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Edgar L. Feige [*]

Abstract

This paper examines the 'currency enigma" which arises because despite financial innovation that has created important new substitutes for cash usage, U.S. per capita currency holdings now amount to $2700. American households and businesses admit to holding only 15 percent of the stock of currency outside of the banking system. Some fraction of unaccounted for currency is held overseas (the dollarization hypothesis) and some is held domestically undeclared, as a store of value and a medium of exchange for transactions involving the production and distribution of illegal goods and services, and for transactions involving incomes that are not reported to the IRS (the underground economy hypothesis).

We first revisit the longstanding controversy concerning the fraction of U.S. currency held abroad and find that newly revised estimates of U.S. overseas currency stocks estimates the fraction overseas at 37 percent, rather than the widely cited figure of 65 percent. A more refined proxy places the fraction abroad closer to 30 percent. New estimates of overseas holdings permit calculation of domestic currency holdings, as well as narrow and broad measures of *domestic* monetary aggregates. These are tested to determine their ability to predict fluctuations in real output and prices. The domestic currency figures are then used to estimate the current amount of "unreported income" which approaches $2 trillion, implying a "tax gap" in 2008 of between $446-$490 billion.

Keywords: Underground economy, unreported, unobserved, tax gap, cash, overseas currency, monetary aggregates.

JEL Classifications: O17, E41, H26, E52, F3.

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New Estimates of Overseas U.S. Currency Holdings, the Underground Economy, and the "Tax Gap"

Edgar L. Feige[1]

Introduction: The Currency Enigma Revisited

One of the most reliable economic statistics is the amount of U.S. currency in circulation held outside of depository intuitions by the public. Over the past decades we have witnessed a host of cash-saving financial innovations, leading to widespread predictions of the advent of a "cashless society". But contrary to expectations, the United States is awash in cash. By the beginning of 2009, U.S. currency in circulation with the public had risen to an astounding $824 billion dollars, amounting to $2700 for every man, woman and child in the country, suggesting that the average American household holds $10,500 in cash. Over the last twenty years, real (inflation adjusted) *per capita* currency holdings increased by 59 percent and currency as a fraction of the M1 money supply rose from 28 percent to 52 percent.

To put these figures in perspective, they suggest that the bulging average American wallet holds 87 pieces of U.S. currency consisting of: 31 one dollar bills; 7 fives; 5 tens; 20 twenties; 4 fifties and 20 one hundred dollar bills. Few of us will recognize ourselves as "average" citizens. Clearly, these amounts of currency are not normally necessary for those of us simply wishing to make payments when neither credit cards nor checks are accepted or convenient.

Federal Reserve surveys (Avery et al. 1986, 1987) of household currency usage found that U.S. residents admitted to holding only $150 in 1986 and a subsequent survey in 1995 lowered that figure to $100. With households admitting to holding less than 10% of the nation's currency supply and businesses (Anderson, 1977; Sumner, 1990) less than 5%, the whereabouts of roughly 85% of the nation's currency supply is unknown. These anomalous findings suggest that the "currency enigma" (Feige 1989, 1994) and the problem of "missing currency" (Sprenkel, 1993) is still very much with us.

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The currency enigma has both a stock and a flow dimension. First we must determine who holds the missing dollars. Specifically, how much of this missing currency is abroad, and how much is held domestically by citizens reluctant to report their true cash holdings. The flow issue concerns the amount of cash payments sustained by that missing currency. If half of the missing currency is hoarded and the other half is used as a medium of exchange, turning over at an average velocity of between 30 and 50 turnovers per year the missing circulating currency stock would give rise to a flow of "missing payments" of an order of magnitude comparable to the entire GNP of the United States.

The location of America's currency stock and the frequency of its use (currency turnover or velocity) have important implications for a variety of economic issues. If a large fraction of U.S. currency is held abroad, U.S. citizens derive considerable benefit from seigniorage, namely, the ability of the U.S. government to obtain interest free loans from foreign citizens holding U.S. dollars. U.S. dollars have historically been perceived to have many desirable properties that made them attractive to both domestic and foreign holders. As a relatively stable currency the dollar functioned as a safe and portable store of value, protecting users against the threat of bank failures, devaluations and inflation. As an anonymous and widely accepted means of payment that left no paper trail, it has long been considered the preferred medium of exchange for "underground" transactions. More recently, the growing popularity of the Euro and the recent economic crisis appear to have weakened overseas demand for U.S. dollars.

From the perspective of conducting domestic monetary policy, the relevant monetary aggregates are the *domestic* money supply and the *domestic* monetary base (Feige, 1994). To determine the domestic components of the monetary aggregates, the Federal Reserve needs to know the fraction of U.S. currency abroad and the annual net outflow of currency overseas. Similarly, foreign monetary authorities need to know the extent to which their nations are "dollarized" and the changes in net inflows of foreign currencies over time.

The whereabouts of U.S. currency also has fiscal consequences. U.S. currency is a preferred medium of exchange for facilitating clandestine transactions, and for storing illicit and untaxed wealth. Knowledge of its location and usage is required to estimate the

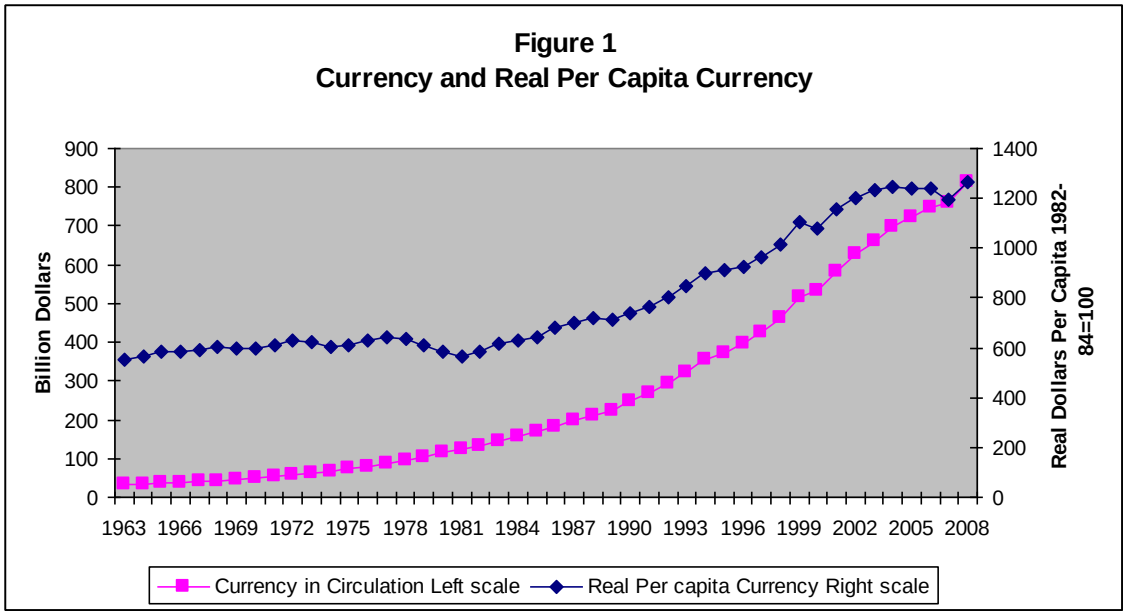
origins and volume of illicit transactions. Most important among these are the drug trade and the amount of income that is not properly reported to the fiscal authorities, namely, "unreported income" and its consequences for the "tax gap". This latter issue gains increasing importance at a time of severe fiscal deficits that could be reduced by increased tax compliance.

It is to these issues we now turn. Section 1 reviews the evolution of the currency stock and its denomination structure. Section 2 reviews the empirical controversy concerning the amounts of U.S. currency held abroad, and Section 3 examines our state of knowledge concerning the specific location of U.S. dollars overseas. Section 4 develops new estimates of domestic monetary aggregates and examines their predictive power in explaining fluctuations in inflation and real output. Section 5 utilizes estimates of the domestic currency supply to calculate the size and growth of the "unreported" economy in the U.S. and provides new fiscal estimates of the "tax gap". The final section summarizes the implications of our findings.

