Revised estimates of the Underground Economy: Implications of US Currency held abroad

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Revised Estimates of the Underground Economy: Implications of US Currency Held Abroad

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A number of important public policy decisions now call for analytical and empirical knowledge of the nature, size, growth, causes, and consequences of the "underground economy." Our purpose here is to

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clarify the meaning of underground activity, update various discrepancy and fiscal estimates of its size and growth, and examine the empirical implications of new evidence on the growing use of US currency throughout the world for monetary estimates of the underground economy within the US itself.

The popular term "underground economy" is inexact, encompassing a wide range of economic activities including the production and distribution of illegal goods and services as well as legal activities whose concealment from or misrepresentation to government authorities involves tax evasion or benefit fraud. Given the diversity of hidden activities, it becomes necessary to develop a taxonomy of "underground economies" that identifies specific types of underground behaviours and suggests appropriate methods for estimating their prevalence.

The general penchant for hiding underground economic activities often precludes direct observation of their occurrence and leaves us to use indirect measures to detect the footprints of hidden activities in the sands of the observable economic continuum. Currency, as an anonymous medium of exchange, is viewed as the preferred means of payment in transactions that economic actors are trying to conceal. This makes cash stocks and flows a natural starting point in our search for the underground economy. The total amount of currency in circulation[2] is one of the best-measured macroeconomic indicators, since the production and distribution of currency by governments is strictly monitored and carefully recorded.

However, our knowledge is meagre when it comes to the location and circulation of the public's US currency holdings. Without reliable estimates of the varying amounts of US currency circulating overseas, we have no way of determining the size of the domestic money supply

2 "Currency in circulation" refers in the US context to the amount of the national currency held outside the Treasury and Federal Reserve. Except for small amounts of currency that may have inadvertently been lost or destroyed by the public (Laurent, 1974), currency in circulation includes the holdings of financial intermediaries and the public. Reliable data on financial intermediary holdings of vault cash are readily available, and it is therefore possible to obtain accurate estimates of the total stock of currency outside the banking system. For a complete description of the cash payments system, see Feige (1994b).

or its change over time. Our intention here is to demonstrate alternative ways of estimating the amount of US currency held domestically and overseas and present some temporal estimates of net US currency outflows. New estimates of domestic US currency holdings will then be used to reestimate the size and growth of the domestic US underground economy.

A puzzling macroeconomic anomaly is the huge amount of US currency outstanding—$390 billion—and its surprisingly persistent growth. Despite widespread predictions of the advent of the cashless society and decades of cash-saving financial innovation, per-capita holdings of United States currency increased from $160 in 1961 to $1,450 by the end of 1994. Adjusting for inflation, real per-capita currency increased by 70 percent and the proportion of the M1 money supply composed of currency rose from 20 percent to 30 percent. More than 60 percent of the outstanding stock of currency is now in the form of $100 bills.[3]

The suggestion that the average American family of four now holds $5,800 in currency, of which $3,480 is in the form of $100 bills, appears implausible. The number of notes in circulation is no less surprising than their value. There are presently some 17 billion common denomination notes in circulation. On a per-capita basis, this implies that each person holds, on average, 63 notes of which 9 are in the form of $100 bills. Adult US residents admit to holding only 12 percent of the nation's currency in circulation outside the banking system (Avery et al. 1986,1987). Allowing for US business holdings of currency, the whereabouts of more than 80 percent of the nation's currency supply is presently unknown.

These anomalous findings give rise to the "currency enigma" (Feige, 1990b, 1994a) which consists of a stock and a flow component. Our inability to identify the holders and locations of a large fraction of the US currency stock gives rise to a $300 billion "missing currency" problem (Sprenkel, 1993). This missing stock of currency is used as both a store of value and a means of payment for goods and services. If half of the missing currency were hoarded and the other half turned over at the rate

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3 Surprisingly large per-capita currency holdings are not limited to the United States. In 1993, per-capita currency holdings in Switzerland, Japan and Germany amounted to (expressed in US dollars) $3,060, $2,944 and $1,579 respectively.

estimated for domestic currency use, this missing currency would generate a flow of "missing payments" roughly equal to the United States' GDP.

Two complementary hypotheses are put forward as possible explanations for the currency enigma. Some fraction of the missing currency may in fact be held by US households for conducting unreported transactions in the US underground economy. A considerably larger portion of the missing currency is more likely to be held abroad in the form of co-circulating currency. US dollars will be a co-circulating currency when they are routinely used by foreigners to effect payments in their own countries. Co-circulating currency (Krueger and Ha, 1995) is also used as a store of value and, in some instances, a unit of account. We will examine the extent to which the currency enigma can be resolved by appeal to both the underground economy hypothesis and the "world dollarization" hypothesis.

We begin with a taxonomic framework for defining different types of underground activity, review alternative methods of estimation, and update available estimates of various "underground economies" in the United States. Our second section presents direct estimates of US currency inflows and outflows derived from Currency and Monetary Instrument Reports (CMIRs) collected by the US Customs Service. Section 3 presents evidence on foreign US currency holdings derived from indirect methods that include a monetary demography model (MDM) and a note ratio model (NRM). Section 4 combines direct and indirect methods to obtain a factor model composite measure of overseas currency flows. To anticipate the results, direct measures of overseas holdings suggest that no more than 25 percent of US currency is presently held abroad: indirect methods yield a wide range of estimates of between 30 and 70 percent held abroad, and the composite estimate is roughly 40 percent. A final section looks at the implications of overseas currency holdings for the measurement of the domestic underground economy.

Defining and measuring underground economies

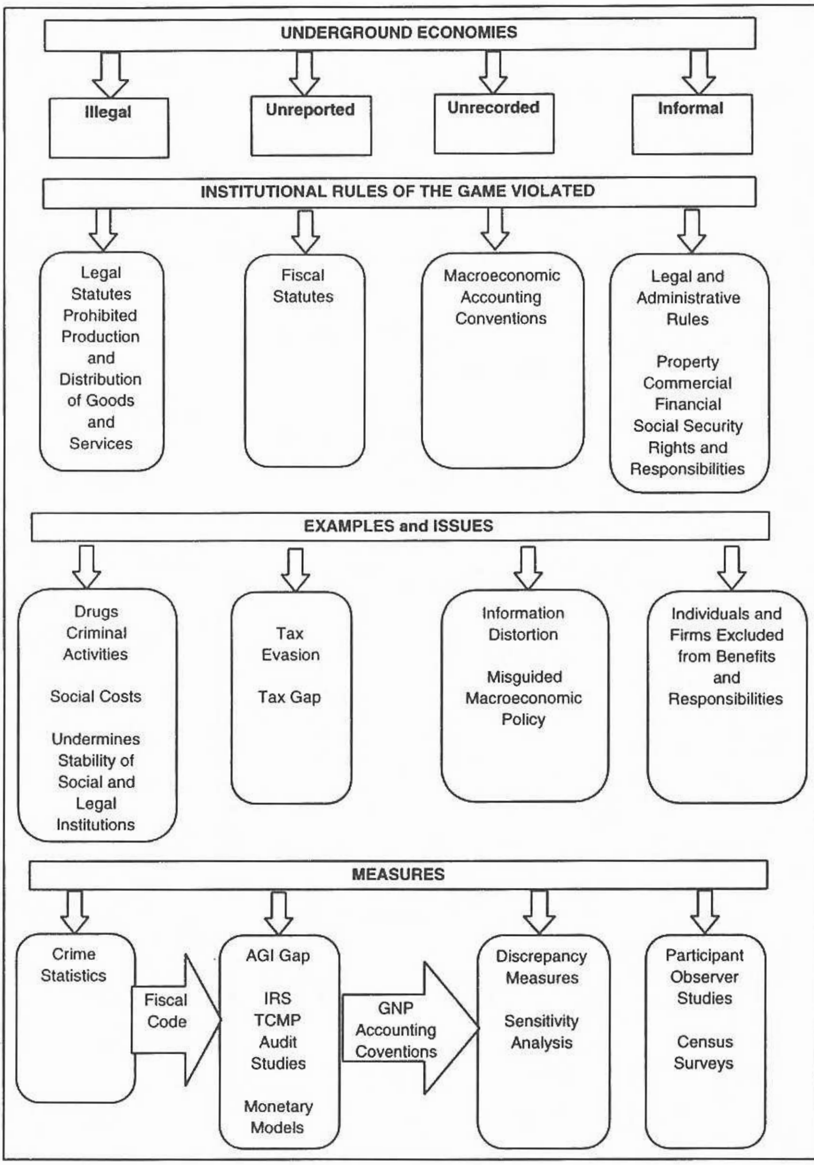
The early literature on the underground economy lacked an accepted taxonomy for classifying various underground activities. These activities were variously described as subterranean, irregular, informal, hidden, grey, shadow, clandestine, parallel, and black, but these modifiers were rarely augmented by explicit definitions to support analytical and empirical investigation. It is now well understood that there exists a variety of underground economies spanning both planned and market economies, be they developed or developing. Agents engaged in underground activities circumvent, escape, or are excluded from the institutional system of rules, rights, regulations, and enforcement penalties that govern formal agents engaged in production and exchange. Different types of underground activities are distinguished by the particular institutional rules they violate. With this criterion, we can identify four specific types of "underground" economic activity: illegal, unreported, unrecorded, and informal. The metric for measuring the dimension of each underground activity is the aggregate income generated by that activity. Table 1 presents a taxonomy of underground economies.

The *illegal* economy consists in the income generated by economic activities pursued in violation of legal statutes defining the scope of legitimate forms of commerce. The most notable illegal activities are the production and distribution of prohibited substances (drugs, for example) and such services as prostitution, pornography, and black-market currency exchange. Estimates of income produced from illegal activities are typically derived from crime-related statistics and range from \$70 to \$100 billion. In 1982, unreported income from drugs and gambling was estimated at roughly \$26 billion (Abt Associates, 1984), and the 1990 retail value of drugs sold in the US has been estimated at around \$40 billion.[4]

The *unreported* economy consists in economic activities that circumvent or evade fiscal rules as set out in the tax code. A summary measure of the unreported economy is the amount of unreported income—namely, the amount of income that should legally be reported to the tax authorities but is not. Since illegal income is taxable, the unreported economy includes both legal and illegal source income that is not properly reported. A complementary measure of the unreported economy is the "gross tax gap," the difference between the amount of tax revenues legally due the fiscal authority and the amount of tax revenues paid voluntarily. Since the "net tax gap" represents the difference be-

4 "What Americans Users Spend on Illegal Drugs": US Office of National Drug Control Policy, Technical Paper, June 1991, p. 5. Reuter (1996) describes the limitations of estimates of the size of the illegal economy.

