1977 to slightly more than 50 percent. Our estimate is obtained by benchmarking foreign holdings to zero at the end of 1964. For details, see the appendix to this paper.

[17] Porter and Judson do not attribute to any specific denomination the 11 percentage points not accounted for by 100 dollar notes. Our examination of 50 dollar notes suggests that about an additional 7.2 percentage points may be accounted for by foreign holdings of 50 dollar notes..

One-hundred dollar notes: Porter and Judson estimate that 74 percent of outstanding 100 dollar notes were held abroad at the end of 1995; accumulating our estimated emissions of 100s to foreign circulation since December 1964 suggests 72 percent.

Overall, the estimates for December 1995 are remarkably close, given the two different methods taken to construct the estimates.

D. Growth Rates of Total, Domestic and Foreign Currency

1. Monthly

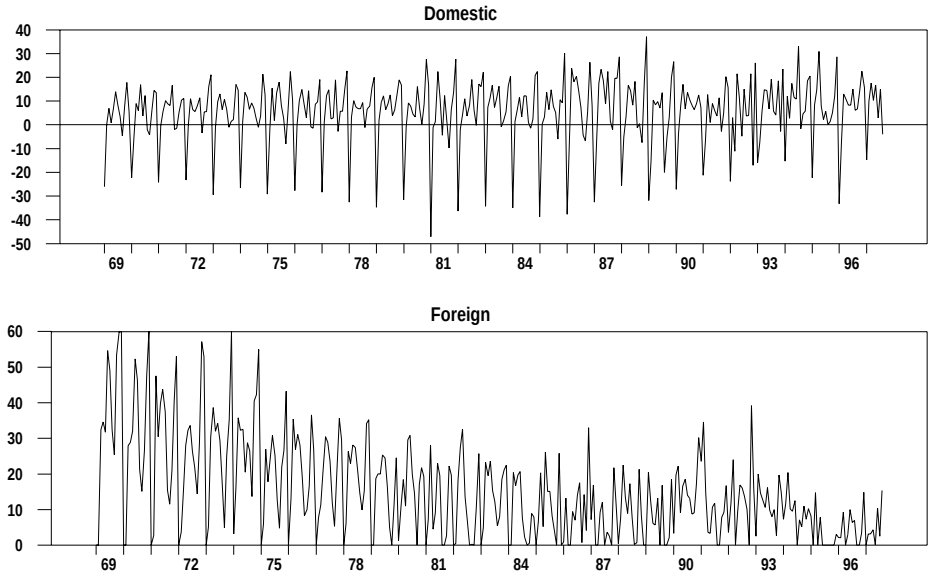
Growth rates of the estimated domestic and foreign currency components (of total currency in M1), not seasonally adjusted, are shown in Figure 16.[18] The estimated foreign component displays significant seasonality, especially before 1980. This seasonality perhaps reflects a largely transaction-based demand for, and use of, U.S. currency abroad during the early part of our sample; that is, the quantity of U.S. currency abroad fluctuated with seasonal fluctuations in business activity as it moved in and out of foreign countries with tourists and business travelers. It seems likely that only relatively small amounts were retained permanently overseas.[19]

[18] Simple monthly percentage change at annual rate.

[19] Recall that our estimation method assumes no returns of 50- and 100-dollar notes from foreign circulation, that is, we seek to measure the permanent U.S. currency stock held abroad. The possible flow of smaller denomination currency in and out of the U.S. during the early years of our sample does not contradict our assumption of zero returns for larger bills; see the discussion of assumption 1, above.

Figure 16

Growth Rates of Domestic and Foreign Currency in M1, monthly, 1969-97
percent, n.s.a.a.r.



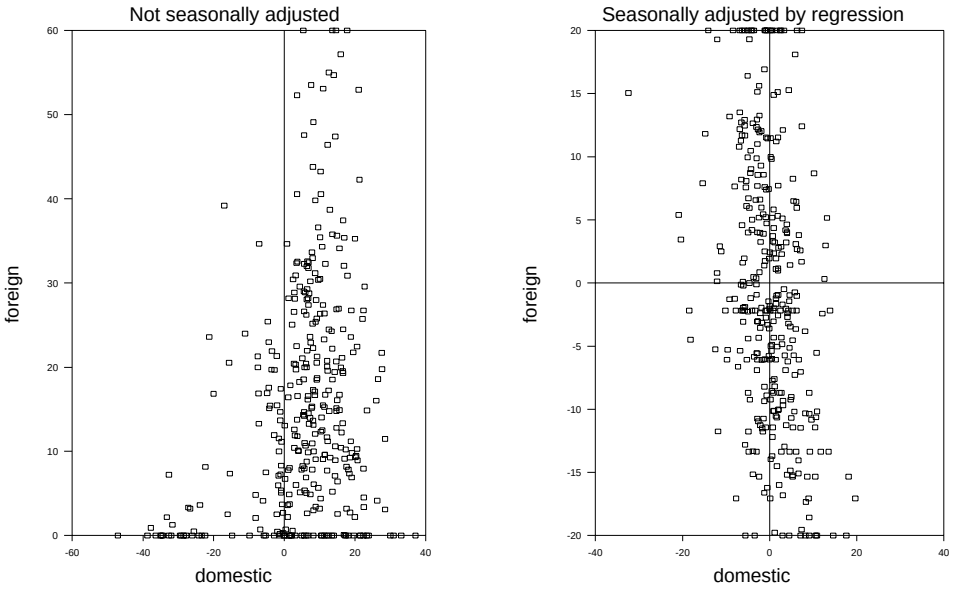
During the latter parts of our sample, and especially after 1980, the increased demand for U.S. currency abroad as a store of value—caused by political unrest and inflation instability—might tend to mask seasonal flows, particularly when holdings abroad are growing rapidly.[20]

The seasonal pattern in our foreign currency flows for early years induces some weak positive correlation between the growth of domestic and foreign currency, shown in the left panel of Figure 17. The correlation disappears after removing from both series a fixed monthly seasonal effect, shown in the right panel of Figure 17.[21]

[20] We are indebted to Richard Porter for this interpretation of the data.
[21] The data are filtered by regressing the log first differences on monthly dummy variables. Because our estimated foreign currency component begins at zero in December 1964, X11 seasonal adjustment methods (which permit time-varying seasonality) may not be applied directly to foreign currency. Domestic currency adjusted via X11-Arima is shown in Figure 19.