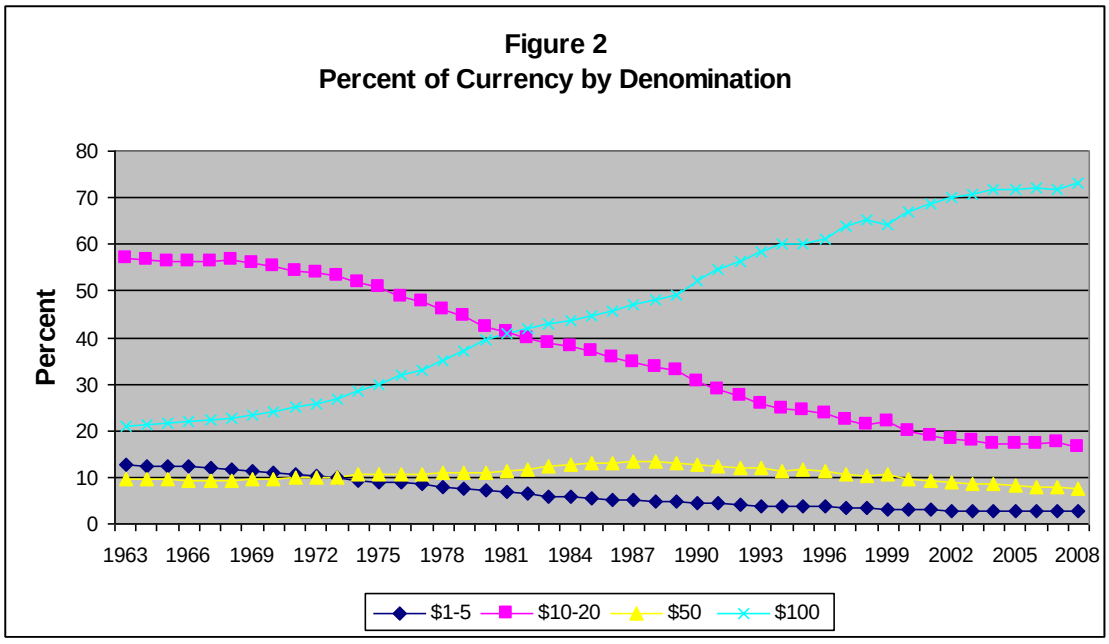
1) The Evolution of Cash and its Denomination Structure

Financial innovation creates many substitutes for cash. Credit and debit cards, electronic payments, EZ pass transponders on toll roads, and pre-paid phone cards are common examples. Yet all predictions concerning the advent of a "cashless" society have proved false as evidenced by the evolution of currency held by the public between 1963 and 2008.

As shown in Figure 1, U.S. cash holdings increased from $32.2 billion in 1963 to $812.4 billion by the end of 2008. Moreover, real per capital cash holdings which remained roughly stable over the first twenty year period have more than doubled during the most recent fifteen years.

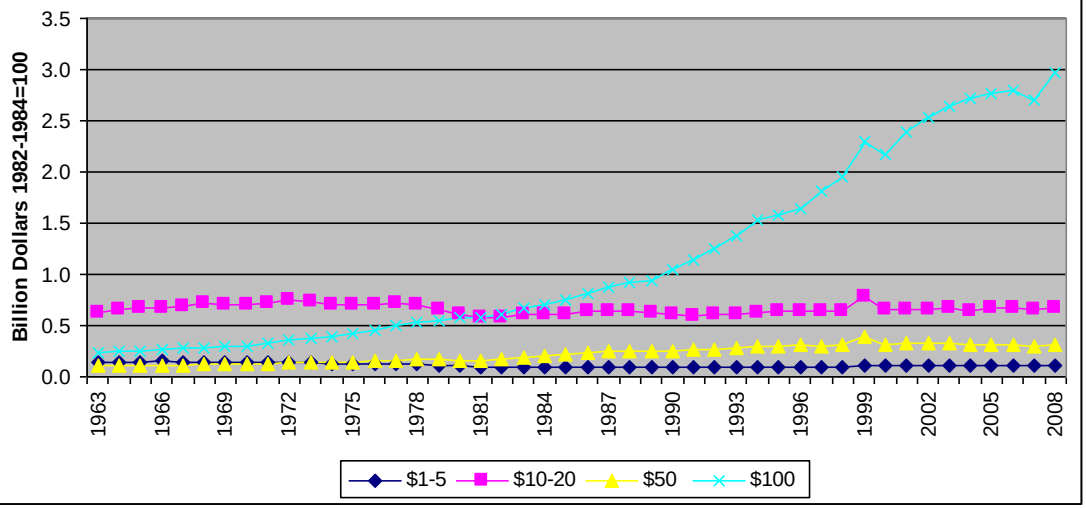


An examination of the evolution of the denomination structure of currency (Figure 2) reveals that fraction of the currency stock made up of the smallest denominations the ($1-5) declined from 12.6 percent to 2.6 percent during the past 35 years while the ($10-20) denominations dropped from 57.1 percent to 16.6 percent. The $50 denomination fluctuated around a 10% level whereas the $100 denomination showed the most dramatic increase, rising from 20.9% in 1963 to 73.3% in 2008.



This radical change in the denomination structure might be explained as a result of changes in the consumer price index which increased more than six and a half fold over the past 35 years. Figure 3 depicts the real value of currency held by the public in different denominations. The real value of smaller denomination notes remained roughly constant with a slight rise in the holdings of the $50 notes. However, the real holdings of $100 bills increased fifteen fold during this period. The $100 bill is most likely used as a store of value although its efficacy as a store of value has declined due to inflation.

Figure 3
Real Value of Circulating Currency by Denomination



Nevertheless, the demand for $100 bills continued to rise in both nominal and real terms. One possible explanation is the "dollarization" hypothesis, (Feige, 2003; 2004) suggesting that U.S. currency, and particularly $100 bills are widely demanded as a second currency in foreign countries experiencing banking crises, political instability and/or hyper-inflations.

An alternative source of cash demand arises from its use as a medium of exchange and store of value in the "underground" economy. One of the key attributes of currency is anonymity, since its usage does not leave a paper trail. As such it is the preferred medium for purchasing illegal goods and for hiding income that should be, but is not reported to the tax authority. The problem then is to determine what fraction of the U.S. currency supply is held abroad and what fraction is held domestically, albeit, somewhat clandestinely.

2) The controversy over how much U.S. currency is abroad

The currency enigma has provoked considerable controversy concerning the fraction of U.S. currency held abroad. Examination of both direct and indirect methods, (employing variants of monetary demography models) led Feige (1996; 1997) to conclude that the most plausible estimates of overseas holdings of U.S. currency "are in the range of 25-45 percent", whereas Porter and Judson (1996), relying on their "seasonal" method, clsimed that by 1995 the share of currency held abroad had reached 70%. Porter and Judson also reported a "median flow estimate" for 1995 of 55 percent abroad, similar to the Anderson and Rasche (1997) estimates of 53.2 percent. Most recently, the United States Treasury Department (2006)[2] concluded that " Today, we estimate that nearly 60 percent of all U.S. banknotes in circulation, or about $450 billion of the $760 billion in circulation as of December 2005, is now held abroad".