TABLE 1


UNDERGROUND ECONOMIES
Illegal
Unreported
Unrecorded
Informal
INSTITUTIONAL RULES OF THE GAME VIOLATED
Legal Statutes Prohibited Production and Distribution of Goods and Services
Fiscal Statutes
Macroeconomic Accounting Conventions
Legal and Administrative Rules
Property Commercial Financial Social Security Rights and Responsibilities
EXAMPLES and ISSUES
Drugs Criminal Activities
Social Costs
Undermines Stability of Social and Legal Institutions
Tax Evasion
Tax Gap
Information Distortion
Misguided Macroeconomic Policy
Individuals and Firms Excluded from Benefits and Responsibilities
MEASURES
Crime Statistics
Fiscal Code
AGI Gap
IRS TCMP Audit Studies
Monetary Models
GNP Accounting Coventions
Discrepancy Measures
Sensitivity Analysis
Participant Observer Studies
Census Surveys

tween the amount of revenue due and the amount actually collected, the difference between the gross and net represents the revenues collected as a direct result of enforcement activities. Benefit fraud, false claims to benefits (welfare or unemployment payments) or subsidies to which the claimants are not legally entitled, should be formally included in "tax gap" measures.

The *unrecorded* economy consists in those economic activities circumventing the institutional conventions that define the reporting requirements of government statistical agencies. A summary measure of the unrecorded economy is the amount of unrecorded income—namely, the amount of income that should, under existing rules and conventions, be recorded in national accounting systems such as National Income and Product Accounts but is not. Unrecorded income represents a discrepancy between total income or output and the actual amount of income or output captured or enumerated by the statistical accounting system designed to measure economic activity. Since national accounting conventions differ with respect to the inclusion of illegal incomes, unrecorded income may or may not include components from the illegal sector.

The *informal* economy encompasses economic activities that circumvent the costs and are excluded from the benefits and rights of property relationships, commercial licensing, labour contracts, torts, financial credit, and social security systems. A summary measure of the informal economy is the income generated by economic agents operating informally.

Estimating the size of these various underground economies remains an inexact science at best. However, more precise definition of alternative underground economies has reduced the tendency to compare disparate measures, while improvements in tax compliance and monetary methodologies are narrowing the range of comparable estimates.

Updated estimates of unreported income in the US

Since underground economic activity typically exposes the participant to a risk of penalties if discovered, anyone engaged in such activity has an incentive to conceal that involvement. This propensity for secrecy creates special problems for the social scientist attempting to observe and quantify underground behaviours. Direct and indirect measures of various types of underground activity have been proposed, and each has well-known limitations (Feige, 1989).

Earlier empirical efforts to measure the extent and proliferation of these activities had revealed underground economies that were large enough to be economically significant and expanding considerably in the latter 1960s and through much of the 1970s. Costly regulation, rising tax rates, and a growing distrust of government were cited as the primary causes of increased underground activity. The conservative politics of the 1980s sought to reverse these trends by reducing government regulation, lessening the tax burden, and restoring a greater sense of trust and confidence in government by overhauling the tax system and reducing what were perceived as wasteful government expenditures. What we want to know is whether these efforts had any real effect on cutting the size and growth rate of the underground economy.

Various macroeconomic measures have been advanced as possible indicators of underground activity. These include the adjusted gross income (AGI) gap discrepancy measure produced by the Bureau of Economic Analysis (BEA); the audit-based discrepancy measure of unreported taxable income produced by the Internal Revenue Service (IRS), and estimates of unreported income derived from various specifications of monetary models. These measures are reviewed and updated below.

Discrepancy measures

The US Government produces two discrepancy measures that are cited as indicators of underground activity. The first of these, compiled by the BEA, calculates the difference between adjusted gross income (AGI) as reported to the IRS and an independent estimate of AGI derived from National Income and Product Accounts (NIPA) estimates of personal income.

This "AGI gap" is not officially acknowledged as a measure of the underground economy: however, with a few qualifications (Carson, 1984; Feige, 1989), the AGI gap can be interpreted as a lower bound measure of non-compliance in the reporting of taxable income—i.e., a measure of unreported income.

Figure 1 sets the AGI gap estimates published by the BEA in 1985 beside the most recently revised estimates. The latest government figures showed that the earlier gap estimates had been much too low, and had to be expanded by $115 billion in 1983: by 1992, the AGI gap had risen to $500 billion. As a percentage of AGI,[5] the gap reached its peak of 16.1 in 1987 and then fell to an estimated 14 percent of AGI in 1992.

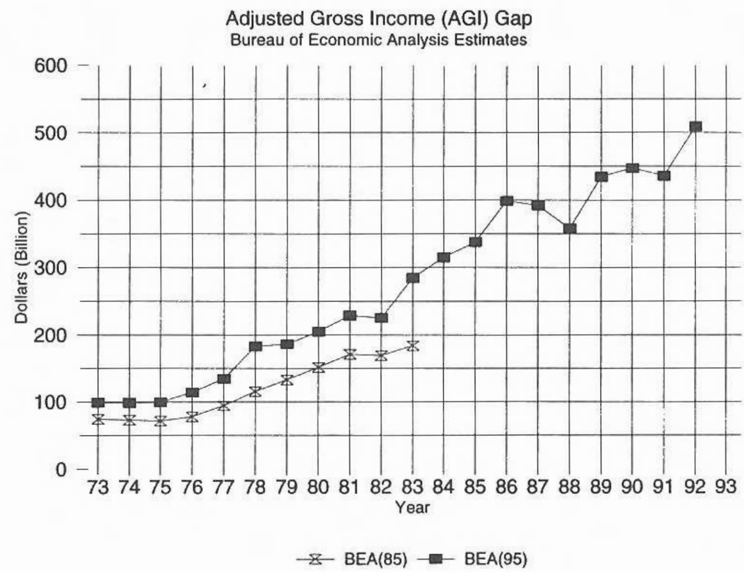


Figure 1

The IRS prepares an alternative discrepancy measure for unreported income using the data from its Taxpayer Compliance Measurement Program (TCMP). Responding to reports of a large underground economy that were based on monetary estimates, the IRS undertook a series of studies of the extent of non-compliance with US tax laws (IRS, 1979; 1981; 1983). The first study concluded that between $75 and $100

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5 A common error in presenting estimates of unreported income is to display unreported income as a percentage of GNP. Since GNP includes non-taxable government and private expenditures, the appropriate scale measure for presenting estimates of unreported income is AGI, which forms the basis for assessing taxable income.

billion in legal source income had not been properly reported on individual 1976 tax returns. The agency estimated the resulting revenue loss to the government at between $12 and $17 billion. At the same time, illegal source unreported income was estimated at $25 to $35 billion, with a further revenue loss of $6 to $8 billion.

The 1983 IRS report increased the estimate for 1976 legal source unreported income by $30 billion: the associated estimate of lost tax revenue more than doubled. On the other hand, the 1983 report slashed the estimate of illegal source income to only $13 billion and cut the corresponding revenue loss from the illegal sector to roughly $4 billion.

Feige (1989) demonstrated the sensitivity of the results from the early IRS TCMP studies to small variations in the questionable set of assumptions used for estimating the magnitude of non-compliance. An IRS admission that 1981 total unreported income amounted to some $283 billion with a corresponding revenue loss of $90 billion led the BEA to undertake a major review of NIPA accounts. The BEA's 1985 "comprehensive revision" included changes in definitions and statistical methods, but its single most important element was an adjustment for income previously unrecorded due to understated tax source data. For 1984, the personal income adjustment for unrecorded wages, salaries, and nonfarm proprietor income amounted to $101 billion, demonstrating the empirical connection between unreported and unrecorded income.

The latest IRS estimates of unreported income (IRS 1988) were based on the agency's TCMP audits of tax returns in the years 1973, 1976, 1979, and 1982 and include estimates of unreported income and corresponding losses in tax revenue projected out to 1992. These 1988 IRS estimates are presented in Figure 2 with the projections for the years 1983-1992.

For each audit year, a sample of roughly 55,000 tax filers was scrutinized by IRS auditors to pinpoint income that should have been reported and was not. Final estimates of unreported income for filers and non- filers from those years were obtained by combining information from audits, information returns, and special surveys. The IRS projections for the period 1985-1992 were based on Office of Management and Budget forecasts of personal income combined with an assumption of constant rates of non-compliance. The projections also assumed that taxpayer behaviour was unaffected by the tax reforms of

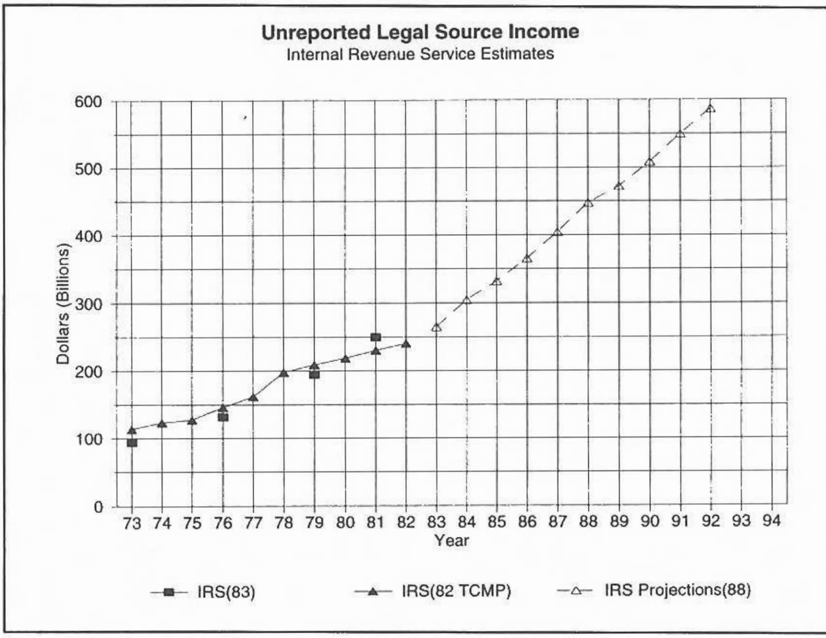

Figure 2

1986. By 1992, actual reported AGI fell more than $500 billion short of IRS projections. The overestimates of projected reportable income and the assumption that compliance rates were unaffected by tax cuts and tax reforms do suggest, however, that the IRS projections of unreported income were overstated.[6]