Figure 17

Domestic and Foreign Currency Growth, monthly, 1969-97

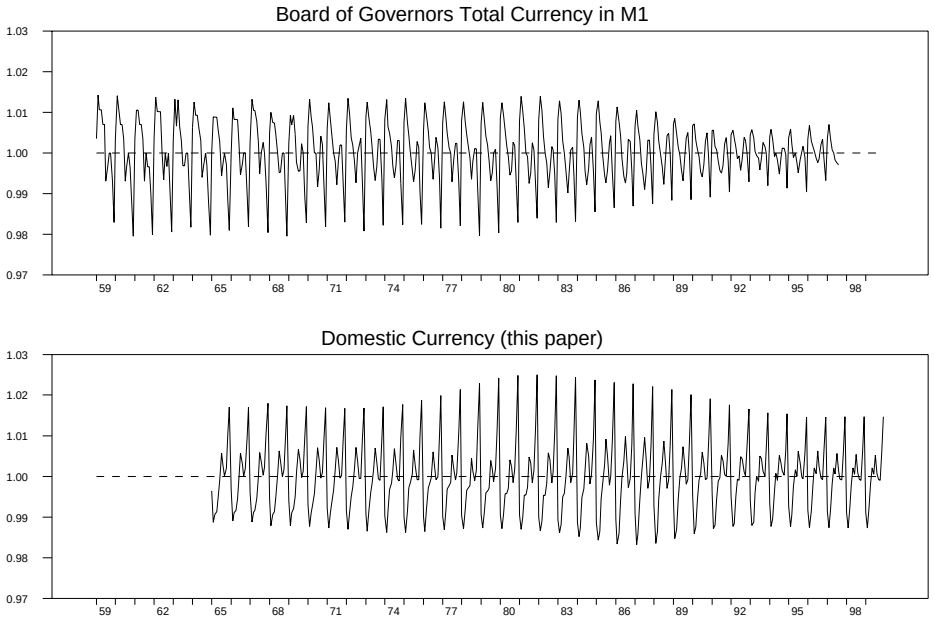


The well-known strong seasonal fluctuations of currency suggest an additional test on the reasonableness of of estimates. Time-varying seasonal factors estimated via X11 are shown in Figure 18. The upper panel shows the seasonal adjustment factor for the total currency component of M1, as published by the Board of Governors; the lower panel shows a factor for domestic currency estimated via X11.[22] The Board's seasonal amplitude decreases rapidly during the latter part of sample, presumably reflecting the increasing share of U.S. currency held abroad. In contrast, seasonal fluctuations in domestic currency display a more constant amplitude: In the 1990s, when large currency outflows are alleged to have caused the estimated seasonal factors for total currency to collapse, the estimated factors for domestic currency are essentially the same as those in the late 1960 and early 1970s. Both features suggest (to us, at least) that our domestic currency series displays reasonable behavior.

[22] The Board of Governors seasonal factor also is estimated by X11.

Figure 18

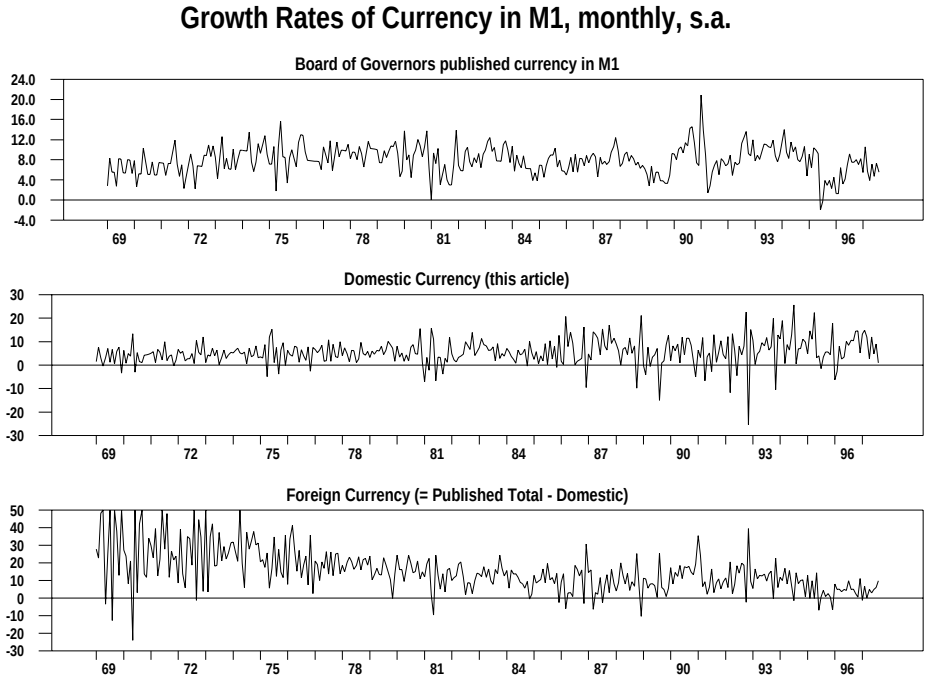
Seasonal Factors for Currency



Monthly growth rates of seasonally adjusted total, domestic and foreign currency are shown in Figure 19.[23] Separating the domestic and foreign components of U.S. currency growth has a significant impact. In recent years, foreign currency shipments have accounted for a large part of monthly fluctuations in currency growth. The recent slowdown of foreign shipments and acceleration of domestic currency growth also are apparent.

[23] The foreign currency data shown in this figure are not directly seasonally adjusted but rather are obtained as the difference between total and domestic currency, each seasonally adjusted.

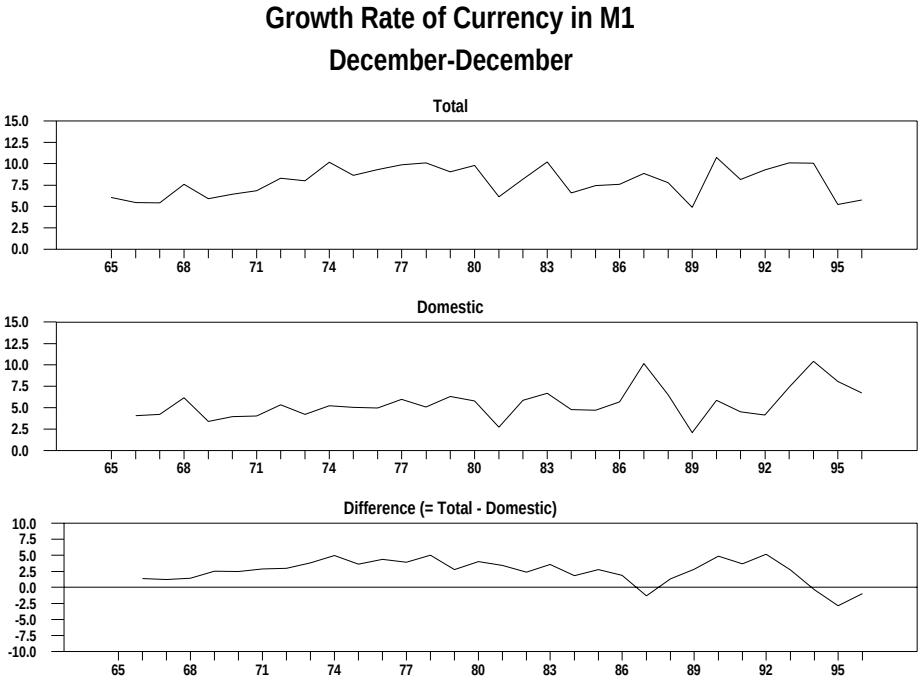
Figure 19



2. Annual

Annual growth rates (December to December) of domestic and foreign currency are shown in Figure 20 for 1965-97. During most of this period, estimated permanent foreign holdings of U.S. currency are estimated to have been increasing. Recently, however, domestic currency growth has accelerated as total growth has slowed, suggesting an acceleration of domestic monetary base growth. This is pursued further in the following section.

Figure 20



E. Estimates of the Domestic St. Louis Adjusted Monetary Base

The St. Louis adjusted monetary base is constructed as a chain index; see Anderson and Rasche (1996 a, b). During each of several time segments, the adjusted monetary base is constructed by adding the monetary source base to a reserve adjustment magnitude, or RAM; different interval-specific RAMs are used in each segment. At the boundary dates of these segments, the separate pieces are chained together to form a time-series chain index.