Because different approaches have produced an unsettlingly wide range of estimates, we review the main data sources employed to determine the amount of U.S. currency overseas and present new estimates which suggest that by 2008; only 30-37 percent of U.S. currency appears to be held overseas. This dramatic downward revision in the estimated amount of currency held abroad (37 percent), has now been officially adopted by both the Bureau of Economic Analysis[3] and the Federal Reserve[4]. Both agencies have recently issued major statistical revisions for the period 1974-2007 reflecting these lower estimated amounts of currency circulating abroad.[5]

Direct Data Sources of Currency Inflows and Outflows Abroad

a) New York Federal Reserve Bank Reports

At present, there is no information system that collects comprehensive data on the total amounts of currency flowing into and out of the U.S. Large shipments of U.S. currency are typically handled by a number of commercial banks who act as bank-note

[2] Page iv.
[3] BEA News release. June 17, 2008.
[4] The new figures appear in the 2008 Flow of Funds Z1 Tables F-204 and L-204, however no mention is made of the change in method employed to estimate the revised series of currency flows abroad.
[5] As recently as 2007, Jankowski, Porter and Rice (2007) continue to assert that "the share of $100 bills held abroad has decreased from its peak of 70 percent, and more recently , held steady at about 65 percent" (p.2)

brokers specializing in wholesale bulk currency transport. Interviews with Federal Reserve officials suggests that the main source of currency provided to these bulk shippers comes from the New York Federal Reserve, with smaller portions originating in the San Francisco and Atlanta Federal Reserve districts.

Since 1988, bulk currency transporters informally reported their overseas shipments and receipts to the New York Reserve Bank which maintains an internal confidential data base on these currency inflows and outflows. The most recent publicly released information pertaining to these figures reports that over the eighteen year period from 1988-2005, net currency shipments abroad reported by wholesale currency brokers amounted to $130 billion.[6]

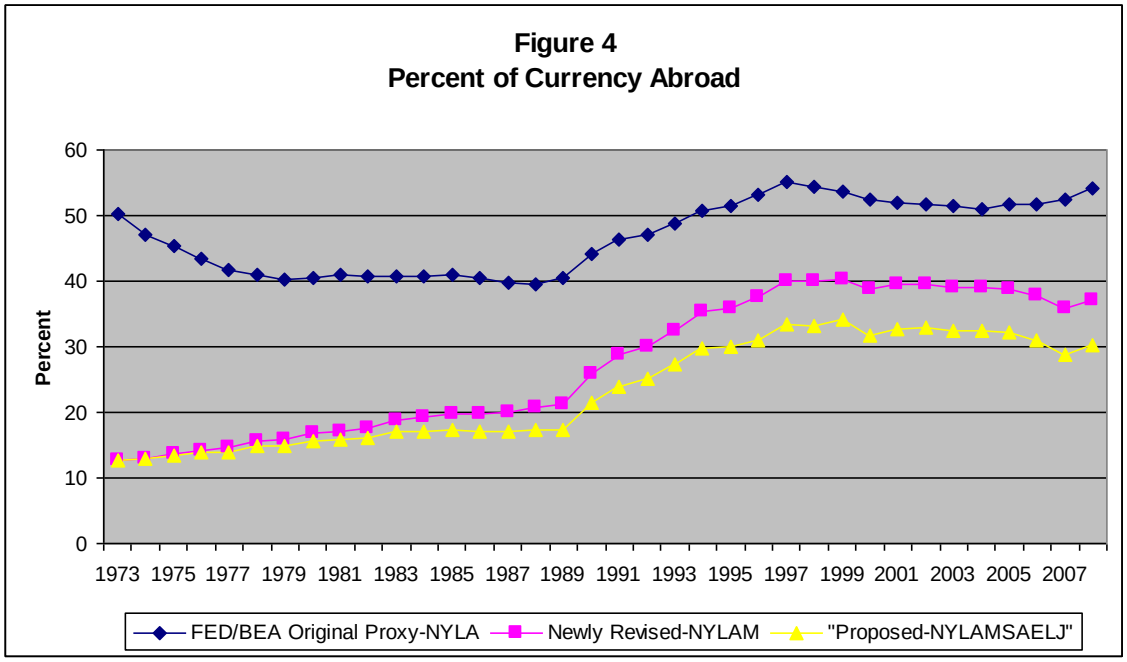
b) The FR-160 Proxy

Since most bulk shipments of currency are in the form of $100 notes, Feige (1994) proposed using a proxy for these confidential data based on the Federal Reserve's FR-160 cash accounting system[7]. The FR-160 reports contain monthly data on denomination specific flows of currency paid into circulation (PIC) and received from circulation (RFC) for each of the 37 Federal Reserve cash offices. The FR-160 proxy, [measuring net injections (PIC-RFC) of $100 by the New York Federal Reserve cash office] was so highly correlated with the internal New York Fed's series on bulk shipments that it was initially viewed as an appropriate proxy for net currency shipments abroad.[8] Recognizing that shipments and receipts of currency to and from the Asian markets often originated at the Los Angeles cash office of the Federal Reserve, the Board of Governors of the Federal Reserve (BOG) and the Bureau of Economic Analysis[9] (BEA) adopted a refinement of the original proxy measure, [total net disbursements of $100 notes from the New York City and Los Angeles cash offices (NYLA)] as the new official measure of currency flows abroad. The NYLA proxy was regularly reported in the Flow of Funds Accounts Z1 (Table F. 204, Line 23) and in the BEA's International Transactions Accounts (Table 1, Line 67). Corresponding estimates of the cumulative

[6] Secretary of the Treasury Report to Congress, 2006. p. 28
[7] The historical background and evolution of the FR-160 reporting system is contained in the Board of Governors technical memorandum #91 entitled " Processing Procedures for the Cash Series", November, 1988.
[8] Feige, 1994.
[9] Bach ,1997.

stock of U.S. currency abroad were published in the Flow of Funds (Table L.204) and in the BEA's annual estimates of the U.S. international investment position accounts. Based on the NYLA proxy, the BEA estimated that by the end of 2007, the amount of U.S. currency held abroad was $398 billion, or 52.5% of the currency in circulation. The original NYLA proxy measure of the percent of U.S. currency held abroad is displayed as the upper line in Figure 4 for the years 1973-2008.

The official NYLA proxy was understood to have several shortcomings. It overstated net shipments abroad because some of the net injections of $100 bills represented domestic demand for those bills in the NY and LA districts and it took no account of net cash inflows from Latin America that were likely to appear in cash offices located in the southern U.S. cities. It understated net shipments abroad because it excluded shipments abroad of lower denomination notes and took no account of currency flows abroad resulting from tourism, immigrant remittances and U.S. military personnel stationed overseas.



In response to some of the aforementioned criticisms, the BEA[10] recently released significantly revised estimates of the stocks and flows of U.S. currency abroad for the

[10] BEA (June 17, 2008) News Release

period 1974-2007. The new estimates are based on an adjusted flow proxy that measures total net disbursements of $100 notes from the New York City, Los Angeles and Miami cash offices (NYLAM). The revised estimates decreased the estimated amount of currency held abroad at the end of 1973 from $30.5 billion to $7.7 billion. The revised series now appears in both the FED Flow of Funds Accounts and the BEA International Transactions and International Positions Accounts.

According to the newly revised estimates displayed as (NYLAM) in Figure 4, the percent of U.S. currency held abroad at the end of 2008 was 37.1 percent, down from the former estimate of 54.1 percent. This substantial downward revision suggests that $138.2 billion, formerly believed to have been held overseas is now officially recognized as circulating domestically.