Whereas the earlier IRS studies had included estimates of both legal and illegal source unreported income, the 1988 study was limited to estimates of unreported legal source income. This study estimated illegal source income as $34.2 billion in 1981, roughly 15 percent of the

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6 On page A-101 of the IRS 1988 report, the agency acknowleges the major limitations of its unreported income projections: "Because we essentially hold constant rates of noncompliance through 1992, these estimates do not reflect recent trends in noncompliance. Second we assume that tax reform has no impact on individuals' behaviour in terms of either their propensity for noncompliance or the types of incomes individuals will receive in future years. Third, these projections are sensitive to changes in macroeconomic model projections of incomes in future years."

revised legal source estimate for that year. If illegal income remained at roughly the same percentage of legal income, it would add an additional $88 billion in unreported illegal source income to the estimated $585 billion of unreported legal source income for 1992. [7]

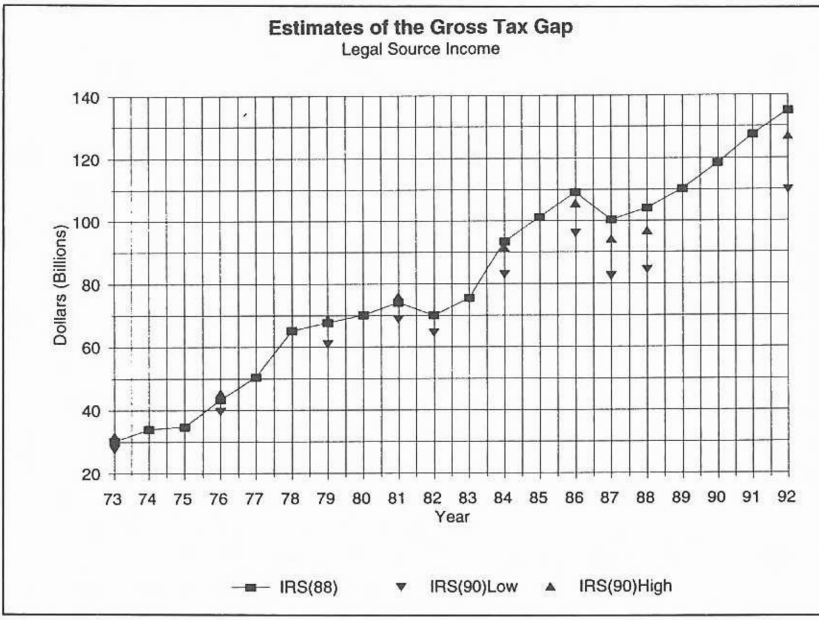

Figure 3

Figure 3 reports alternative IRS estimates of the "gross tax gap" on individual and corporate legal source incomes. The gross tax gap overstates revenue lost to the government through non-compliance to the extent that IRS enforcement activities collect some of the amounts due. The yield from these enforcement activities was estimated at $15.4 billion in 1981, $18.9 billion in 1984, and $21.9 billion in 1987.[8]

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7 The IRS estimates reported above are based on the recommendations of the tax examiners. Since some of these recommendations are challenged by the taxpayer, the IRS also prepared an alternative set of estimates on an assessed basis (IRS, 1988).

8 IRS (1990), p. 10, Table 2.

On the other hand, the gross tax gap understates the loss of revenue to the government because it excludes revenue lost in illegal source income as well as losses from non-compliance with other federal taxes including employment, excise, gift, and estate taxes and customs duties. For the year 1987, income taxes represented only 56 percent of federal budget receipts: another 36 percent came from employment taxes and 5 percent from gift, estate, and excise taxes. Virtually no information is available on losses from non-compliance with these other important revenue sources and we have no estimates of amounts of public money wasted through benefit fraud.

Currency ratio models

The most common method of estimating the size of the unreported 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 is affected only by the growth of unreported transactions; that the income velocities of reported and unreported transactions are identical; and that in some base period, unreported income was zero, so that the observed base period currency deposit ratio serves as a proxy for the desired currency ratio in the official economy.[9]

Figure 4 shows estimated unreported income as a percentage of recorded AGI as obtained from the simple currency ratio model under the assumptions that in 1940 there was no unreported income and all currency outside the banking system was then held by the domestic public. As pointed out in earlier studies, the ratio of unreported income rose sharply during World War II and then declined to remain relatively stable until the early 1960s. Unreported income then spurted upwards from less than 5 percent of AGI in 1960 to 15 percent by 1980. The

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9 As described in Feige (1989), the foregoing restrictions imply that the ratio of unreported (Yu) to reported income (Yo) can be estimated as follows: $Yu/Yo = (C\text{-}ko+D)/(ko+1)D$, where: C = Currency; D = Checkable Deposits; $ko = Co/Do$.

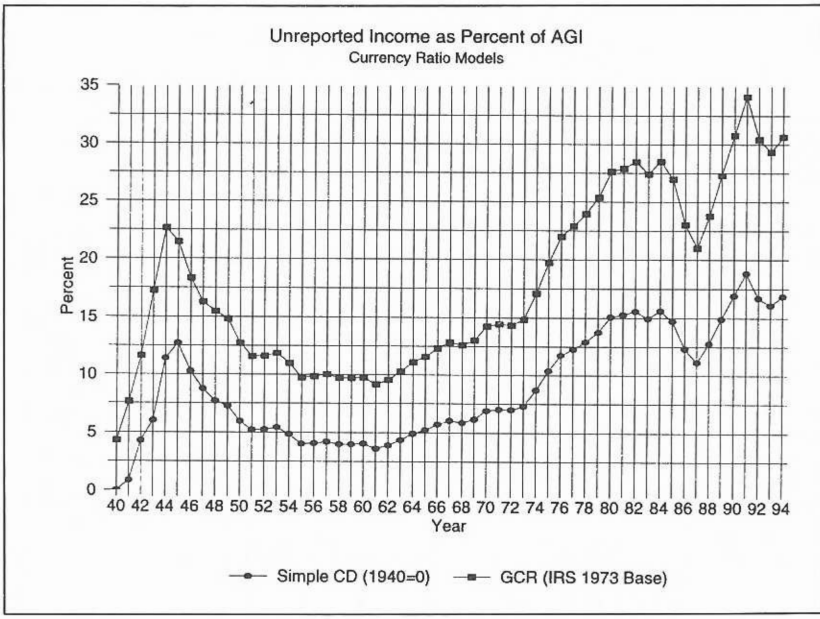

Figure 4

percentage of unreported income reached a plateau during the early '80s, and it actually declined around the time of the 1986 tax reform act before rising steeply between 1987 and 1991.

The figure also presents the results of a more general specification of the currency ratio model. The general currency ratio (GCR) model[10] takes the IRS estimate of unreported 1973 income as its benchmark and assumes that 75 percent of unreported income transactions are made in currency, with the remaining 25 percent made by checkable deposits. The resulting estimates display a time path similar to that of the more

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10 The GCR model permits a relaxation of several of the assumptions employed in the simple currency ratio model. In particular, currency need no longer be the exclusive medium of exchange for unreported transactions, and any year can serve as a benchmark for which an independent estimate of unreported income is available. The GCR model can be solved to obtain the equation for the ratio of unreported income, which is: $Yu/Yo = (ku+1)(C-koD)/(ko+1)(kuD-C)$ where ku and ko respectively represent the currency deposit ratios in the unreported and reported economies.

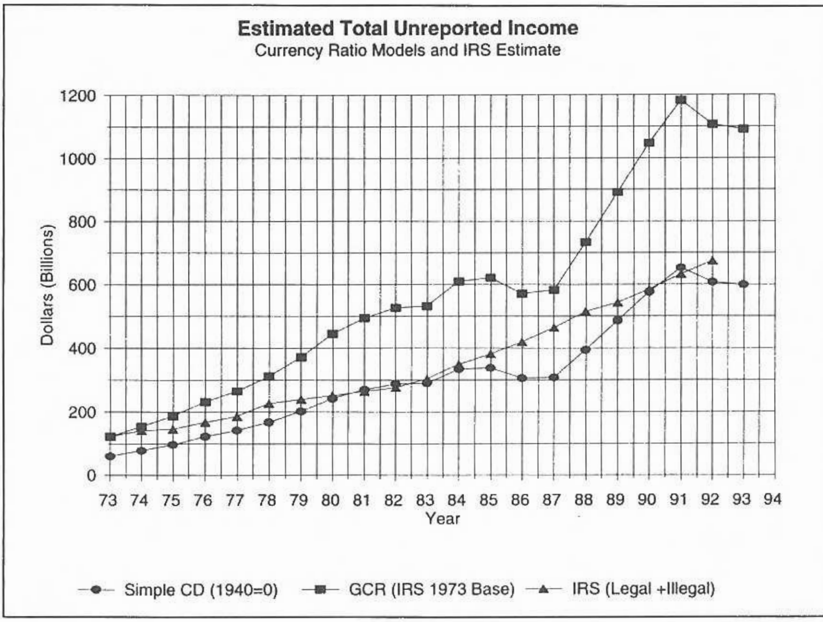

Figure 5

restrictive estimates: however, the percentage of unreported activities is considerably higher in all periods.

Figure 5 shows three estimates of total unreported income from both legal and illegal sources for the period 1972-1993.[11] The IRS projections are remarkably similar to those obtained with the simple currency ratio model, suggesting that by 1991, total unreported income amounted to roughly $650 billion, or 17 percent of reported AGI. Assuming this unreported income had been subject to a marginal income tax rate of 20 percent, we find that $130 billion in tax revenues—roughly equal to 62 percent of the federal budget deficit—escaped government collection.

The GCR model results suggest that unreported income grew gradually during the first half of the 1980s to decline in mid-decade and then

11 The IRS estimate is the sum of the legal source unreported income estimate in Figure 2 plus a 15 percent imputation for illegal source income. The imputation for illegal source income is based on the estimates reported in the earlier study (IRS, 1983). The currency ratio models yield estimates of total unreported income from all sources.

resume growing until the early 1990s: in fact, unreported income appears to have risen to about $1 trillion in the latter years after doubling in the last half of the previous decade. Now all these currency ratio model estimates are predicated on the assumption that US currency exclusively is being used to fuel domestic transactions in both the official and underground economies. There is, however, a growing body of anecdotal evidence to suggest that US dollars also circulate as a medium of exchange in foreign countries. If a large and perhaps variable fraction of US currency is held abroad, conventional currency ratio models employing the total currency supply would be overstating the size of the domestic US underground economy.