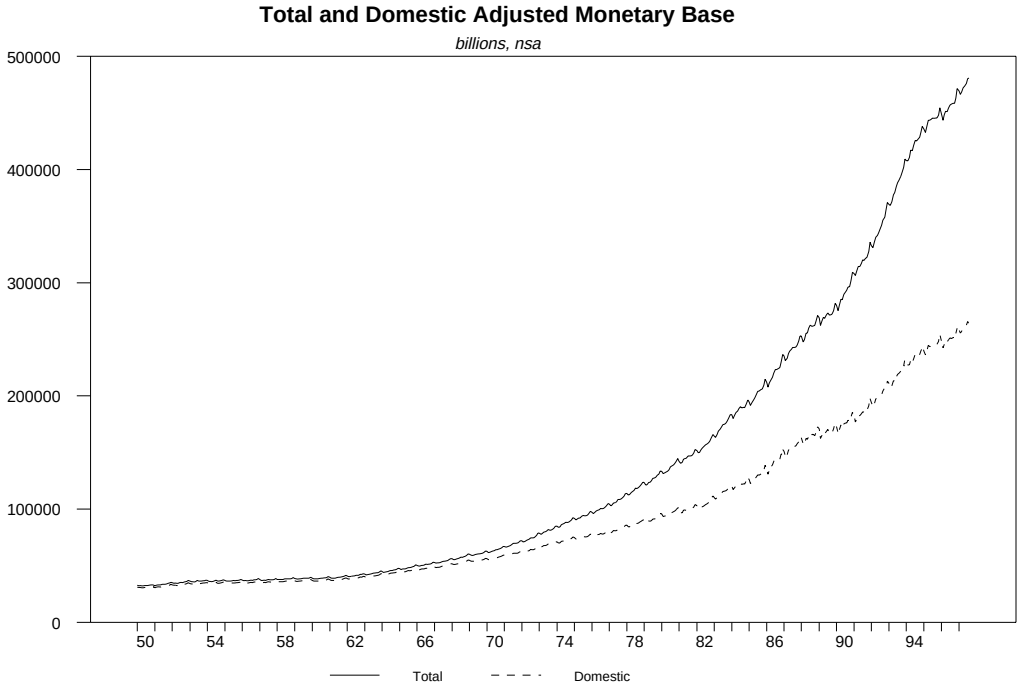
The *total* monetary source base is defined as the sum of currency in circulation outside the Federal Reserve and the Treasury, plus the deposits of domestic depository institutions at Federal Reserve Banks.[24] The *domestic* monetary source base is measured as the total monetary source base minus the estimated amount of currency held abroad. We have calculated this measure of the domestic monetary source base monthly from January 1950 through August 1997,

[24] Federal Reserve Bank deposits held by foreign central banks and the U.S. Treasury are excluded.

and obtain the domestic adjusted monetary base by adding the RAM adjustment used in building the total St Louis adjusted monetary base.[25]

The total and domestic St Louis adjusted monetary base measures are shown in Figure 21. The difference between them increases steadily after 1965, for two reasons: an increasing share of currency is being held abroad, and currency is becoming a larger share of the source base.

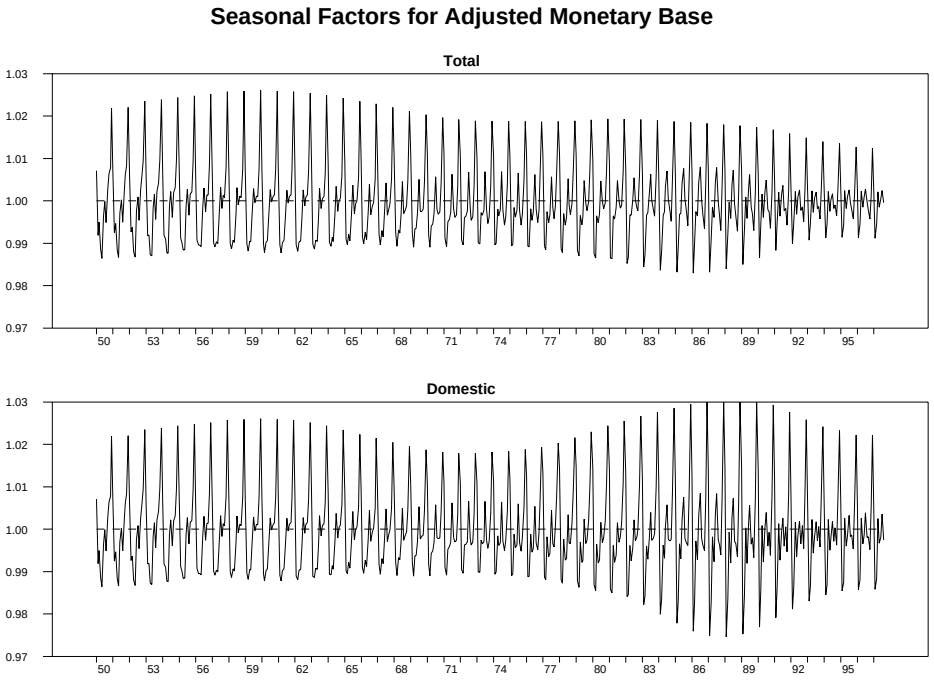
Figure 21



[25] RAM measures, for every date in the time series, the effect of changes in statutory reserve requirement ratios on depository institutions' demand for the monetary source base relative to a specified base period. A single RAM adjustment is not appropriate for our entire sample period. When there is a major change in the structure of reserve requirements – such as a change in the types of institutions or categories of deposits subject to requirements – then the RAM adjustment for the preceding period must stop and a new RAM adjustment begin. Over our sample period of 1950-1997, four RAM adjustments are used spanning the periods 1936-1972, 1972-1975, 1975-1980 and 1980-1997. The beginning and end of each adjustment is marked by legislation that significantly changed the structure of statutory reserve requirements. Finally, both the adjusted total monetary base and adjusted domestic monetary base, each equal to the sum of appropriate monetary source base measure plus RAM, are created as a chain index, spliced in 1972, 1975, and 1980 following the methods suggested by Tatom (1980). The final total and domestic adjusted monetary base series are seasonally adjusted by X11, with standard default settings for all parameters.

Estimated seasonal adjustment factors for the adjusted monetary base series are shown in Figure 22. In sharp contrast to those for the total adjusted monetary base, factors for the domestic base resemble during the 1990s those estimated for 1950–80.

Figure 22



Monthly growth rates of the total and domestic adjusted base are shown in Figure 23, and year-over-year (December to December) growth rates are shown in Figure 24. Although monthly rates are too noisy to permit easy interpretation, the annual rates show that currency exports accounted for three to four percentage points to base growth during much of the sample period since 1973.

Figure 23

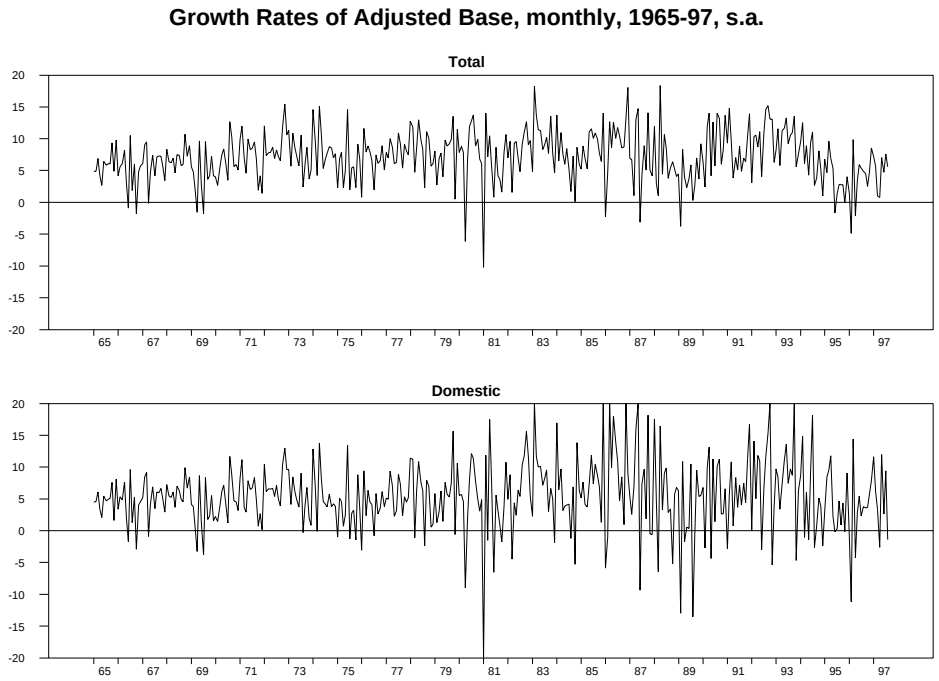
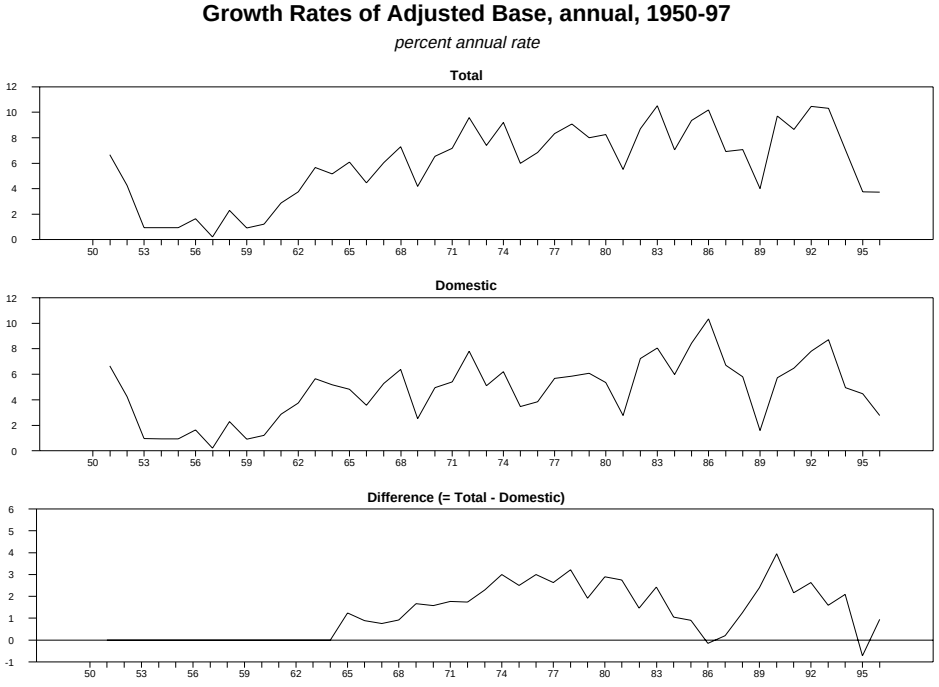