Further scrutiny of net cash disbursements of $100 bills from the Federal Reserve's cash offices in San Antonio (SA), El Paso (EL) and Jacksonville (J) reveals an unusual pattern of net cash inflows that cannot be readily explained by tourist inflows from other cash offices. These offices, located near our Southern border entry points, are likely recipients of funds flowing in from Central and South America. We therefore propose to add the net cash disbursements from these additional border cash offices to the currency proxy in order to obtain a more reliable estimate of net currency flows abroad. The resulting estimated percentage of currency held abroad as measured by the proposed proxy (NYLAMSAELJ) is displayed in Figure 4 and suggests that at the end of 2008; roughly 30% of U.S. currency was held abroad, amounting to $245.4 billion.

c) Currency and Monetary Instrument Reports

Another important direct source of information on currency outflows and inflows to and from abroad is collected by the U.S. Customs Service as part of its regulatory responsibility under the Currency and Foreign Transactions Reporting Act. This act requires persons or institutions exporting or importing currency or other monetary instruments in excess of $5000[11] to file a "Report of International Transportation of Currency or Monetary Instruments". Commonly know as "CMIRs" these reports have been collected by the U.S. Customs Service since 1977. The CMIR records contain all reported cross border currency inflows and outflows including currency physically

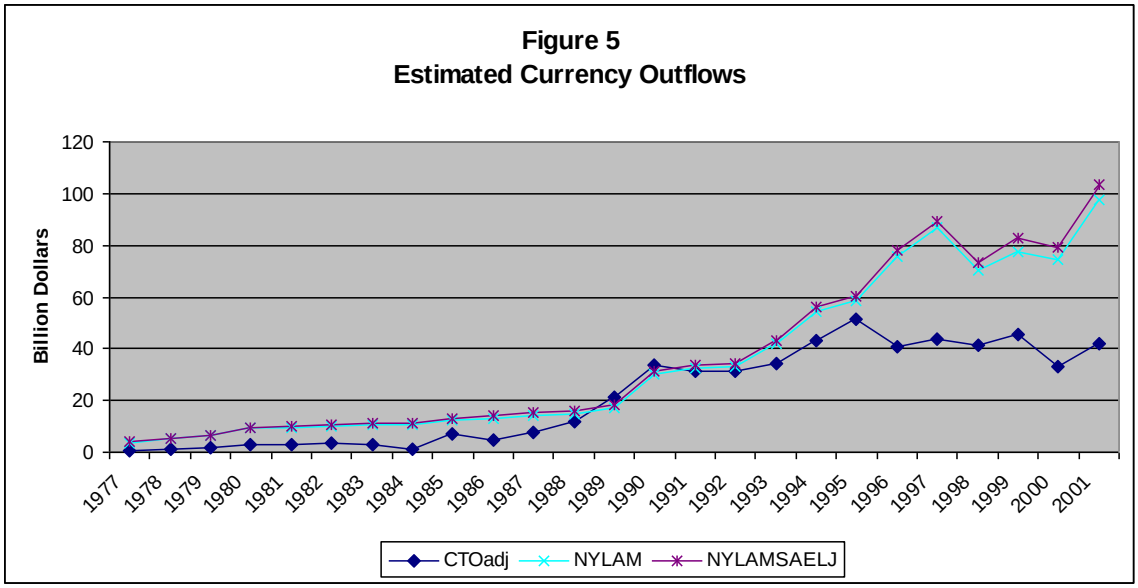
[11] In 1980 the reporting threshold was raised to $10,000.

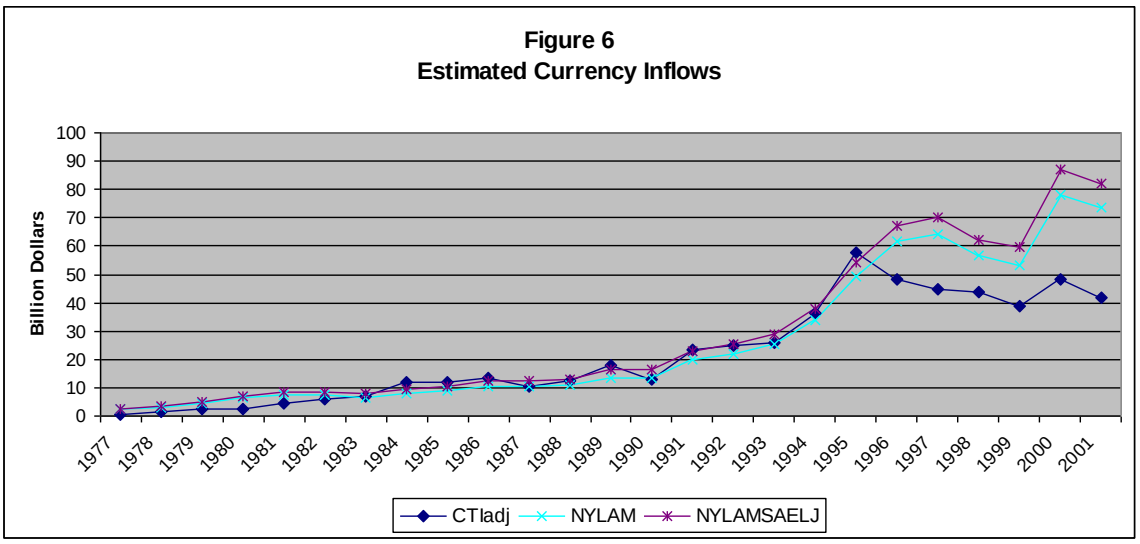
transported by currency retailers, non-financial businesses and individuals and currency shipped by financial institutions specializing in wholesale currency transactions.[12]

The unique feature of the CMIR reports is that reported currency inflows and outflows can be aggregated by origin and destination. With the cooperation of the U.S. Customs Service and the U.S. Treasury Department Financial Crimes Enforcement Network, the information contained in the millions of accumulated confidential CMIR forms was combined by a specially designed algorithm that aggregated CMIR outflows (CTO) and inflows (CTI) so as to maintain the confidentiality of individual records in the CMIR data system. CMIR reports have their own limitations in so far as they exclude currency transactions that fall below the reporting requirement; shipments that circumvent the legal reporting requirements and direct shipments by Federal Reserve Banks which are not required to file a CMIR. In the analysis that follows we have adjusted the CMIR data to include shipments and receipts of currency made directly by the New York Federal Reserve. We denote these adjusted aggregated CMIR outflows as CTO_{adj} and the adjusted aggregated CMIR inflows as $CTI_{adj.}$.

Figures 5 and 6 respectively display alternative estimates of currency outflows and inflows for the period for which the CMIR data were available. Figure 5 reveals that between 1977 and 1995, reported CMIR outflows were generally below the two alternative FR 160 proxy measures.[13] This shortfall results in part from the failure of CMIR's to capture currency outflows falling below the filing threshold and because there is a general lack of awareness and enforcement of the requirement for individuals to file these reports when leaving the country. Individuals entering the country typically pass through customs and are specifically asked to fill out a CMIR form if they are carrying cash amounts above the threshold. The differential awareness and enforcement is reflected by the fact that roughly five times as many arriving travelers filed CMIR forms than did departing travelers and that recorded CMIR inflows for the period 1977-1995 are highly consistent with the two proxy flows as displayed in Figure 6.[14]

[12] For a detailed analysis of the CMIR data see Feige (1997).
[13] The correlation coefficients between CMIR outflows and NYLAM and NYLAMSAELJ outflows for the period 1977-1995 are respectively .897 and .892. However the mean annual outflow for CMIR is almost $5 billion below the means of the two alternative outflow measures.
[14] The correlation coefficients between CMIR inflows and NYLAM and NYLAMSAELJ inflows for the period 1977-1995 are respectively .988 and .989 with comparable means.





We conclude that for the period 1977-1995 CMIR estimates of net currency flows abroad are understated, and should, at best, be considered as a lower bound estimate of the net currency sent abroad.

In 1996 the Treasury Department introduced a newly designed $100 denomination banknote with improved security features. In order to facilitate the rapid introduction of the new notes and to expedite the repatriation of older designed notes, the Federal Reserve established the Extended Custodial Inventory (ECI) program, creating

overseas cash depots managed by the New York Federal Reserve. One of the unintended consequences of the establishment of the ECI program was to degrade the quality of CMIR reports, which now failed to appropriately capture currency outflows from the ECI's to other countries as well as currency reflows from foreign countries back to the overseas ECIs. Figures 5 and 6 displays the decline in measured CMIR outflows and inflows following the introduction of the ECI program. Taking the currency NYLAM proxy as a basis, it appears that the CMIR data understate net outflows during the period 1996-2001 by roughly $19 billion per year.