Federal Reserve Surveys of Currency and Transaction Account Usage (SCTAU: Avery et al., 1986; 1987) reinforce the notion that a substantial portion of US currency holdings cannot be accounted for by the behaviour of US households. In both 1984 and 1986, SCTAU determined that US households admitted to holding at most 12 percent of the national currency supply. Since business firms are very concerned with efficient cash management to minimize interest losses associated with cash inventories, they are likely to hold considerably smaller cash inventories than households. The scant evidence on US currency holdings by business firms (Anderson, 1977; Sumner, 1990) suggests that domestic firms hold less than 3 percent of the currency in circulation.

A conservative estimate of the stock of currency required to sustain cash payments in the US unreported economy can be obtained with the IRS projection of 1992 unreported income as $675 billion. If we assume that roughly 75 percent of this unreported income is paid with cash, and take currency turnover[12] to be roughly 50 times per year, we get a stock of currency used for underground transactions that is less than 4 percent of currency in circulation with the public. In short, since US households

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12 Also called the income velocity of currency. The methodology for estimating the velocity (turnover) of currency is described in Feige (1990b). The estimates are based on the Federal Reserve Survey of Currency and Transaction Usage, which finds that the income velocity of household cash holdings is roughly 50 turnovers per year. Share-weighted, denomination-specific velocities are obtained by estimating the average lifetime of each note denomination derived from Federal Reserve FR-160 data on currency issues (births) and redemptions (deaths).

admit to holding less than 12 percent of the nation's currency in circulation, firms hold roughly 3 percent, and underground transactions absorb another 4 percent, the ownership of more than 80 percent of circulating US currency is currently unexplained. This anomaly of missing currency gives rise to the stock component of the "currency enigma" (Feige, 1994a).

The flow component of this currency enigma denotes the volume of cash payments made with the outstanding currency stock. Admitted household holdings give rise to an estimated $1.7 trillion in cash payments for 1992, roughly 41 percent of recorded personal consumption expenditures. Business cash holdings generate some $400 billion, 70 percent of total intermediate payments, and the underground economy accounts for $675 billion in cash payments. If the stock of the remaining "missing" currency circulates at roughly the same rate as currency held by US households, it would generate an additional volume of unaccounted cash payments in excess of $10 trillion.

Several hypotheses have been advanced to explain these monetary anomalies. One holds that the US underground economy is substantially larger than currently estimated and domestic holdings of US currency are much larger than households tell currency surveys.[13] The "world dollarization" hypothesis suggests that a substantial fraction of US currency is held abroad by residents of other nations. The complementary "hoarding" hypothesis suggests that overseas hoards are being held as a store of value rather than as a medium of exchange. The dollarization hypothesis requires independent estimates of the fraction of US currency held abroad. The hoarding hypothesis requires evidence confirming that overseas holdings of US currency circulate at slower rates than domestic currency holdings.

Anecdotal reports of US currency circulating in parts of Latin America, the Middle East, Eastern Europe, and Russia are widespread, as are

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13 The currency usage survey of US households is likely to understate actual domestic currency holdings for several reasons. The survey undersamples high-income households and may underestimate household hoards. Porter and Judson (1995) suggest that these two sources could add another 5 percent to domestic holdings. The survey may also understate actual domestic currency holdings as a result of self selection bias and underreporting bias, but the extent of these biases cannot be determined.

suggestions that foreign demand for US currency can fluctuate quite dramatically. Initial efforts to estimate the amount of US currency held abroad (Feige, 1994) range as high as 45 percent. Since the size, variability, and velocity of foreign US currency holdings have important implications for the measurement of the domestic underground economy and the conduct of domestic monetary policy, we now turn our attention to further efforts to locate this "missing" US currency.

Direct estimates of net outflows of US currency

At present, there is no information system collecting complete data on total amounts of US currency flowing in and out of the country. Large US currency shipments are typically handled by a small number of commercial banks that specialize in the business of wholesale bulk currency transport. These large currency shipments have been informally reported to the Federal Reserve Bank of New York cash office since 1988. Although the period spanned by the confidential estimates is short and the data are not comprehensive, being limited to major wholesale shippers operating largely in the New York Federal Reserve District, they provide useful information on a substantial segment of bulk cash shipments to and from the US.[14] We will denote the Federal Reserve bulk shipment outflow series as FSO and the bulk shipment inflow series as FSI. Net bulk outflows (FSN) equal FSO-FSI.

Interviews with Federal Reserve officials suggest that much of the currency for wholesale overseas currency shipments by the major transporting banks is supplied by the New York Federal Reserve Bank in the form of $100 bills. All Federal Reserve banks maintain monthly, denomination-specific records of the number of notes paid into circulation (PIC) and the number received from circulation (RFC). These records, main-

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14 During the interwar period between 1923 and 1941, the Federal Reserve published data on net currency shipments to European countries (*Banking and Monetary Statistics: 1914-1941*, pp. 417-418). Over the entire period for which data are available, cumulative net inflows from Europe amounted to 4.8 percent of the average outstanding stock of currency during the period. The average annual net inflow of currency from Europe amounted to .25 percent of the average outstanding currency stock.

tained in the Federal Reserve system's FR-160 database, enable us to identify the net injections into circulation (PIC-RFC) of each denomination of currency by each Federal Reserve bank. Feige (1994a) observed a close relationship between the net value of $100 denomination notes injected into circulation by the New York Federal Reserve (NYN) and the net amount of currency shipped overseas as confidentially reported to the New York Federal Reserve Bank (FSN). Feige used NYN as a proxy for FSN, and this proxy was subsequently used by Porter and Judson (1995) as a measure of total currency flows overseas.

Although useful as a proxy for the confidential FSN series, net injections of $100 bills by the New York Federal Reserve (NYN) should not be viewed as an accurate measure of overall net currency flows abroad. The NYN proxy will overstate net outflows because some fraction of net injections of New York $100 notes are used to satisfy domestic demand. The proxy will understate true net outflows to the extent that it excludes the net export of smaller-denomination notes. Finally, the NYN proxy takes no account of net currency outflows from other Federal Reserve districts.

The most important direct measure of overseas currency inflows and outflows is collected as part of the regulatory responsibility of the US Customs Service. Enacted in October 1970, the *Currency and Foreign Transactions Reporting Act*, also known as the "Bank Secrecy Act," requires persons or institutions importing or exporting currency or other monetary instruments in amounts exceeding $5,000 to file a "Report of International Transportation of Currency or Monetary Instruments." Commonly known as "CMIRs," these reports have been collected by US Customs since 1977. In 1980, the reporting threshold was raised to $10,000.

Although the CMIR data system was established to record individual cross-border inflows and outflows of currency and monetary instruments, its micro-records can be usefully aggregated to study the size, origin, and destination of these cross-border movements. Since its inception, the CMIR system has collected 2.3 million inbound filings and more than 300,000 outbound filings. With the cooperation of US Customs and the US Treasury Department Financial Crimes Enforcement Network (FinCEN), the information contained in the millions of accumulated confidential CMIR forms was combined by a specially designed algorithm that aggregated CMIR currency inflows (CTI) and CMIR outflows (CTO) by mode of transportation, origin, and destination. Net CMIR outflows are represented by CTN=CTO-CTI.

The CMIR data system is the most comprehensive source of direct information on currency flows into and out of the US. It differs from the informal reports to the New York Federal Reserve in several important respects. CMIR records contain all reported currency inflows and outflows, including currency physically transported by currency retailers, non-financial businesses and individuals, and currency shipped by financial institutions specializing in wholesale currency transactions. The only transactions excluded are those that fall below the reporting requirements, direct shipments by Federal Reserve banks, and shipments that circumvent legal reporting requirements. [See 31 code of Federal Regulations 103.23(c)]. The CMIR data are thus more inclusive than the Federal Reserve (FED) informal series, which is limited to currency shipments to and from the New York Federal Reserve district by large wholesale bulk shippers.

Comparison of the estimated cumulative net outflows of US currency during the period spanned by each of the foregoing measures (1988-1994) reveals some important empirical differences. Informal FED reports (FSN) suggest that roughly $92.5 billion was added to foreign holdings, while the FR-160 proxy of net injections of $100 notes (NYN) suggests an $118.6 billion figure. The CMIR data as represented by CTN produce a much lower figure of $51.2 billion in cumulative net outflows. To track down the source of these important empirical discrepancies, we turn now to a detailed comparison of the conceptual differences in content and coverage among the three series.

Conceptual and empirical comparisons of direct measures of currency flows

Table 2 presents a conceptual comparison of coverage in the CMIR reporting system and the Federal Reserve informal system. The table reveals major differences in content and coverage between CMIR and FED currency flow data. To derive meaningful comparisons of information content in the two, we had to segregate total CMIR inflows (CTI)

Table 2: Content Comparison of CMIR and FED Currency Flow Reporting Systems

Characteristics	CMIR	Federal Reserve
Level of aggregation	Individual transactions	Aggregate transactions of wholesale bulk shippers
Number of records	2.3 million inflow records 300,000 outflow records	Approximately 62,000 records (7 years x 12 months x 8 banks x 93 countries)
Time periods	Monthly, 1977 - 1994	Monthly, 1988-1994
Private institutions	All reporting banks	Major New York banks
Federal Reserve banks	Not included	New York Federal Reserve
Retail currency dealers Non-financial firms Individuals	Reported cross-border currency transport $\geq$ \$5,000 (pre-1980); $\geq$ \$10,000 (1980-1994)	Not reported
Domestic coverage	Entire US (all Federal Reserve districts)	New York Federal Reserve Branch
Overseas coverage*	220 countries	93 countries

* The countries reported in the two data systems do not match exactly: differences reflect temporal name changes and different levels of country aggregation (e.g., United Kingdom vs England and Scotland). A separate comparison algorithm was written to resolve these difficulties and creates two country sets: those included in both the Federal Reserve and CMIR systems and those included in the CMIR system but not in the FED system.

and outflows (CTO) by mode of transportation.[15] An algorithm was therefore developed to aggregate the CMIR microdata into currency flows originated by wholesale bulk shippers and flows stemming from

15 To maintain the strict confidentiality of individual records in the CMIR data system, aggregations were performed at the offices of the US Treasury (FinCEN). Subsequent analysis was performed on the aggregated data. Since Federal Reserve banks are not required by law to file CMIR statements, the CMIR shipment series was augmented to include direct overseas currency shipments to and by the Federal Reserve Bank of New York. For a more refined breakdown of CMIR inflows and outflows by mode of transportation, origin, and destination, see Feige (1996).