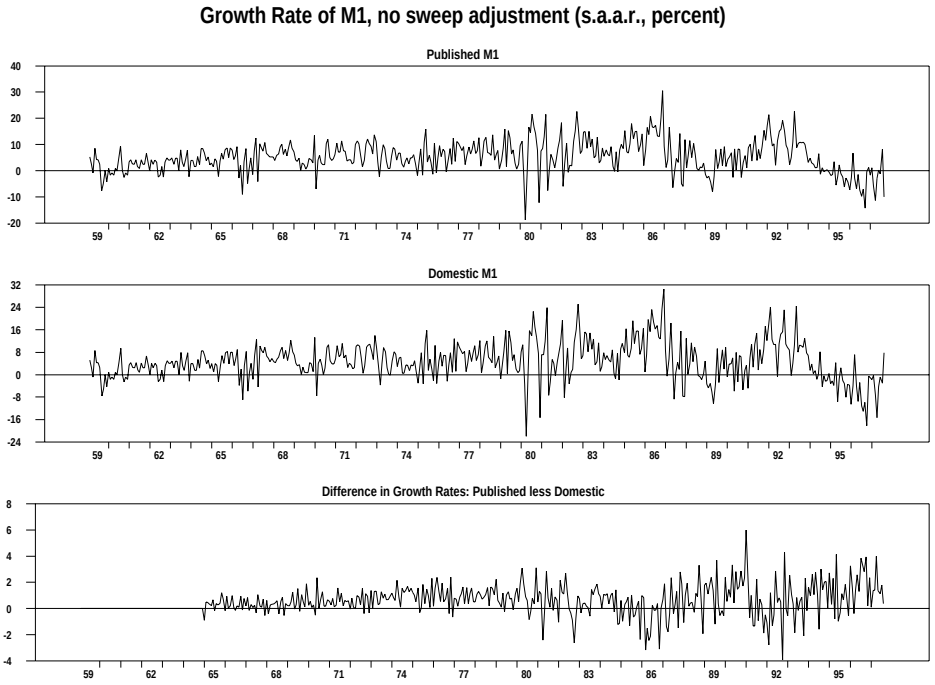
Figure 24



F. Total and Domestic Monetary Aggregates

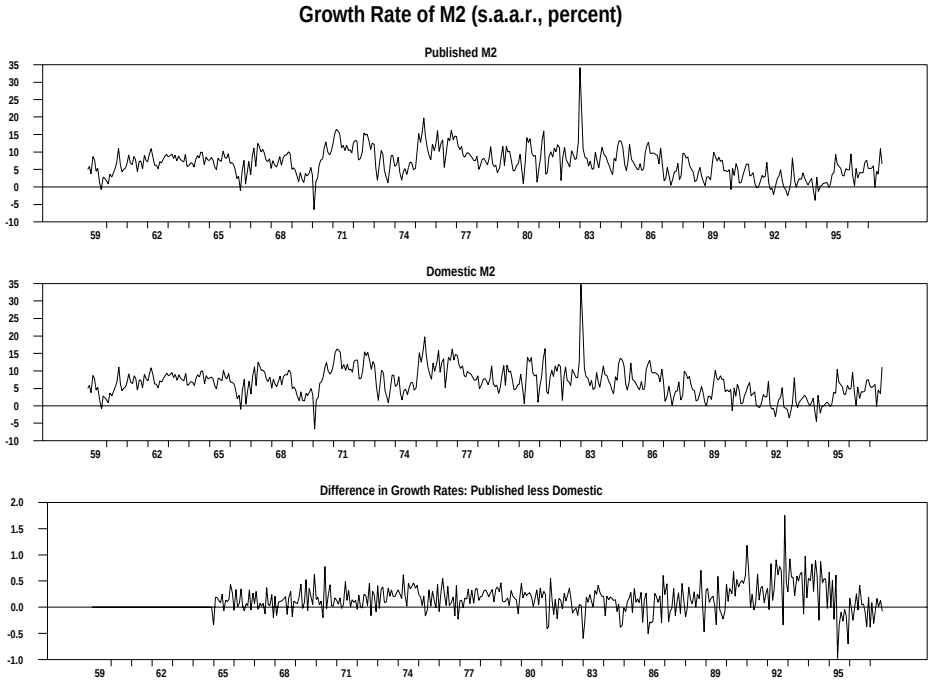
Outflows of U.S. currency to foreign circulation have been large enough since 1980 to significantly distort inferences regarding the stance of monetary policy based on broader monetary aggregates such as M1 and M2. Growth rates of the total (published) and domestic aggregates are shown in Figures 25 and 26.[26] For both M1 and M2, growth rates of the published data are significantly larger than those of their domestic counterparts during the late 1980s and early 1990s. More recently, the situation is reversed: since 1995, domestic money growth has been relatively stronger than is suggested by growth of the published aggregates.