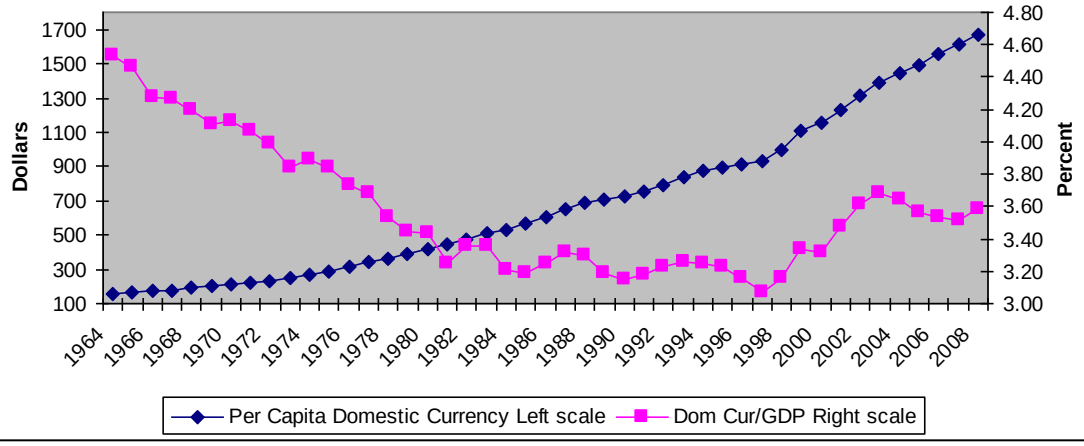
The most significant conclusion resulting from our review of alternative measures of overseas currency is that far less currency appears to be circulating overseas than was previously thought to be the case. For 2008, the original "official" estimate of the percent of currency overseas was 51.4 percent whereas the new FED/BEA estimate stands at 37.3 percent. If we include data from the three additional southern border cash offices that are known to receive considerable amounts of currency from Latin America, the estimate is reduced to 30.1 percent abroad. When the official estimate of the stock of currency held abroad in 1987 is combined with the estimated flows of currency shipped abroad between 1988 and 2005 by specialized currency brokers[15], the calculated percent of currency held abroad in 2005 is 24.0 percent. CMIR estimates of overseas currency holdings would be considerably lower. Based on direct data, the most plausible range of estimates of currency held abroad in 2008 is 30 - 37 percent. These new estimates fall far below the previously reported estimates (Porter and Judson, 1996) which indicated "that between 50 percent and 70 percent of the U.S. currency is now held outside the United States".[16]

The finding that overseas holdings of U.S. currency are considerably smaller than were previously thought implies that domestic holdings are even more puzzling. Figure 7 displays the temporal growth in per capita domestic currency holdings which increased from $171 in 1966 to $1674 by the end of 2008.[17] Real per capita domestic holdings increased by 53 percent during the period. As a percentage of GDP, domestic currency declined secularly from 1965 to 1998. The observed increase in the ratio between 1998 and 2003 may have been stimulated by concerns of a millennium interruption in the

[15] As reported by the New York Federal Reserve. op.cite. footnote 4.
[16] Secretary of the Treasury Report to Congress, 2006. p. 28.
[17] These figures are based on the new official Federal Reserve/BEA data employing the NYLAM proxy.

functioning of ATM machines and similar concerns resulting from the aftermath of 9/11. After 2003 the ratio of domestic currency to GDP resumed its secular decline.

Figure 7
Ratio of Domestic Currency to GDP and Per Capita Domestic Holdings



3) The Location of U.S. Currency Held Abroad

Two sources of data are available for estimating the location of U.S. dollars overseas. Between 1994 and 2005 officials from the U.S. Treasury, the Board of Governors of the Federal Reserve, the New York Federal Reserve and the U.S. Secret Service visited forty-one countries to conduct informal surveys concerning the amount of U.S. currency in circulation. The amounts of U.S. currency believed to be held in each country are reported in the United States Treasury Department (2006) Table 3.3 and are reproduced in Table 1. Unfortunately, the Treasury Report gives no indication of the method employed to obtain these "survey" estimates other than to obliquely state in a footnote: "For currency holdings, estimates were provided during the teams visit to each country and thus are estimates as of the most recent trip to each country".[18]

Table 1 also includes estimates of currency held abroad in 12 additional countries not visited by the official teams. These additional country estimates are based on aggregated CMIR reports of currency inflows and outflows organized by country of origin and destination.

[18] P. 25.

Table 1
Foreign Holdings of U.S. Currency

Country	U.S. Currency $ Billion	Country	U.S. Currency $ Billion
Argentina*	50.0	Indonesia*	2.0
Armenia**	0.2	Korea*	15.0
Azerbaijan**	1.3	Latvia*	0.5
Belarus*	3.0	Lithuania*	0.5
Bolivia***	1.2	Mexico*	5.0
Brazil*	1.0	Nicaragua***	0.7
Bulgaria*	1.0	Panama*	2.0
Cambodia*	2.0	Peru*	5.0
Chile*	0.3	Paraguay*	0.1
China*	50.0	Philippines*	2.0
Colombia*	2.0	Poland*	1.0
Costa Rica***	0.8	Romania*	2.0
Dominican Republic*	1.5	Russia*	80.0
Ecuador*	1.0	Singapore*	1.0
Egypt*	1.0	South Africa*	2.0
El Salvador*	1.0	Taiwan*	1.0
Estonia**	0.6	Thailand*	0.3
Hong Kong*	2.0	Turkey*	10.0
Hungary**	0.3	Ukraine**	6.4
Kazakhstan**	17.1	Uruguay***	2.6
Kyrgyzstan**	0.1	Venezuela***	2.5
		Vietnam*	3.0
		Total	**281.7**

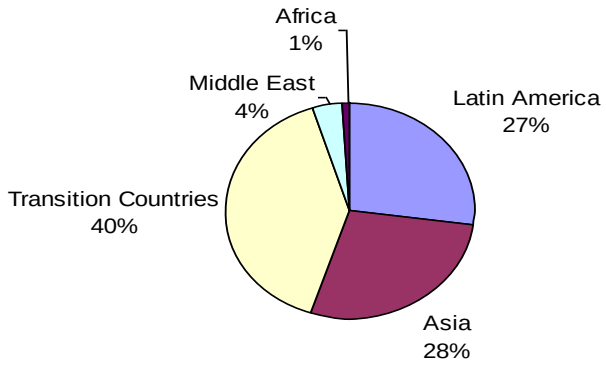
Sources:* Secretary of the Treasury Report (2006) P.25; ** Feige and Dean (2004) Table 14.1, p.309; *** Feige et al. (2003) Table 2.1. p. 53.

To examine the consistency of the "informal survey" results with the BEA/FED estimates of total currency abroad, we note that the amount of currency reportedly held in the 31 visited countries ($248.1 billion) during the period 1994-2005 exceeds the new official BEA/Fed estimate of the average amount of currency held abroad ($205.4 billion) during this period by $42.7 billion. The additional CMIR country estimates bring this discrepancy to $76.3 billion. We suspect that the anecdotal evidence presented as survey results grossly overstate U.S. currency holdings abroad.

Table 1 does however provide a rough insight into the distribution of U.S currency by major region. Figure 8 displays the regional composition of overseas holdings of U.S. currency. The greatest degree of dollarization appears to occur in the

transition countries with Russia being the most dollarized country. Latin America and Asia each hold over a quarter of the reported overseas holdings with Argentina and China being the major consumers.

Figure 8
Distribution of US Currency Abroad



The key finding that foreign holdings of U.S. currency amount to roughly one third of total U.S. currency in circulation implies that estimated seigniorage earnings (the value of the interest free loan obtained from overseas currency holders) is lower as well. Over the past decade, the revised data suggest that the U.S. government's annual seigniorage earnings averaged $8.6 billion from foreign holders of U.S. currency.