Table 3: CMIR and Federal Reserve Currency Flow Notation

Mode of transportation	Wholesale bulk bank shipments	Physical transportation by individuals, currency retailers, and non-financial firms	Total
Gross Outflow Measures			
CMIR	CSO	CCO	CTO
FED	FSO	NA	NA
FED PROXY	NA	NA	NYO
Gross Inflow Measures			
CMIR	CSI	CCI	CTI
FED	FSI	NA	NA
FED PROXY	NA	NA	NYI
Net Outflow Measures			
CMIR	CSN	CCN	CTN
FED	FSN	NA	NA
FED PROXY	NA	NA	NYN

the physical transportation of currency by individuals, currency retailers, and non-financial firms.

Table 3 shows the notation used to describe alternative direct estimates of currency inflows and outflows. Total CMIR outflows (CTO) are divided into outflows originating from wholesale bulk bank shipments (CSO) and outflows physically transported by individuals, currency retailers, and non-financial firms (CCO).[16] Correspondingly, total CMIR inflows (CTI) are disaggregated into wholesale, bulk-shipped inflows (CSI) and physically transported inflows (CCI).

Since the Federal Reserve data are limited to wholesale bulk shipments, Federal Reserve recorded outflows (FSO) would be expected to be roughly comparable to CSO and, similarly, Federal Reserve recorded inflows (FSI) would be expected to be roughly comparable to the CSI

16 Non-financial firms include armoured carriers and travel transportation companies such as airlines and cruise ships.

derived from the independently collected CMIR data.[17] The FR-160 proxy flows (NYO, NYI, and NYN) cannot be disaggregated by mode of transportation; nor can we determine what fraction of net injections of $100 bills is used to satisfy overseas demand.

Table 4 shows the means of each of the quarterly flows in Table 3. Comparison of the mean Federal Reserve and CMIR inflow and outflow estimates reveals the CMIR data as considerably more inclusive than the FED. CMIR recorded average quarterly total currency outflows (CTO) exceed Federal Reserve recorded wholesale currency shipments (FSO) by some $1.39 billion per quarter. Similarly, CMIR recorded average total currency receipts (CTI) exceed Federal Reserve (FSI) wholesale currency receipts by $2.86 billion per quarter.

The finding that CMIR gross flows exceed Federal Reserve gross flows is to be expected because the CMIR data include the physical transportation of currency by individuals, currency retailers, and non-financial firms as well as currency flows with origins and destinations not included in the FED data. The asymmetry in the outflow and inflow discrepancies is due to the fact that individuals, currency retailers, and non-financial firms physically transport only 10 percent of reported total gross outflows but account for 31.8 percent of reported total gross inflows.[18] There is another reason for the discrepancy: though 82.9

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17 The Federal Reserve database excludes currency shipments from or to the 11 non-New York Federal Reserve districts as well as shipments from or to countries other than those in the FED system. The FED data also exclude all inflows and outflows of currency physically transported by individuals or non-financial firms. Feige (1995, 1996) takes account of these finer distinctions.

18 The series on individual inflows and outflows appear to differ greatly from bulk shipments by financial institutions. There are two possible explanations for this significant disparity. The data for physical transportation by individuals include travel transportation companies such as airlines and cruise ships that generate US currency outside the US and regularly transport it back for deposit in their domestic banks. The discrepancy may also be due to differing levels of compliance with CMIR reporting requirements. Individuals transporting currency out of the country are not monitored as carefully by US Customs as individuals returning to the US. There may thus possibly be a lower rate of reporting compliance for physically transported outflows than for physically transported inflows.

Table 4: Direct measures of Quarterly Gross Currency Flows 1988-1994

Mean Quarterly Gross Outflow ($ millions)					
CCO	CSO	CSO*	CTO	FSO	NYO
724	6535	6015	7259	5869	6265
Mean Quarterly Gross Inflow ($ millions)					
CCI	CSI	CSI*	CTI	FSI	NYI
1729	3700	2765	5429	2567	2028
Mean Quarterly Net Outflow ($ millions)					
CCN	CSN	CSN*	CTN	FSN	NYN
-1005	2835	3250	1830	3303	4237

percent of wholesale bulk outflows originate in New York, only 50.9 percent of such shipments are returned there.

Given these differences in coverage, we find that the less inclusive Federal Reserve data understate gross outflows less than they understate gross inflows. This asymmetry in underreporting leads to an overstatement of net currency outflows in the FED data. This is even more strikingly true of the shipment proxy (NYN). Any conclusions derived exclusively from Federal Reserve data or from series closely correlated with FED data (such as NYN) are therefore likely to overstate net outflows and lead to the erroneous conclusion that foreign holdings of US currency have increased at a faster rate than is the case.

Table 4 also includes more refined measures of the CMIR flows that are conceptually comparable to the flows captured by the FED data system. CSO* represents CMIR gross reported bulk-shipped outflows originating exclusively from the New York Federal Reserve District and destined exclusively for countries included in the Federal Reserve's informal data collection system. Similarly, CSI* represents CMIR gross reported bulk-shipped inflows headed for the New York Federal Reserve District from countries included in the Federal Reserve data system. CSN* represents the corresponding net outflows (CSO*-CSI*). These adjusted flows are conceptually most comparable to the flows informally reported to the Federal Reserve.

When these refined CMIR measures (CSO* and CSI*) are compared with the conceptually comparable measures obtained from the FED data (FSO and FSI), they are, as expected, empirically compatible as well. The average discrepancy in estimated outflows of bulk shipments from the New York district (CSO* minus FSO) is $.15 billion per quarter and the corresponding discrepancy between comparable inflow measures (CSI* minus FSI) is $.20 billion per quarter. The comparable quarterly net outflow bulk shipment discrepancy (CSN* minus FSN) is only $.05 billion per quarter. CMIR and Federal Reserve data suggest that during the period 1988-1994, wholesale bulk currency shipments from New York resulted in a net cumulative outflow of between $92.1 (CMIR) and $92.5 billion (Federal Reserve). For the longer period covered by CMIR reports (1977-1994), cumulative net currency outflows in wholesale bulk shipments from New York amounted to $97.7 billion.

Table 5 presents the correlation matrix of quarterly inflows, outflows, and net outflows for the period 1988-1994. Examining the relationship between alternate measures of net outflows, Table 5-C reveals that the Federal Reserve bulk shipment series (FSN) is very highly correlated with the proxy series of net injections of $100 notes in New York (NYN). As expected, both series have a much weaker relationship with the broader CMIR measure of all bulk shipments (CSN): however, the refined CMIR estimate of New York net bulk outflows (CSN*) is more closely related to the comparable FSN and NYN measures. This is confirmed when inflows and outflows are examined separately (Tables 5A and 5B).

We conclude that when comparable direct measures of inflows and outflows are examined, the CMIR data represent the most comprehensive and accurate estimate of bulk shipment activity to and from the New York district. Moreover, the CMIR data contain direct information on both bulk shipments and physical currency transportation that is not captured by either the Federal Reserve data or its New York $100 injections proxy. Table 5 reveals that the movements in the CMIR measures of physically transported currency (CCI, CCO) are virtually uncorrelated with the narrower New York bulk shipment measures. Indeed, as will be demonstrated below, the additional information contained in the more comprehensive CMIR measures tell a very differ-

Table 5A: Correlation Matrix of Quarterly Currency Inflows (1988:1-1994:4)					
	CCI	CSI	CSI*	FSI	NYI
CCI	1.000	-0.109	-0.139	-0.158	-0.132
CSI	-0.109	1.000	0.987	0.924	0.904
CSI*	-0.139	0.987	1.000	0.954	0.935
FSI	-0.158	0.924	0.954	1.000	0.967
NYI	-0.132	0.904	0.935	0.967	1.000

Table 5B: Correlation matrix of Quarterly Outflows (1988:1-1994:4)					
	CCO	CSO	CSO*	FSO	NYO
CCO	1.00	-0.001	-0.92	-0.171	-0.178
CSO	-0.001	1.000	0.983	0.925	0.916
CSO*	-0.093	0.983	1.000	0.945	0.946
FSO	-0.171	0.925	0.945	1.000	0.982
NYO	-0.178	0.916	0.946	0.982	1.000

Table 5C: Correlation Matrix Of Quarterly NET Currency Outflows (1988:1-1994:4)					
	CCN	CSN	CSN*	FSN	NYN
CCN	1.000	0.384	0.197	0.190	0.137
CSN	0.384	1.000	0.904	0.654	0.579
CSN*	0.197	0.904	1.000	0.850	0.804
FSN	0.190	0.654	0.850	1.000	0.978
NYN	0.137	0.579	0.804	0.980	1.000

ent story from that suggested by the less comprehensive, New York-centred measures.

Direct CMIR estimates of total net currency outflows

Having demonstrated the close correspondence between the CMIR and Federal Reserve estimates of bulk-shipped inflows and outflows to and from the New York district, we now turn to direct CMIR estimates of other flows of US currency for which no other direct information source is available. These include:

- wholesale bulk shipments to and from Federal Reserve districts other than New York;
- reported currency physically carried into and out of the New York district; and
- reported currency physically carried into and out of other Federal Reserve districts.

Table 6 presents a breakdown of the key components of CMIR cumulative net outflows for different periods. The CMIR reports reveal that New York wholesale currency shipments resulted in a $92.1 billion cumulative net outflow of US currency during the period 1988-1994 as compared with a $5.7 billion net outflow for the decade 1977-1987. Wholesale shipments of currency to and from all other Federal Reserve districts produced a cumulative net currency inflow of $12.7 billion during 1988-1994 from $1.1 billion over the earlier decade.

Table 6: Direct Estimates of CMIR Cumulative Net Outflows ($ billions)

Period	Wholesale shipments New York	Wholesale shipments other	Carried New York	Carried other	All wholesale shipments	All carried	Net outflow
1977-1987	5.7	-1.1	-7.5	-33.9	4.6	-41.5	-36.9
1988-1994	92.1	-12.7	-2.7	-25.4	79.4	-28.2	51.2
1977-1994	97.7	-13.8	-10.2	-59.4	84.0	-69.6	14.4

CMIR reports are the only data source for currency transported by currency retailers, non-financial businesses, and individuals. These sources of physical currency transportation accounted for a cumulative net inflow of currency into the US of $28.2 billion in 1988-1994 and an even larger inflow of $41.5 billion in the previous decade. The combined estimates from all CMIR sources therefore suggest that cumulative net outflows of currency in the period 1988-1994 amounted to $51.2 billion and for the entire period 1977-1994, only $14.4 billion. It appears that failure to take account of physically transported currency and wholesale shipments from districts other than New York will lead to a serious overstatement of the amount of currency transferred abroad.