Figure 25



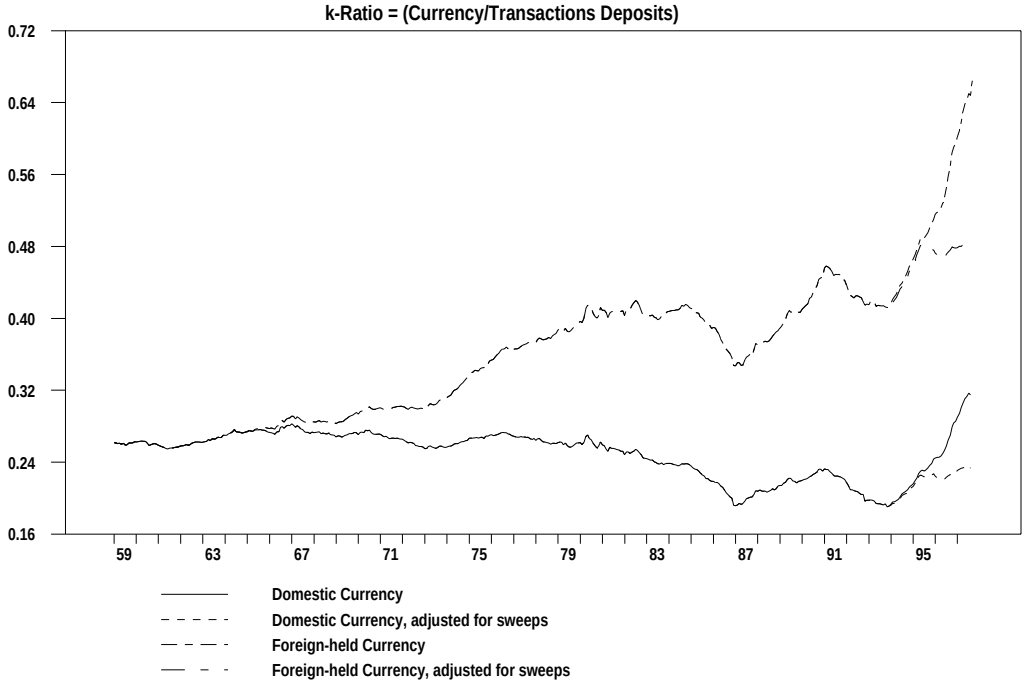
[26] Except in Figure 27 below, neither M1 nor the monetary base has been adjusted in any way for the effects of sweep programs which reclassify transactions deposits as savings deposits to reduce a bank's required reserves. For a discussion of sweeps and data, see http://www.stls.frb.org/research/swdata.html.

Figure 26



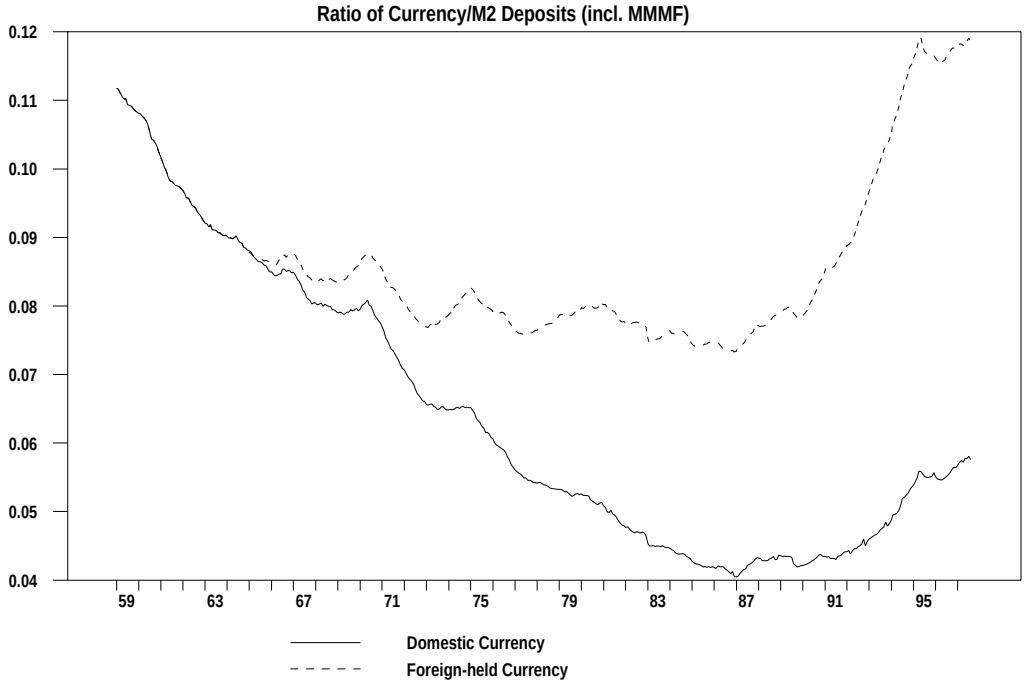
Exports of currency also have distorted components of money multipliers, sometimes suggesting less stability in aggregate portfolio behavior than the domestic aggregates. The "k" ratio, equal to the currency component of M1 divided by net transactions deposits, is shown in Figure 27. The time series data for *k* based on domestic currency holdings displays a remarkable stability during 1959–97, with the ratio hovering around 0.24. Reports of the imminent death of currency as a domestic transactions medium perhaps are overstated.

Figure 27



An alternative *k* ratio that uses all the liquid deposits in M2 as its denominator is shown in Figure 28. Through 1986, the domestic nonbank public's holdings of currency relative to liquid deposits decreases steadily. Since then, however, currency has experienced a rebound, perhaps due in part to low, stable inflation rates (and the lower opportunity cost of currency).

Figure 28



3. Conclusions

U.S. currency held abroad is an important asset for residents of many countries, and provides a substantial non-interest bearing loan to the U.S. Treasury. Recent revisions to both the Flow of Funds Accounts and the National Income and Product Accounts recognize the importance of currency held abroad. In addition, exports of U.S. currency have significantly distorted in recent years the growth rates of narrow and broad monetary aggregates, including the monetary base, M1 and M2.

The method in this article, unlike previous methods, provides an estimated monthly time series of foreign holdings of U.S. currency. The time series is benchmarked to relatively early dates (December 1964 and December 1968) when it is likely that relatively little U.S. currency was held abroad. As a result, the method permits more accurate construction of domestic monetary aggregates, including the domestically held monetary base and domestic M1 and M2.

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Appendix

1. The Porter-Judson Estimates

In a recent article, Richard Porter and Ruth Judson (1996) review the Federal Reserve Board staff's estimates of foreign holdings of U.S. currency. They use several alternative methods to estimate the proportion of currency held abroad, and provide a great deal of additional anecdotal evidence. In this appendix, we review these estimates in a form that facilitates comparison with our own. Interested readers are urged to consult Porter and Judson's paper for details.

Of Porter and Judson's methods, 8 have sufficient data to provide annual time-series estimates of the share of total currency held abroad. Two methods are "stock-based" and exploit differences between U.S. and Canadian seasonal patterns in the amounts of currency and coin in circulation. These methods suggest very different proportions of U.S. currency held abroad—70 and 30 percent, respectively, as of December 1995—which approximately bracket the proportions suggested by the other methods. Five methods are "flow-based" and analyze data such as U.S. Customs Department reports on currency entering and exiting the U.S., shipments of currency from the 37 Federal Reserve System cash offices, and residual outliers in estimated currency-demand regressions. The eighth method is to take the median of the annual flows suggested by their other seven methods. We denote their 8 estimates of the annual flows of U.S. currency to foreign circulation as $\Delta\hat{C}^{F}_{i,t}$, $i = 1,...,8$; $t = 1977,...,1995$.

From each of these 8 estimated time-series, Porter and Judson construct 3 time series estimates of the *stock* of U.S. currency held abroad, $\hat{C}^{FL}_{i,t}$, $\hat{C}^{FH}_{i,t}$, and $\hat{C}^{FM}_{i,t}$. The first, $\hat{C}^{FL}_{i,t}$, is obtained by assuming that *no* U.S. currency was held abroad at the end of 1976 and the second, $\hat{C}^{FH}_{i,t}$, by assuming that *all* U.S. currency was held abroad at the end of 1976; the third, $\hat{C}^{FM}_{i,t}$, is

simply the average of $\hat{C}_{i,t}^{FL}$ and $\hat{C}_{i,t}^{FH}$.[27] Dividing each element of these time series by the amount of U.S. currency in circulation outside banks yields 24 time-series estimates of the share of U.S. currency held abroad, $\hat{C}_{i,t}^{F,j} \big/ C_t$, i = 1,...,8; j = L, H, M.[28]

Although Porter and Judson do not include charts of their estimated shares, they do provide the sums $\sum_{t=1977}^{1995} \Delta \hat{C}_{i,t}^{FM}$ and, for December 1995, the estimated proportions $\hat{C}_{i,t}^{F,M} \big/ C_t$. Values of $\hat{C}_{i,t}^{FL}$, $\hat{C}_{i,t}^{FH}$, and $\hat{C}_{i,t}^{FM}$ based on these data are shown in Table 1.