4) The Money, Output, Inflation Controversy

The stability and information content of the relationship between monetary aggregates and real output and inflation has been the subject of considerable controversy in macroeconomics since Sims (1972) discovered a unidirectional causality from money and income. Feige and Pearce (1979) showed that this empirical finding was highly sensitive to alternative specifications and concluded that "the relationship between money and income appears to be casual rather than causal."

As time series analysis became more sophisticated, Friedman and Kuttner (1992) reexamined the relationship between monetary aggregates and real income and prices in a trivariate autoregressive framework and found that the "the U.S. experience does not indicate a close relationship between money and non-financial economic activity." Their key finding that "there is no evidence to show that fluctuations in money contain any

information about subsequent movements in income or prices" is the hypothesis we wish to reexamine in light of our new information concerning the amounts of currency circulating abroad.

Feige (1994) suggested that "if a sizable and variable fraction of currency is held abroad, reliance on conventional monetary aggregates which include total currency in circulation would be misleading. The appropriate monetary aggregates to monitor would be the *domestic* monetary base and the *domestic* money supply rather than the total monetary base and the total money supply." Aksoy and Piskorski (2006) recently provided partial evidence to support this conjecture. They reexamined the Friedman Kuttner (1992) results employing earlier estimates of the domestic currency supply and found that 'currency corrected for foreign holdings has increased marginal predictive content for U.S. inflation and real output relative to standard unadjusted money series." Employing the same autoregressive specification for real output changes and inflation as used by Friedman and Kuttner (1992) and Aksoy and Piskorski (2006), we compare the results of Granger causality relationships between the newly revised *domestic* monetary aggregates and output and inflation and those based on conventional monetary aggregates.

Empirical consideration of whether monetary aggregates can usefully play a role in monetary policy depends upon whether they help to predict future fluctuations in real income or prices that are not already predictable on the basis of fluctuations of income itself or price fluctuations. We therefore examine χ-square tests of the null hypothesis that all of the coefficients on the lagged growth of various monetary aggregates are zero in autoregressions of the form:

1) $$\Delta y_t = \alpha + \sum_{i=1}^{4} \beta_i \Delta y_{t-i} + \sum_{i=1}^{4} \lambda_i \Delta p_{t-1} + \sum_{i=1}^{4} \delta_i \Delta m_{t-1} + \nu_t$$

2) $$\Delta p_t = \alpha + \sum_{i=1}^{4} \beta_i \Delta p_{t-1} + \sum_{i=1}^{4} \lambda_i \Delta y_{t-1} + \sum_{i=1}^{4} \delta_i \Delta m_{t-1} + \nu_t$$

where Δy, Δp, and Δm are respectively, the quarterly growth rates of real output, inflation and alternative monetary aggregates.[19]

Table 2 presents the p-values of the Granger causality χ-square statistics computed with White (1980) heteroskedasticity consistent standard errors. The null

Table 2
p-Values:Granger Causality: X square-Statistic

Variable		**Real Output 1974:2-2008:4**	**Inflation 1974:2-2008:4**
Domestic Monetary Aggregates			
Domestic Currency component current	△ln(Cdom)NYLAM	0.098	0.003
Domestic Currency Proposed	△ln(Cdom)NYLAMSAELJ	0.039	0.001
Domestic M1adj Current	△ln(M1dom)adjNYLAM	0.324	0.015
Domestic M1adj proposed	△ln(M1dom)adjNYLAMSAELJ	0.321	0.016
Domestic M2 Current	△ln(M2dom)NYLAM	0.119	0.783
Domestic M2 proposed	△ln(M2dom)NYLAMSAELJ	0.115	0.786
MBBoG domestic Current	△ln(Mbdom)BoG.NYLAM	0.267	0.317
MBBoG domestic Proposed	△ln(Mbdom)BoG.NYLAMSAELJ	0.292	0.236
MBSL domestic current	△ln(Mbdom)SL.NYLAM	0.115	0.456
MBSL domestic proposed	△ln(Mbdom)SL.NYLAMSAELJ	0.114	0.382
Uncorrected Monetary Aggregates			
Currency Component of M1	△ln(C)	0.150	0.736
M1	△ln(M1)	0.464	0.010
M1adj for Sweeps	△ln(M1)adj	0.303	0.013
M2	△ln(M2)	0.099	0.748
MBBoG	△ln(Mb)BoG	0.062	0.871
MBSL	△ln(Mb)SL	0.021	0.982
FED Funds rate	△ln(Funds)	0.000	0.229

[19] Real output is measured by real GDP; inflation by the GDP deflator and the monetary aggregates are respectively, C = Currency component of M1, M1= the M1 money supply; M2= M2 money supply; MbSL = the St. Louis Federal Reserve monetary base; ; MbBoG=Board of Governors Monetary base; C_{dom} = domestic currency; $M1_{dom}$ = domestic M1 money supply; $M2_{dom}$ = domestic M2 money supply; Mb_{dom} = domestic monetary base.

hypothesis is that all coefficients on the lagged financial variables, considered individually in the autoregressive specifications, are zero.

Table 2 is similar to the presentation in Aksoy and Piskorski (2006) who used the earlier estimates of domestic currency based on the NYLA proxy for foreign holdings described in section 2 above. Our estimates of domestic currency holdings are derived from the newly revised official BEA/FED estimates of foreign holdings based on the NYLAM proxy, and on our proposed NYLAMSAELJ proxy. Additionally, we examine estimates of the M1, M2, and MB aggregates corrected for alternative estimates of domestic currency holdings.

Table 2 reveals that in the real output equations, the only variables significant at 5% are the Fed Funds rate, the St. Louis monetary base and the proposed domestic currency component. At the 10% level we find that the conventional BOG monetary base, the M2 monetary aggregate and the current estimate of domestic currency component are significant. We find no significant predictive content for either the conventional narrow monetary aggregates or the domestic monetary aggregates other than the currency component.

The conclusions are quite different for the inflation equations. At the 5% significance level we find that the domestic currency component and both the conventional and domestic narrow money supply aggregates are significant. However, none of the other conventional monetary aggregates, (M2 and monetary base) nor the domestic M2 and base aggregates have significant predictive content for inflation.

Our findings, covering a longer time period, and revised estimates of the domestic currency component confirm the Askoy and Piskorski (2006) results that domestic currency has significant predictive content for both real output and inflation. However, with the exception of the domestic M1 money supply in the inflation equation, none of the other domestic monetary aggregates appear to have significant predictive content for either real output or inflation.

5) Implications for the Underground Economy and the Tax Gap

In order to generate a time series estimate of the relative size of the underground economy (Yu/Yo), we confine our discussion to the estimation of "unreported income"

(Yu), namely the difference between the amount of income that should be reported to the tax authority (under full compliance with the tax code) and the amount actually reported (Yo), namely adjusted gross income (AGI). The most common method for estimating the relative size of the underground economy relies on some variant of the general currency ratio model described in Feige (1989).