This conclusion is subject to several caveats. First, it is possible that the CMIR filing compliance rate is higher for currency physically transported by individuals entering the US than it is for currency physically transported by individuals leaving the US, since customs forms are routinely collected from incoming travellers only. The period 1988-1994 shows roughly nine inflow filings for every outflow filing. The average size of each inflow filing for physically carried currency was $39,000, whereas the average size of each outflow filing was $119,000.

The large average size of physically carried inflows and outflows suggests that most of these filings were probably made by currency retailers or non-financial businesses rather than individuals. Inflows mainly represent the physical transportation of currency consolidated from tourist centres and returned to the US by armoured carrier or courier: travel companies such as cruise ships, airlines, and hotel chains routinely collect small amounts of currency from outbound travellers and return these funds for deposit in the US. Businesses that regularly transport currency into and out of the US are aware of the legal filing requirements and liable to penalties if they fail to report. Individuals carrying large sums of currency into and out of the US, however, are more likely to file incoming rather than outgoing CMIR forms. A lower rate of outgoing individual filing compliance would impart a downward bias to physically transported net outflows. Without further analysis of the distribution of incoming and outgoing individual carriers, it is impossible to determine the magnitude of the bias.

Secondly, we must take account of currency flows that fall below the CMIR reporting requirement threshold. Unrecorded inflows include

US currency carried into the US by foreign travellers in amounts under $10,000. Similarly, unrecorded outflows include smaller amounts of US currency taken abroad by US travellers and net remittances of US funds sent abroad.

Unrecorded net outflows

Unrecorded net currency outflows from travel are estimated from data on total spending (net of air fares) in the US by foreign travellers and total overseas spending by US travellers going abroad. Net currency outflows from remittances are estimated as a percentage of net remittances sent abroad.[19]

We have estimated travellers' unrecorded net currency outflows falling below the filing threshold under two alternative scenarios. The first scenario (TR1) assumes that both foreign travellers to the US and US travellers to foreign countries make 20 percent of their purchases of goods and services with US currency and that 20 percent of net remittances are paid in US currency. The second scenario (TR2) assumes respective percentages of 20, 15, and 20. Since foreign travellers to the US will expect to make purchases with US dollars and typically have less access to credit cards than US travellers going abroad, the second scenario appears the more plausible.

Table 7 summarizes the assumptions underlying each of the scenarios and presents our estimates of cumulative net currency outflows below reporting requirements under each set of assumptions. The results suggest that for the period 1977-1994, cumulative unreported net currency outflows below the filing threshold ranged from $2.9 billion to $24.7 billion.

Estimating changes in the domestic stock of US notes

A change in domestic holdings of US banknotes outside the banking system (ΔN^d) can be estimated as the difference between the change in

19 The travel data were generously provided by the United States Travel and Tourism Administration, Washington, DC.

Table 7: Cumulative Unrecorded Net currency Outflows from Travel and Remittances ($ billions)

Period	Scenario 1	Scenario 2
	Travel in, 20%; Travel out, 20%; Remittances, 20%	Travel in, 20%; Travel out, 15%; Remittances, 20%
1997 - 1987	18.9	10.2
1988 - 1994	5.8	-7.3
1977 - 1994	24.7	2.9

the total note stock in circulation with the public (ΔN) and the estimated change in overseas holdings (ΔN^o). Then,

$$(\Delta N^d) = (\Delta N) - (\Delta N^o) = (\Delta N) - (CSN + CCN + TR)$$

where CSN = net bulk shipments of currency abroad as reported on CMIR forms; CCN = net currency physically transported overseas by currency retailers, non- financial firms, and individuals as reported on CMIR forms; and TR = estimated unrecorded net currency outflows arising from travel and remittances falling below the filing threshold.

The stock of US notes in circulation with the public is calculated as the difference between the currency component of M1 minus coins in circulation. Net wholesale currency shipments (CSN) and net currency physically transported by currency retailers, non-financial businesses and individuals (CCN) are obtained from CMIR records. Unreported travel and remittance outflows (TR1 and TR2) are estimated from travel expenditure and remittance data as described in the previous section. All net outflows are assumed to be in the form of notes rather than coins.

Table 8 shows the allocation of net additions to the note supply for different periods under the assumption that a change in domestic holdings will equal a corresponding change in total holdings minus net outflows overseas. Using all available data, the results from direct measures of net currency outflows suggest that between 85.2 and 93.4 percent of the increase in the note stock between 1977-1994 was accounted for by increases in domestic holdings.

Table 8: Allocation of Net additions to Note Stock ($ billions)

Period	(ΔN)	CSN	CCN	TR1	TR2	($\Delta N^d 1$)	($\Delta N^d 2$)
1977-1987	110.6	4.6	-41.5	18.9	10.2	128.6	137.3
1988-1994	153.6	79.4	-28.2	5.8	-7.3	96.6	109.7
1977-1994	264.1	84.0	-69.6	24.7	2.9	225.0	246.8

Direct estimates of the share of US notes held abroad

Given direct estimates of net currency outflows and net additions to domestic stocks between 1977 and 1994, we can now simulate the current percentage of US notes held overseas, given alternative assumptions about the share of notes held abroad in 1977. Table 9 presents a range of estimates of the share of US notes presently held overseas for different starting values in 1977 and different combinations of measures of net outflows going abroad.

The results in Table 9 suggest that our estimates for US notes held abroad are sensitive both to CMIR estimates of physically transported

Table 9: Percentage of US Notes held Overseas, End 1994 (Alternative Estimates)

Estimated Outflows	1977=20%	1977=40%	1977=60%
CSN	25.5	29.8	34.1
CSN+CCN	4.8	9.1	13.4
CSN+TR(1)	32.9	37.2	41.5
CSN+TR(2)	26.4	30.7	35.0
CSN+CCN+TR(1)	12.6	16.4	20.7
CSN+CCN+TR(2)	5.7	9.9	14.2

currency and to various estimates of net travel and remittance outflows. On the basis of CMIR reports of wholesale shipments alone, the percentage of currency now held abroad ranges between 25.5 and 34.1 percent. However, the inclusion of reported net flows physically transported by currency retailers, non-financial firms, and individuals reduces the estimated range of overseas holdings to between 4.8 and 13.4 percent. The further addition of estimated unreported net currency travel and remittance flows that fall below the filing threshold produces a range of 5.7 to 20.7 percent.

If we entirely ignore the CMIR evidence on reported physical currency transportation but include estimates of unreported travel expenditures and remittances, we obtain an upper-bound estimate suggesting that between 26.4 and 41.5 percent of US currency is held abroad. The hypothesis that from 60 to 95 percent of US currency is held domestically contrasts starkly with evidence from surveys of US currency use that only 20 percent of US currency is so held.

In the light of the substantial range of estimated overseas holdings reflecting combinations of different components of overseas flow estimates, we now turn to the empirical relationship between the known change in the total stock of notes and empirical proxies for domestic and overseas changes. Let change in demand for domestic notes depend on change in domestic personal income (ΔPI) and the Federal Funds Rate (R). Change in overseas stock is measured by the various components of estimated currency outflows. Change in total note stock (ΔN) is represented as:

$$(\Delta N) = f(\Delta PI, R) + g(CSO, CSI, CCO, CCI, TR)$$

Table 10 reports the results of regressing the change in total stock of notes on determinants of the change in domestic note demand and CMIR measures of inflows and outflows. Change in personal income does not significantly affect change in note demand, but the Federal Funds Rate is significant and has the expected sign. All CMIR flow variables have the expected signs, although the coefficient for physically transported outflows is not significant, reinforcing the view that there may be a downward compliance bias in this component.

It is also noteworthy that the coefficient estimates of the flow variables suggest that only some fraction of each dollar of inflow or outflow effects the change in the total stock of notes held outside the

Table 10: Regression Estimates*

Dependent variable is change in total note stock, 1977:1 - 1994:4			
Variable	Coefficient	Std. Error	T-Statistic
ΔPI	0.0007	0.0015	0.493
FFR	-120.196	44.886	-2.739
CSO	0.778	0.067	11.572
CSI	-0.326	0.139	-2.350
CCI(-1)	-0.249	0.130	-1.913
CCO(-1)	0.208	0.254	0.819
TR2	1.398	0.855	1.634
C	3741.381	1893.149	1.976
AR(4)	0.873	0.078	11.217
MA(1)	0.561	0.118	4.756
MA(2)	00.629	0.120	5.249
Regression statistics	**R - squared**	**Durbin-Watson Statistic**	
	0.917	1.810	

*Heteroskedasticity Consistent Standard Errors and Covariances.

banking system. This observation is consistent with the hypothesis that some recorded cross-border flows simply represent a transfer between domestic and overseas currency hoards that are held outside the international banking system. Such transfers would leave the total note stock unaffected. Our results suggest that this is more likely to be the case for physically transported currency than for bulk currency shipments.

Indirect methods of estimating foreign holdings of US currency

As will be demonstrated below, we are able to estimate the share of currency held overseas by a variety of indirect methods. Unlike the direct observations of reported currency flows discussed in the preceding sections, indirect methods require behavioral assumptions about domestic and overseas demand for US currency. Since the US government satisfies all domestic and overseas demand for its dollars, the total amount of currency outstanding is completely demand-determined.

Monetary demography model (MDM)

Consider the general demographic problem of estimating the proportions β_1 and β_2 of members in two sub-populations C_1 and C_2, which comprise the total population C, and X_1 and X_2 the corresponding measured characteristic in sub-populations C_1 and C_2. The average population characteristic X can be represented as a weighted average of the sub-population characteristics with the weights being the unknown proportions β_1 and β_2.

$$(1) \quad X = \beta_1 X_1 + \beta_2 X_2$$

Since $\beta_1 + \beta_2 = 1$, it follows that the proportions can be estimated from the measured characteristics:

$$(2) \quad \beta_1 = (X - X_2)/(X_1 - X_2)$$

$$\beta_2 = (X_1 - X)/(X_1 - X_2)$$

A meaningful solution for parameters β_1 and β_2 exists so long as the characteristics of the sub-populations are different ($X_1 \neq X_2$) and the calculated proportions lie between 0 and 1.

This demographic framework suggests a monetary demography model (MDM) capable of estimating the proportion of US currency held domestically (β^d) and the proportion held overseas (β^o). To estimate these unknown proportions, we require measures of characteristics of the overall US currency population and of its domestic and overseas components. Examples of measurable characteristics which might be employed to estimate the MDM are the age, quality, velocity, denomination, series or seasonal characteristics of the US currency population and its domestic and overseas sub-populations.