Table A-1

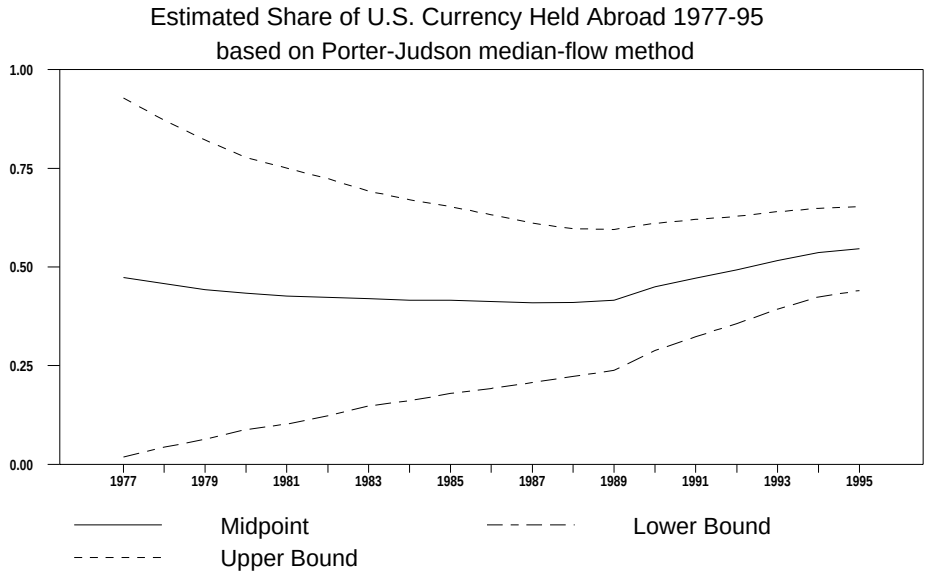
i =	Porter-Judson Method	Total Flow to Foreign Circulation, Dec 1976–Dec 95 (billions)	Estimated Share Held Abroad in December 1995 (percent)		
			$\hat{C}_i^{FL} / C$	$\hat{C}_i^{FH} / C$	$\hat{C}_i^{FM} / C$
1	Seasonal	223.6	60	81	70
2	Coin	173.8	47	68	57[29]
3	Customs reports	5.2	1	23	12[30]
4	Shipment proxy	183.3	49	71	60
5	Cash Office flows	163.1	44	65	55
6	Money demand	119.6	32	53	43
7	Signal extraction	179.6	48	70	59
8	median flow	163.8	44	65	55

Note: increase in currency component of M1, Dec 1976 - Dec 1995: $293.1 billion

In their article, Porter and Judson emphasize their median-flow estimate's December 1995 foreign-held share of 55 percent. But calculation of this share estimate, like all others, is conditional on selection of a benchmark to serve as a starting point for the accumulation of subsequent foreign currency flows. As before, they consider two starting point assumptions: that

[27] Stock estimates also are prepared for 100-dollar Federal Reserve notes.
[28] This statement is not fully correct. Porter and Judson (1996), footnote 13, note that they use currency in circulation for some calculations and the currency component of M1 (currency held by the nonbank public) for others. In this appendix, we use the latter for all calculations.
[29] Value shown is calculated from the flow data reported by Porter and Judson. They report 29 percent for this method, based directly on stock data.
[30] Value shown is calculated from the flow data reported by Porter and Judson. They report 17 percent for this method, due to a judgmental adjustment.

Figure A1



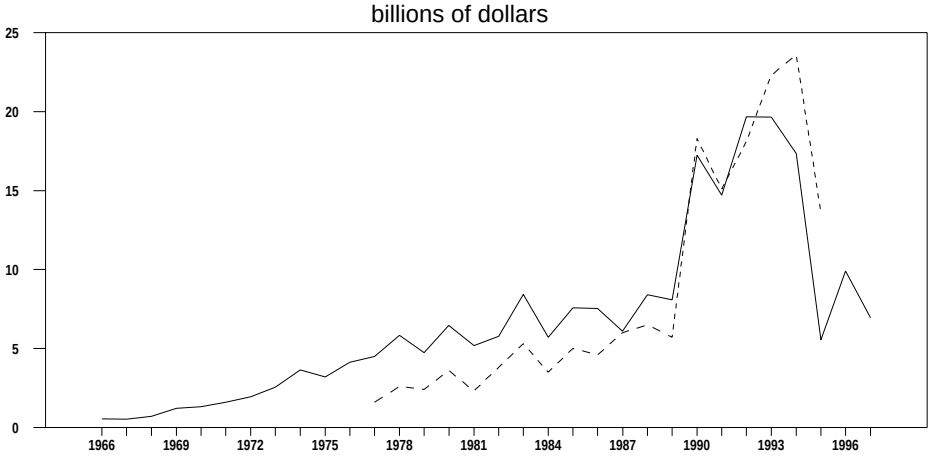
the amount of foreign-held U.S. currency was zero in December 1976, used in $\hat{C}_{i,t}^{FL}$, and that the entire outstanding currency stock was held abroad, used in $\hat{C}_{i,t}^{FH}$. They emphasize the fragility of these assumptions by noting the trial-and-error, or best-effort, nature of their estimates. Unlike their other methods, however, for the median-flow estimate it is possible (using data from Table 6 in their article) to calculate the time series $\hat{C}_{i,t}^{FL}$ (lower bound), $\hat{C}_{i,t}^{FH}$ (upper bound), and $\hat{C}_{i,t}^{FM}$ (midpoint) for 1977–95. These are shown in Figure A1.

The "midpoint" line in Figure A1 makes clear that Porter and Judson's preferred median-flow method suggests foreign-held shares that are approximately the same as assuming that half of the outstanding U.S. currency stock has been held abroad each year since 1977.

The Anderson-Rasche estimates presented in this article are compared to the Porter-Judson median-flow estimates in Figures A2 and A3.

Figure A2

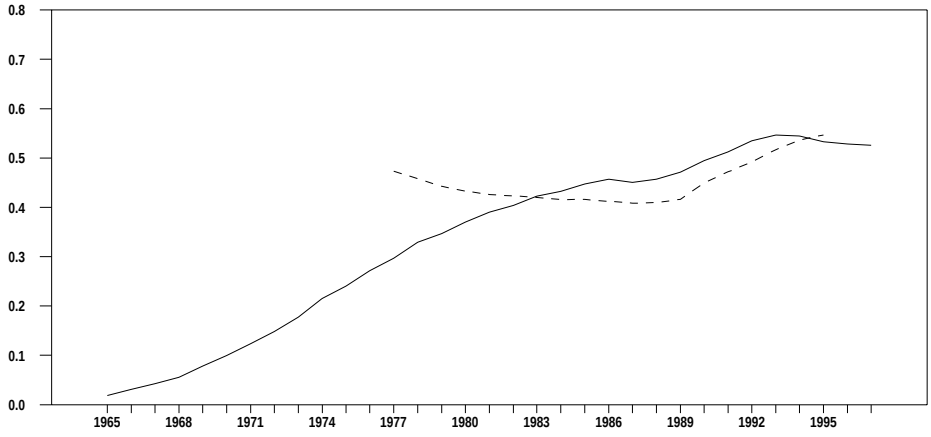
Annual Flows of U.S. Currency to Foreign Circulation
billions of dollars



Anderson-Rasche method
Porter-Judson median-flow method

Figure A3

Estimated Share of U.S. Currency Held Abroad 1965-95
based on Porter-Judson and Anderson-Rasche methods



Anderson-Rasche method
Porter-Judson median-flow method

Our method, based on the outstanding amounts of 50- and 100-dollar Federal Reserve notes and on the patterns of receipts and payment of various denomination notes at Cash Offices, assumes that only a very small amount of U.S. currency was held abroad during the mid-1960s.[31] It is useful to discuss differences in the Anderson-Rasche and Porter-Judson methods separately for flows to foreign circulation and for the overall share of currency held abroad.