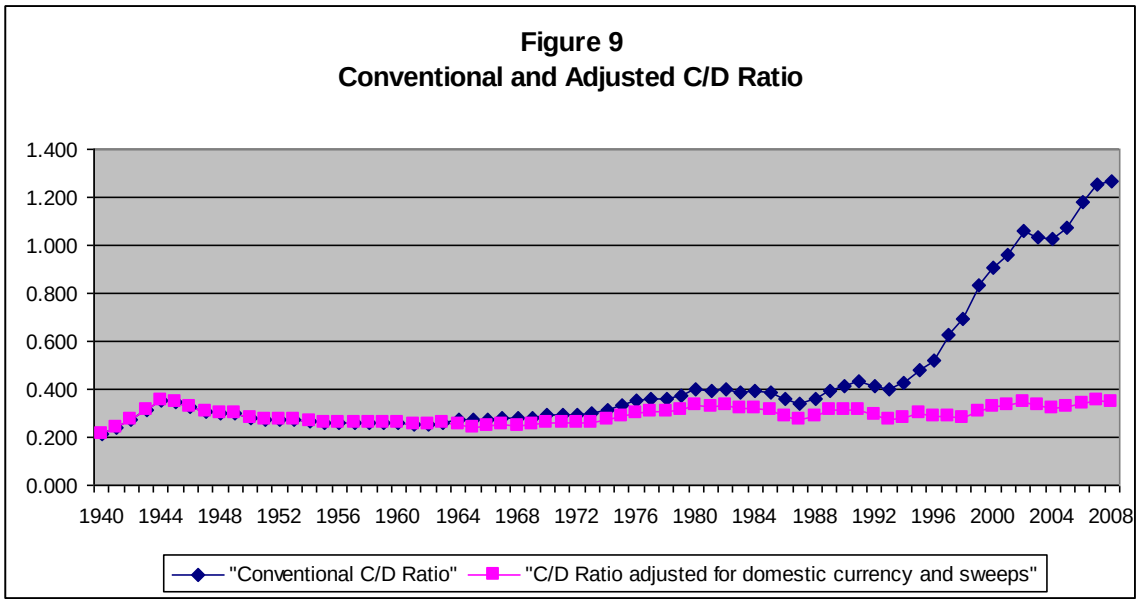
The most restrictive specification of the currency ratio model [Cagan (1958), Gutmann (1977)] assumes that currency is the exclusive medium of exchange for unreported transactions, that the ratio of currency to checkable deposits remains constant except for changes induced by the growth of unreported income and that the amount of unreported income produced by a dollar of currency transacted in the unreported sector is the same as the amount of reported income produced by a dollar of currency transacted in the reported economy. In order to obtain a benchmark estimate of the size of the unreported sector, the restrictive model assumes that in some benchmark year (1940) the underground economy (unreported income) is zero.[20]

In the analysis that follows, we relax the restrictive model with several important modifications. Since our concern is with estimating the amount of unreported income in the U.S., the first modification is to employ estimates of domestic currency in circulation (C_{dom}) rather than the total amount of currency in circulation (C). The second modification involves taking account of the technological innovations in the financial industry which significantly reduced the volume of "checkable deposits" (D) in the mid 1990's.[21] During this period, banks began to offer retail sweep programs, in which checkable deposits were swept into money market deposit accounts, enabling banks to profitably reduce the level of demand deposits subject to reserve requirements. During the first quarter of 1994 these "sweeps" amounted to only $7.5 billion dollars but have subsequently increased to $775 billion in 2008. By including these "sweeps" in our definition of "checkable deposits", we take account of an important factor affecting the conventional C/D ratio which is unrelated to developments in the unreported economy.

[20] As described in Feige (1989) these restrictions imply that the ratio of unreported income(Yu)to reported income Yo can be estimated as follows:
Yu/Yo =(C-koD)/ (ko+1) D where C = Currency, D= Checkable deposits and ko= (Co/Do), the currency deposit ratio in the official economy which is observed in the year (1940) when the underground economy is assumed to be zero.

[21] Checkable deposits are defined as the sum of demand deposits and other "checkable deposits".

Figure 9 displays the effects of these two adjustments by comparing the conventional C/D ratio employed in many published estimates of the underground economy with the new C/D ratio adjusted for both domestic currency holdings and sweeps.



A further modification of the conventional currency ratio model is to drop the assumption that unreported income in 1940 was zero and instead to benchmark estimates of unreported income to a year in which an independent estimate of the ratio $Yu_t/Yo_t = \alpha_t$ is available.[22] Two years were chosen for our benchmark estimates, 1988 and 2001. The 1988 benchmark is taken from the IRS (1988) report which estimates unreported incomes[23] and the corresponding tax gaps[24] for the years 1972-1992. These IRS projections are based on the Taxpayer Compliance Measurement Program (TCMP) undertaken in the years 1979 and 1982.[25] For the year 1988, the ratio of legal misreported income to total reported taxable income was 18.8 percent and the ratio of legal misreported income to adjusted gross income was 14.5 percent. Our 1988 benchmark estimate for Yu/Yo is 16.7 percent, where Yu represents legal plus illegal unreported

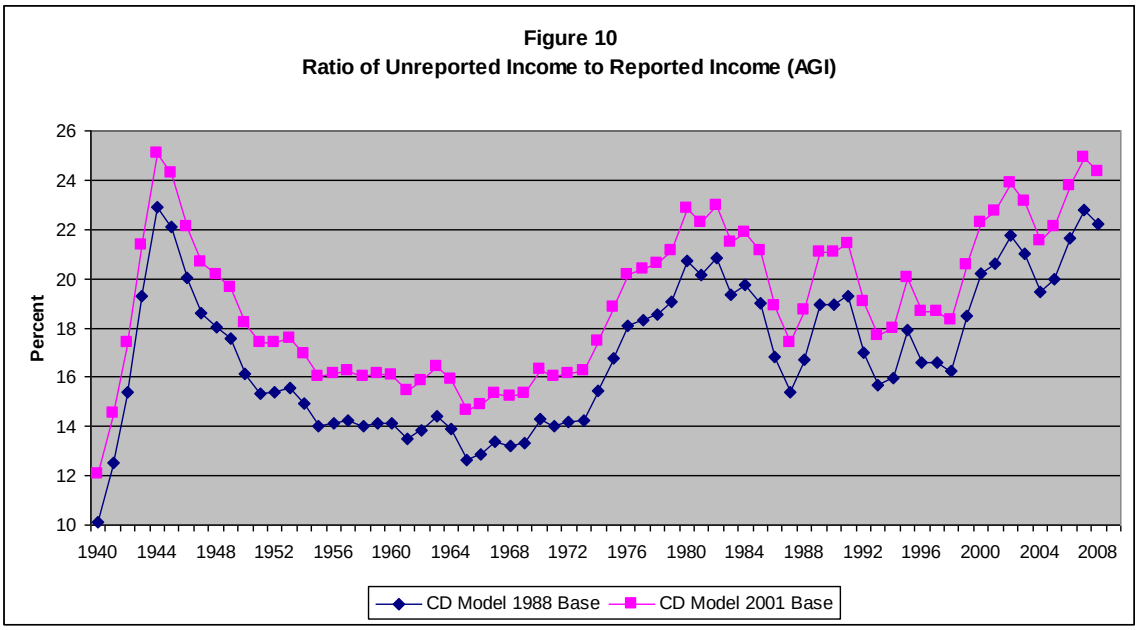
[22] Given α_t, the equation in footnote 19 can be solved for ko_t to derive a new benchmark estimate for generating the temporal development of Yu/Yo.
[23] IRS (1988) Table D-17.
[24] IRS (1988) Table D-17 and Table F1.
[25] These latter TCMP audits were more accurate than earlier audits because the examiner now had information return documents on individual returns available during the time of the audit.

income and Yo represents AGI. We regard this as a lower bound estimate since the IRS acknowledges that "despite the intensity of the TCMP examinations, some income still goes undetected."[26]

The most recent year for which the IRS published a "tax gap"[27] estimate was 2002. The tax gap was estimated to be $345 billion dollars.[28] In order to construct a benchmark estimate of Yu/Yo for 2001, we first divide the IRS tax gap estimate by the average marginal federal income tax rate from the NBER TAXSIM model in order to obtain an estimate of total unreported income (Yu). We then divide (Yu) by actual AGI (Yo) in order to obtain the benchmark estimate Yu/Yo for the year 2001. This benchmark underestimates the true value of Yu/Yo because the IRS tax gap excludes unpaid taxes on illegal income, and hence the unreported illegal income that we consider to be part of Yu.