Given estimates of any currency population characteristic X and the corresponding domestic (X^d) and overseas (X^o) currency characteristics, the proportion of notes circulating domestically (β^d) can be estimated as:

$$(3) \quad (\beta^d) = (X - X^o)/(X^d - X^o)$$

MDM using age and quality characteristics

Applying general demographic concepts to currency populations leads naturally to a consideration of possible differences in the age and quality of denomination-specific notes circulating domestically and overseas. Estimates of the age, quality, and quality by age distributions of the corresponding domestic and overseas sub-populations were obtained from a special study conducted by the Federal Reserve.[20] Based on a sample of some 4 million individual notes, note quality was ascertained by recording light reflectivity measures from an optical densitometer that scanned individual notes during routine processing by high-speed sorting machines at the Federal Reserve banks in all 12 Federal Reserve districts.

Individual serial numbers were recorded for a subsample of approximately 150,000 domestic and returning overseas notes to determine the date when the Bureau of Engraving and Printing had sent each note to a Federal Reserve bank. An inventory model was then used to estimate the date when the note had actually been put into circulation, thereby establishing its date of birth. Each note's age was then determined as the difference between this date of birth and the date of sampling. For each denomination—$1, $5, $10, $20, $50, and $100—it was thus possible to construct univariate age and quality distributions for notes sampled domestically and notes returning from abroad.

Casual observation suggests that domestic notes are likely to be used predominantly as a medium of exchange, whereas overseas notes are more likely to be held as a store of value. Accordingly, it was anticipated that the univariate age and quality distributions of domestic and overseas notes and the corresponding bivariate quality by age distributions would differ greatly. Domestic notes sampled on their return to the Federal Reserve were expected to be relatively younger than notes coming back from abroad and generally of poorer quality for a given age. Considering these expected differences in domestic and

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20 See the Federal Reserve Soil Level Impact Task Force (SLITF) study entitled "Comprehensive Assessment of US Currency Quality, Age & Cost Relationships" (1990).

overseas characteristics, age, quality, and quality by age distributions were thought to be promising characteristics for estimating the percentage of notes held overseas.

Surprisingly, analysis of the quality and quality by age distributions of the domestic and overseas samples revealed that they were not sufficiently different to yield robust estimates of percentages of notes held domestically and overseas. Initial efforts to estimate the MDM were therefore based on differences in univariate age distributions between overseas and domestic notes for each specific note-denomination population. Denomination-specific age distributions for the entire population were derived from FR-160 data on note births and deaths (redemptions) combined with estimates of average note lifetimes.

Given the age characteristics of the relevant populations, the problem is then to estimate the proportions of US currency circulating domestically (β^d) and overseas ($\beta^o = 1-\beta^d$) from the MDM(A) specified for each denomination as follows:

$$(4)\quad A = \beta^d A^d + (1-\beta^d)\, A^o,$$

$$\text{and } \beta^d = (A - A^o)/(A^d - A^o)$$

where A, A^d, and A^o respectively represent the denomination-specific age distributions for the total, domestic, and overseas note populations. Estimated percentages of notes of different denominations circulating abroad in mid-1989 were then obtained from estimates of the notes' overall, domestic, and overseas age distribution.[21]

Table 11 presents the resulting denomination-specific estimates of percentages of banknotes held overseas. The MDM(A) estimates for age distribution characteristics suggests that between 45.8 and 53.0 percent of the US currency stock was held overseas in 1989: 68.3 percent in large-denominations—$100s and $50s; approximately 28 percent in

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21 The estimates for the $1, $5, $50, and $100 denominations are averages from Baselines 1 and 2 of the SLITF study (n. 20). The Baseline 1 model for the $10 denomination and the Baseline 2 estimates for the $20 denomination failed to converge, requiring significant outliers to be deleted from the samples. We therefore report a range of estimates for these two denominations. The similatity of the age distributions for overseas and domestic notes suggests that the reported results are likely to be imprecise.

Table 11: Estimates of the Demographic Model: MDM(A) age distribution characteristics

Denomination	Overseas share in 1989 (%)	Notes in circulation ($ billions)	Value of notes overseas, 1989 ($ billions)	Denomination composition of overseas notes (%)
	(1)	(2)	(4)	(5)
$1	35.7	4.0	1.4	1.6
$5	37.6	5.0	1.8	2.1
$10	19.3 - 35.0	10.3	2.0 - 3.6	4.0
$20	49.0 - 69.3	54.7	21.9 - 37.9	24.1
$50	45.3	26.3	11.9	13.1
$100	51.1	98.2	50.1	55.2
Total	45.8 - 53.0	198.3	89.2 - 106.8	100.0

mid-sized denominations—$20s and $10s, and 3.6 percent in small denominations—$5s and $1s.

MDM using seasonality, series and coin/note ratio characteristics

Porter and Judson (1995) employ several variants of the MDM to estimate the proportion of US currency held overseas by exploiting assumed differences in seasonality, series, and coin/note ratio characteristics of domestic and overseas US currency holdings.

Since the seasonal characteristic of the total US currency population (S) is directly measurable while the seasonal characteristics of the domestic (S^d) and foreign (S^o) stocks are unobservable, Porter and Judson assume that for the period 1947-1994, seasonal variations in domestic US currency holdings are identical to the observed seasonal pattern for the Canadian currency supply.[22] They further assume no significant seasonal component in foreign demand for US currency, so that the seasonal characteristic of overseas US currency holdings (S^o) can be

22 The assumption is justified by the argument that the US and Canada have similar currency denomination structures and that the Canadian dollar is rarely used overseas.

Table 12: Estimates of the Demographic Model: MDM(S) annual seasonal characteristics

Denomination	Overseas share in 1989 (%)	Notes in circulation, 1989 ($ billions)	Value of notes over seas, 1989 ($ billions)	Denomination composition of overseas notes (%)
	(1)	(2)	(3)	(4)
$1	10.0	4.0	0.4	0.3
$5	54.2	5.0	2.7	2.2
$10	44.2	10.3	4.5	3.7
$20	59.1	54.7	32.3	26.1
$50	50.7	26.3	13.3	10.7
$100	72.0	98.2	70.6	57.0
Total	62.4	198.3	123.9	100.0

assumed to be equal to unity. The seasonal variant of the MDM(S) can then be estimated with the equation:

$$(5)\quad S = \beta^d S^d + (1-\beta^d)\, S^o$$

where the seasonal characteristics are time-dependent and $S = S^{US}$, $S^d \approx S^{CAN}$, and $S^o \approx 1$. From (3), it follows that the domestic share of currency holdings (β^d) is estimated as:

$$(6)\quad \beta^d = (S-1)/(S^d-1)$$

Table 12 presents Porter and Judson's reported estimates of the denomination-specific share of US currency held overseas in 1989. The denomination-specific MDM(S) yields an overall estimate of 62.4 percent as compared with the 45.8 to 53.0 percent range obtained with the age characteristic model. The MDM(S) results suggest that 67.8 percent of foreign holdings are in large denominations, with 29.7 and 2.5 percent in mid-sized and small denominations respectively.

A second variant of the MDM exploits differences in the series composition characteristics (SR) of domestic and overseas notes to estimate percentages of $100s and $50s circulating abroad. In 1991, the Federal Reserve introduced a 1990 series note which was distinguished from the pre-1990 notes in circulation by a polyester strip and micro printing to frustrate counterfeiters. Let the series characteristic (SR) be the proportion of the circulating note population (N) made up of new 1990 series notes (N^{90}) so that:

$$(7) \quad (SR) = N^{90}/N.$$

The series composition of the total currency population is known, but the domestic and overseas components are not. Porter and Judson assume that the series composition of overseas notes is adequately proxied by an estimate of the series composition of notes processed by the New York Federal Reserve, and that an estimate of the series composition of the notes processed by all other Federal Reserve banks adequately reflects domestic composition.[23] The MDM(SR) can then be represented as:

$$(8) \quad SR = \beta^d SR^d + (1-\beta^d)SR^o$$

where $(SR) = N^{90}/N$ is known and, by assumption, $SR^d \approx SR^{Non\ NY}$ and $SR^o \approx SR^{NY}$.

The proportion of notes held domestically can then be estimated as:

$$(9) \quad \beta^d = (SR - SR^o)/(SR^d - SR^o)/$$
$$\approx (SR - SR^{NY})/(SR^{Non\ NY} - SR^{NY})$$

Porter and Judson use two different procedures for estimating domestic and overseas series characteristics. Table 13 presents their upper- and lower-bound estimates for the \$50 and \$100 denominations.

A third MDM variant uses the ratio of coins to notes as the characteristic distinguishing domestic from overseas currency holdings. The coin/note ratio of the total US currency population is directly observable: it remains to identify the coin/note ratio of domestic and overseas holdings. The domestic coin ratio is proxied by Canada's coin/note ratio, and the overseas ratio is zero with virtually no US coin held overseas.

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23 Porter and Judson claim that almost all currency sent to and received from abroad is processed by the New York Federal Reserve Bank. The veracity of this assumption can be tested by an examination of CMIR data disaggregated by Federal Reserve district of origin and destination. The CMIR data reveal that only 52 percent of all reported currency inflows for the period 1977-1994 had the New York Federal Reserve District as their point of destination. The New York district was reported as the point of origin for 85 percent of total outflows during the period.

Table 13: Estimates of the Demographic Models MDM(SR) and MDM(C/N) series and coin ratio characteristics

Denomination	Series model (% overseas, 1994) lower bound	Series model (% overseas, 1994) Upper bound	Series model (% overseas, 1994) average	Coin Ratio (% overseas, 1989)
	(1)	(2)	(4)	(5)
$1-20	NA	NA	NA	NA
$50	28.0	48.0	38.0	NA
$100	55.6	70.7	63.2	NA
Total	NA	NA	NA	20.9

Let C/N represent the population ratio of coins to notes, $(C/N)^d$ the domestic coin ratio, and $(C/N)^o$ the overseas coin ratio. If β^d represents the fraction of US currency held domestically, then it follows from equation (1) that the MDM(C/N) can be represented as:

$$(10)\ (C/N) = \beta^d(C/N)^d + (1-\beta^d)\ (C/N)^o$$

By assumption, $(C/N)^d \approx (C/N)^{CAN}$ and $(C/N)^o \approx 0$. Therefore, (10) reduces to:

$$(11)\ \beta^d = (C/N)/(C/N)^{CAN}$$

As shown in Table 13, the MDM(C/N) estimates 20.9 percent of US currency held abroad in 1989. This estimate falls within the range of estimates obtained from the CMIR data.[24]

To test the robustness of the Porter and Judson MDM(S) results, we reestimated the model with the X11 ARIMA method for calculating the multiplicative seasonal component of notes in circulation for the US and

24 The reported results included an adjustment of the coin/note ratio to take account of the introduction of a $1 coin in Canada in July, 1987. The Bank of Canada continued to issue $1 banknotes until June 30, 1989, at which time there were 246 million $1 coins in circulation. By the end of 1989, the number of $1 coins in circulation had risen to 464 million. The reported results are based on a time series forecast of what the coin/note ratio would have been in the absence of the introduction of the $1 coin.