Flows: During the 1970s and most of the 1980s, our method suggests relatively larger foreign currency outflows; during the late 1980s and early 1990s, the two methods suggest almost the same amount of annual currency outflows; and, during the mid-1990s, our method suggests significantly slower currency exports.

Stocks: By 1977, the Porter-Judson method suggests that almost one-half of outstanding U.S. currency was held abroad, about two-thirds larger than the share suggested by our method. During the 1980s, our method suggests a nearly continuous increase in the share of currency held abroad, while the Porter-Judson method suggests a decreasing proportion up to about 1989. More recently, our method suggests a much sharper slowing of foreign demand for U.S. currency than the Porter-Judson method.

Implications for the Domestic Monetary Base: Relative to the Porter-Judson method, our method suggests that the domestic monetary base grew more slowly during the 1970s and 1980s but has grown more rapidly since 1993.

2. The Feige Estimates

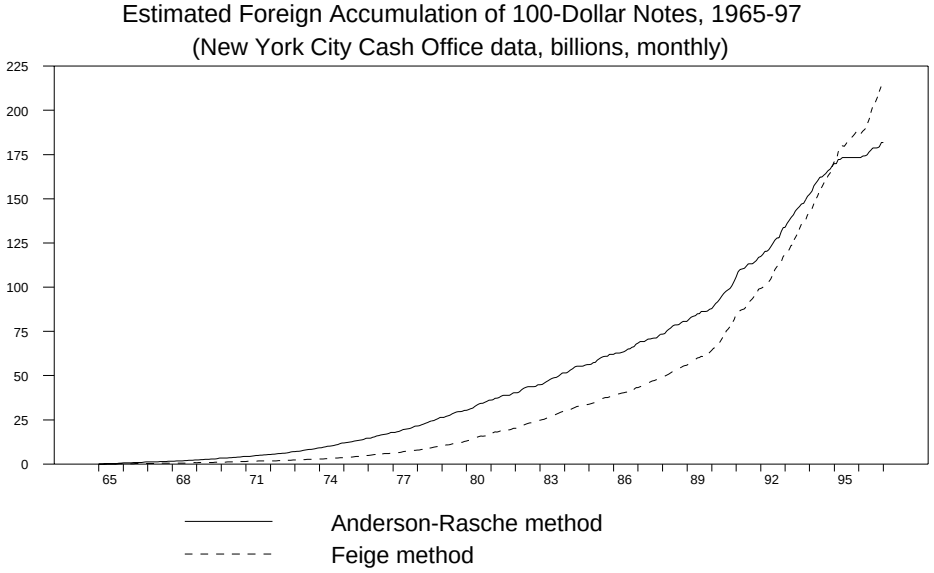
In two recent papers, Edgar Feige (1994, 1996) has discussed several methods to estimate the share of U.S. currency held abroad, along with the amount of currency that might be

[31] In one method that extends back in time to earlier years, Porter and Judson note that their seasonal method suggests that 40 percent of U.S. currency was held abroad as early as 1960. We find this estimate implausible. Total currency held by the nonbank public in January 1960 was $28.7 billion. Forty percent of this total is a dollar amount equal to the sum of all 50- and 100-dollar Federal Reserve notes in circulation plus half of the 20-dollar notes. See *Banking and Monetary Statistics 1941-1970*, p. 625.

used in underground, illicit, illegal or unreported economic activities. We review here only his estimates of foreign holdings of U.S. currency based on shipments of 100-dollar Federal Reserve notes from the New York City Cash Office (Feige, 1994, pp. 126-8), and refer readers to his original articles for details and other methods.

Feige (1994) estimates the flow of U.S. currency to foreign circulation as net emissions ($E_t^{L,NYC} - R_t^{L,NYC}$) of 100-dollar Federal Reserve Notes at the New York City cash office. To compare the implicit stock of foreign-held currency using his methodology with the method that we employ, we accumulated the net emissions at the New York City cash office since December, 1964, shown in Figure A4.[32] The data indicate that the Feige methodology

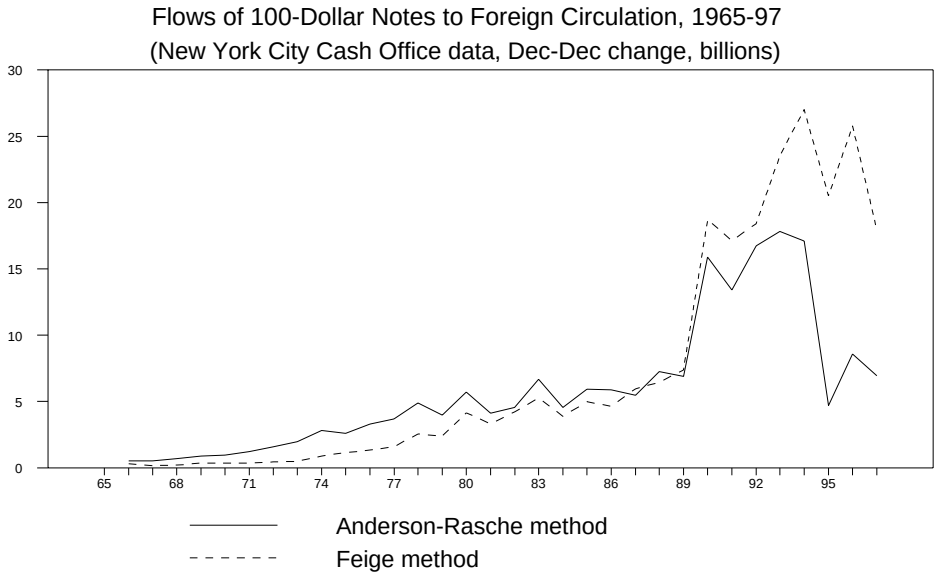
Figure A4



produces a slower accumulation of foreign holdings until the late 1980s and thereafter produces a much faster accumulation, as shown in Figure A5. It is particularly noteworthy that the Feige approach

exhibits very rapid growth of foreign holdings in 1995-6, while our method indicates that foreign holdings leveled off during this period. Assuming that the stock of foreign-held currency was very small in 1964, Figure A6 shows estimated shares of U.S. currency held abroad suggested by the Anderson-Rasche and Feige methods. Consistent with the flow data, the Anderson-Rasche method suggests a foreign-held share during the mid-1980s that is about twice as large as the Feige method's share. The two methods' share estimates coincide by the mid-1990s. Further, the shares are "close" to those reported in Figure 6 of Feige (1994, p. 128). In that figure, the foreign share is about 30 percent in 1980 and 42 percent in 1992. The former is approximately the same as the Anderson-Rasche method's share in Figure A6, while the latter is about the same as the Feige method's share in Figure A6.[33]

Figure A5

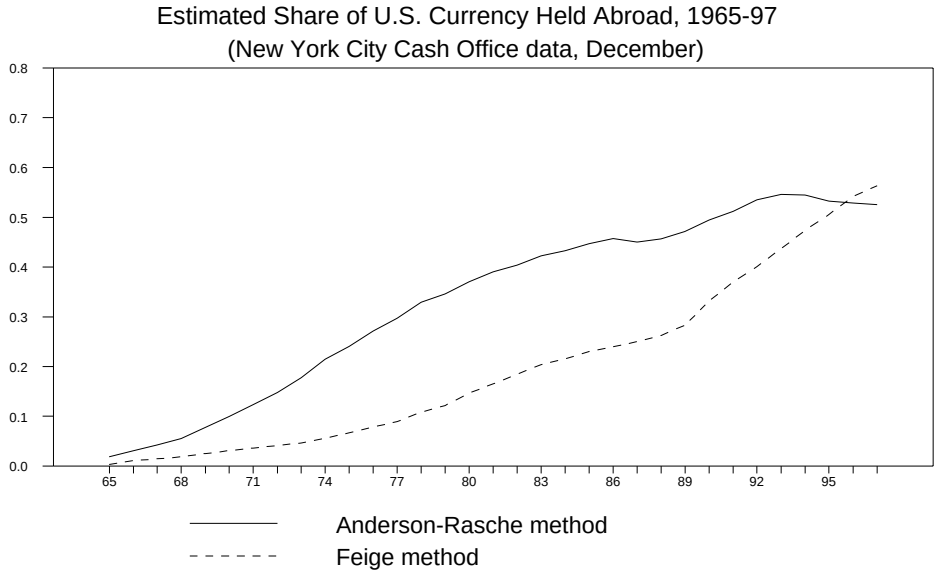


[32] Feige's published data cover the period 1974-92. Here, we extend begin the series in 1965 using newly available data that we have retrieved manually from Federal Reserve microfilm archives.