Figure 10 displays the currency model's time series estimates of the ratio of unreported income to reported income (AGI) based on the IRS benchmarks for 1988 and 2001 respectively.

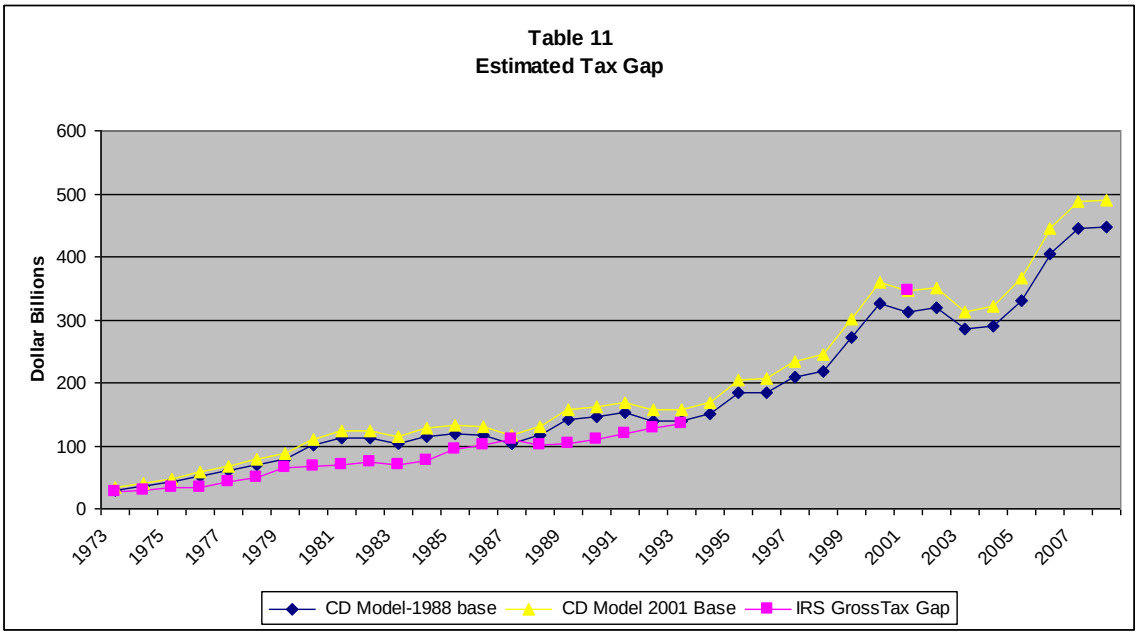
Figure 10
Ratio of Unreported Income to Reported Income (AGI)



[26] IRS (1988) p. A-5.
[27] The tax gap is defined by the IRS "as the aggregate amount of true tax liability imposed by law for a given tax year that is **not paid voluntarily** and **timely.** It is important to emphasize that IRS estimates of the tax gap are associated with the **legal** sector of the economy only. Although tax is due on income from whatever source derived, legal or illegal, the tax attributable to income earned from illegal activities is extremely difficult to estimate." IRS (2007) p.6.
[28] IRS (2007) p.1.

The percentage of unreported income rose dramatically during World War II, declined during the post war period and then remained roughly stable until 1973, when it again rose to a temporary peak in 1982. The 1980's and 90's displayed considerable fluctuations in the Yu/Yo ratio which Cebula (1997) and Cebula et. al. (1998) showed could be explained by variations in tax rates, dissatisfaction with government and audit rates. During the past decade the percentage of unreported income increased substantially approaching the peak levels attained during the World War II period. By 2008 unreported income as a percent of AGI is estimated to range between 22.2 and 24.4 percent.

The implications for the estimated tax gap over the past four decades are displayed in Figure 11 which also includes the IRS estimates of the tax gap for the years it published such estimates. During the past five years the tax gap appears to have increased dramatically, and by 2008 the gap is estimated to be between $447 - $490 billion dollars.[29]



It should be noted that our estimate of both unreported income and the tax gap are based exclusively on the use of domestic currency in unreported activities. Recent attention has been focused on an additional tax gap resulting from income earned abroad in tax havens. Although we can not trace the source of estimates of overseas tax haven evasion, figures as high as $100 billion have been mentioned in the press. Taking account

[29] The estimate for 2008 is based on a projection of AGI.

of the tax gap resulting from overseas tax havens, overall tax evasion may cost the U.S. government as much $600 billion per year.

6) Summary and Conclusions

Financial innovations have created major substitutes for currency, yet by 2009 per capita holdings of U.S. currency in circulation outside of the banking system amounted to $2700. Surveys of American households and businesses found that they admitted to holding less than 15% of this huge stock of U.S. currency, giving rise to what has been called the "currency enigma". Two complementary hypotheses have been advanced to explain the whereabouts of the remaining 85% of the currency supply.

Some fraction of the currency is believed to be held abroad in nations whose citizens and businesses feel it prudent to employ US currency as a substitute for their own national currencies as both a medium of exchange and as a store of value. Evidence has been brought to bear (Table 1) that extensive "dollarization" occurred, primarily in Russia, Argentina and China, but the percentage of the U.S. currency supply believed to be held abroad remained in dispute. Porter and Judson (1996) and Jankowski et. al. (2007) suggest that at its peak in 1995 as much as 70% of the nation's stock of $100 bills was held abroad and that in recent years the percentage abroad has stabilized around 65%. We demonstrate that a new proxy officially endorsed by the Federal Reserve and the U.S Bureau of Economic Analysis now places the figure at 37%. A more refined proxy that includes net currency outflows from the U.S. southern Border States puts the estimate of total currency abroad at closer to 30%.

These new figures imply that domestic per capita holdings of U.S. are in the range of $1674-$1855 and that the overwhelming portion of these holdings is in the form of $100 bills that are used both as a store of value and as a medium of exchange. Jankowski et. al. (2007) studied the Chicago metropolitan area and concluded that Latin American immigrants demand "more $100 bills than both native-born residents and immigrants from regions other than Latin America."[30] Their empirical findings suggest that this high currency demand group only holds an average of between $266 and $329 per capita, less

[30] P. 15. This increased demand for currency is explained by the fact that this group encounters "obstacles to obtaining and using deposit accounts at financial institutions."(p.17.)

than 20% of what we now know to be average per capita domestic holdings. Thus the problem of missing currency is still very much alive.

Once the effects of overseas dollarization are taken into account, one is left to explore a complementary hypothesis concerning the "currency enigma". Domestic currency is known to be the preferred medium of exchange for transactions that individuals and businesses wish to conceal. Such transactions include: the production and distribution of illegal goods (drugs) and services (prostitution); and incomes earned that are not reported to the fiscal authority in order to evade taxes. We employ a modified currency ratio model to estimate both the volume of "unreported income" and the "tax gap" resulting from this underreporting. Our findings suggest that by 2008, unreported income was in the neighborhood of $2 trillion resulting in a "tax gap" ranging from $446 to $490 billion per year. The time series evidence suggests that the ratio of unreported income to reported Adjusted Gross Income has reached levels not seen since World War II.

Given the revised estimates of overseas currency holdings, we reexamine the relationship between monetary aggregates and output and inflation. Particular interest centers on the question of whether new estimates of domestic currency holdings and of domestic monetary aggregates have better predictive power in explaining output and price fluctuations than do conventional monetary aggregates that take no account of overseas currency holdings. Following the specifications of Friedman and Kuttner (1992) we confirm the limited findings of Aksoy and Piskorsky (2006) that the revised domestic currency component has significant predictive power for real output and inflation. However, with the exception of the domestic M1 money supply in the inflation equation, none of the other domestic monetary aggregates appear to have significant predictive content for either real output or inflation. Thus, with the surprising exception of the domestic monetary component, it appears that adjusting the conventional monetary aggregates to reflect only the domestic money supply does not significantly improve the predictive power of these aggregates in forecasting future real output or price fluctuations.

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