[33] In Feige (1994, figure 6), the foreign-held share decreases sharply from 36 percent in 1974 to 30 percent in 1980. We find this implausible, and attribute it to Feige benchmarking his series to Porter's 1974 data

Overall, comparison of the Anderson-Rasche and Feige methods reemphasizes an earlier point: most foreign currency exports have been in the form of 100-dollar notes shipped from the New York City cash office, but other cash offices also have furnished significant amounts of currency for export.

Figure A6



3. Patterns of Emissions and Returns for Various Denominations

The method used to estimate foreign holdings of U.S. currency introduced in this paper uses the ratio of the number of 10-dollar notes paid into circulation (emissions) each month at the New York City Federal Reserve cash office divided by the number received from circulation (receipts). In this section, we explore further the reasons for our choice of this ratio.

Ratios of emissions to receipts by note denomination are shown in Figures A7 and A8, respectively, for the aggregate of all Federal Reserve cash offices and the New York City cash

(Feige, 1994, p. 127). In our research, we found that foreign-share estimates (based on cumulated flows to foreign circulation) are highly sensitive to initial benchmark stock assumptions, and feel that our estimates are superior to previous studies because we have been able to use 1965 as a benchmark for 100-dollar notes and 1969 for 50-dollar notes.

office. In general, we expect that a note denomination which is not widely held abroad will display two characteristics: the ratio of emissions to returns will be centered about 1.0, and the variance of the ratio (largely seasonal) will be approximately constant through time.[34]

The ratios for 1, 5, and 10 dollar notes shown in the Figures A7 and A8 generally have these characteristics except for the New York City data during 1984-88 when there was an unusual surge in their variance. As noted above in the main text of this paper, the New York City ratio for ten dollar notes has a mean of approximately 1.1 versus a mean of about 1.0 for the nationwide data. Although we have no specific evidence to explain this differential, it perhaps reflects a general upward trend in domestic circulation of larger denomination notes as the purchasing power of each specific denomination has eroded. The nationwide ratios for 20, 50 and 100 dollar notes in Figure A7 display a decreasing seasonal pattern relative to the 10 dollar note. For the 50 and 100 dollar note, this likely reflects the effects of a larger share held abroad. It is less clear whether currency exports might be contributing to the decrease for the 20 dollar note. Although the anecdotal evidence cited by Porter and Judson (1996) and by Feige (1994, 1996) suggests that almost all of the dollar value of U.S. currency held abroad is accounted for by 50 and 100 dollar notes, this leaves open the possibility that some substantial number of 20 dollar notes also might be held abroad.

We use the emissions-receipts ratio for 10 dollar notes in our method because it is the largest denomination note whose emissions to returns ratio satisfies the two characteristics above. Our use of the New York City rather than the nationwide ratio makes our estimated flows of currency to foreign circulation smaller (or, perhaps, more conservative) relative to the size of flows that would be obtained by using the nationwide ratio.

[34] In our analysis, we implicitly assume that the emissions-to-return ratio for a denomination is invariant to the quantity of notes in circulation (although not to the domestic and foreign shares). Other studies have

Figure A7: Ratio of Notes Paid to and Received from Circulation

nationwide cash office data, 1974-1997, varying scales

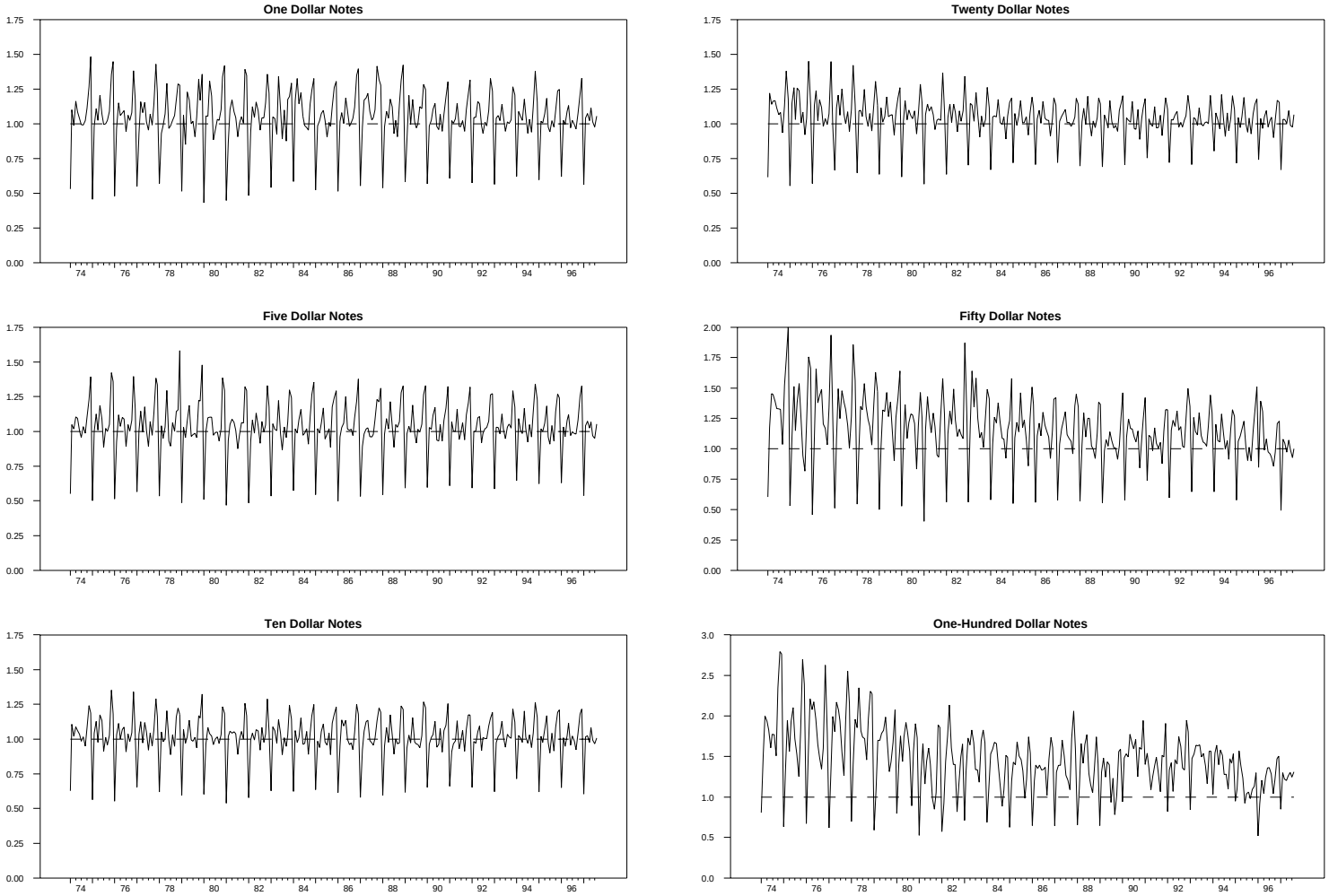


Figure A8: Ratio of Notes Paid to and Received from Circulation

New York City cash office 1974-1997, varying scales