Canada.[25] Our reestimate of the MDM(S) confirms the Porter and Judson finding that the model is incapable of producing sensible monthly or quarterly estimates. Indeed, monthly and quarterly estimates of the overseas share of US currency reveal a strong seasonal component, suggesting that the assumption that ($S^{o} \approx 1$) may be unsustainable. Even annual time series estimates of overseas share obtained from the annual average of monthly seasonal components are quite different from Porter and Judson's result with their seasonal amplitude metric of the difference between the December and February seasonals.

Figure 6 presents the Porter/Judson time series of estimated overseas share, MDM(S):DEC-FEB, and the corresponding estimate based on average monthly seasonal components: MDM(S):Monthly Average. The figure also includes the range of 1989 point estimates from the age characteristic model, MDM(A1) and MDM(A2), the overseas shares derived from the coin ratio model, MDM(C/N), and the average share of $100 notes obtained with series characteristic model MDM(SR).

As shown in Figure 6, the monetary demographic models produce a wide range of estimates of the overseas share of US currency and different temporal patterns for change in overseas holdings. Given the diversity of these results and the strong assumptions required to pro-

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25 Porter and Judson obtained their seasonal components by applying the STL seasonal adjustment procedure to the currency component (coin plus notes) of the Canadian and US M1 series. In our replication, we used the X11 ARIMA procedure on the Canadian and US notes in circulation series, since neither Canadian nor US coins are assumed to circulate overseas.The results reported by Porter and Judson are based on the ratio of seasonal amplitudes of the US and Canadian series, derived by taking the difference between the December and February seasonals (Porter and Judson, 1995, pp. 16-17). Our replication suggests that the results are relatively insensitive to the use of different seasonal adjustment procedures and the substitution of the note series for the currency component series. However, the time series estimates of the share abroad is quite sensitive to the use of the seasonal amplitude metric employed by Porter and Judson. In particular, when the MDM(S) is estimated on a monthly or quarterly basis and the estimated monthly or quarterly overseas share are estimated as the ratio of each of the seasonal components minus one as suggested by equation (6), the estimated monthly and quarterly shares abroad fluctuate wildly within a year, often yielding estimates of the share abroad that exceed 100 percent.

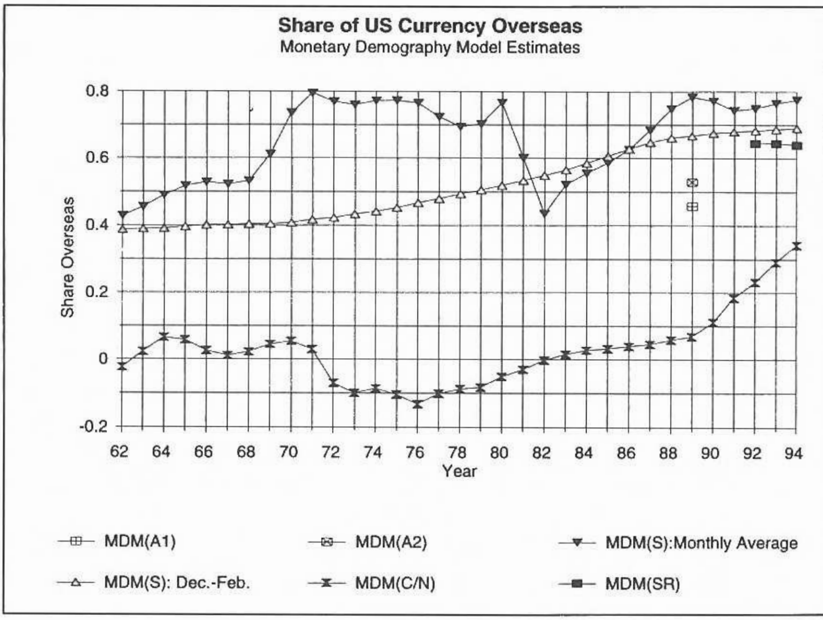

Figure 6

duce them, it is difficult to view them with much confidence. The age characteristic model required the elimination of sample outliers before convergence could be obtained. The coin ratio model produces negative overseas shares for the period 1972-1982, and the seasonal characteristic estimates yield implausible results at monthly and quarterly frequencies. Both the seasonal and serial characteristic models require strong assumptions concerning unobserved domestic and overseas characteristic specifications. Given these difficulties, we turn to some alternative approaches for estimating the share of US currency held abroad.

Note ratio models

The Note Ratio Model (NRM) provides an alternative means of indirectly estimating the currency percentage held abroad. The known amount of US notes in circulation (N) can be broken down into unknown quantities of notes in domestic and overseas circulation (N^d and N^o). Let Z denote any scale variable assumed to affect the demand for notes. Then:

$$(12)\, N/Z = N^d/Z + N^o/Z$$

As with the MDMs, we assume that the domestic US ratio (N^d/Z) can be proxied by the same ratio in Canada, so that:

$$N^d/Z \approx (N/Z)^{Can}$$

Substituting the Canadian ratio $(N/Z)^{Can}$ into equation (12), multiplying through by Z and dividing both sides by N yields a solution for the unknown fraction of notes overseas (β^o):

$$(13)\, (\beta^o) = N^o/N = [N - (N/Z)^{Can}.Z)]/N$$

The simple note ratio model (NRM) is estimated for several variants where Z alternatively represents:

- personal consumption expenditures (PCEs),
- personal disposable income (PDI), or
- population (POP) x the Consumer Price Index (CPI).

Figure 7 presents the estimated share of US currency held overseas obtained from each variant of the note ratio model: NRM(PCE), NRM(PDI), and NRM(POP). The results suggest that the overseas share

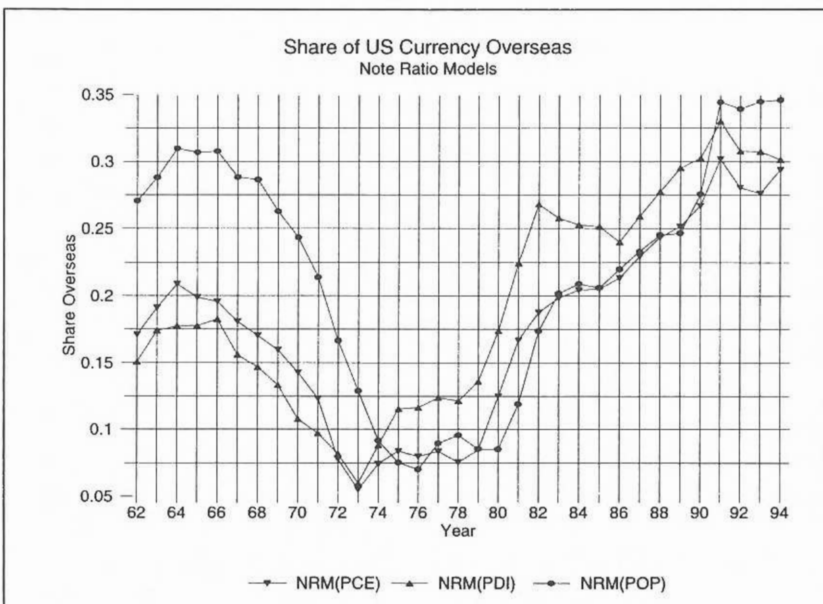

Figure 7

Table 14: Correlation Matrix of Indirect Annual Estimates of Overseas Currency Shares, 1962-1994

	MDM (C/N)	MDM (S)	MDM (S-PJ)	NRM (PCE)	NRM (PDI)	NRM (POP)
MDM (C/N)	1.000	0.079	0.601	0.879	0.744	0.835
MDM (S)	0.079	1.000	0.393	-0.136	-0.026	-0.301
MDM (S-PJ)	0.601	0.393	1.000	0.678	0.864	0.231
NRM (PCE)	0.879	-0.136	0.678	1.000	0.916	0.828
NRM (PDI)	0.744	-0.026	0.864	0.916	1.000	0.552
NRM (POP)	0.835	-0.301	0.231	0.828	0.552	1.000

declined for almost a decade between the early 1960s and early '70s, then rose significantly over the following two decades. The peak in overseas holdings appears to have come in 1990, when roughly 30 to 35 percent of US notes in circulation are estimated to have been held abroad. The time series of estimated shares of overseas currency derived from the NRMs are markedly lower than the results from the seasonal MDM and higher than the MDM(C/N) results.

Table 14 presents the correlation matrix of overseas currency share estimates obtained by each of our indirect methods. This matrix shows relatively close correlations among all the NRM estimates and the MDM(C/N) estimate. Comparison of the MDM(S) estimate with the MDM(S-PJ) estimate reveals that the two alternative methods of computing the seasonal estimates yield very different results. The correlation between the two seasonal estimates is only .393, suggesting that the model is quite sensitive to the arbitrary choice of a metric. The MDM(S) shows low and negative correlations with the other estimates, whereas the smoothed MDM(S-PJ) series displays positive correlations with the others.

Indirect estimates of net outflows of US currency

Given the wide range of overseas share estimates produced by our various models, we now turn to estimate the net currency outflows implied by each of the MDM and NRM variants. Given the known total stock of notes in circulation and indirect estimates of the share of

Table 15: Correlation Matrix of Annual Indirect Estimates of Net Outflows of Currency Overseas: 1962-94

	MDM (C/N)	MDM (S)	MDM (S-PJ)	NRM (PCE)	NRM (PDI)	NRM (POP)
MDM (C/N)	1.000	0.884	0.859	0.770	0.660	0.872
MDM (S)	0.884	1.000	0.990	0.793	0.732	0.853
MDM (S-PJ)	0.859	0.990	1.000	0.791	0.758	0.847
NRM (PCE)	0.770	0.793	0.791	1.000	0.726	0.763
NRM (PDI)	0.660	0.732	0.758	0.726	1.000	0.769
NRM (POP)	0.872	0.853	0.847	0.763	0.769	1.000

currency abroad, we can develop year-end estimates of the total stock of currency held abroad.[26] The difference in these estimated year-end overseas stocks yields estimates of annual net outflows of currency from the US.

Table 15 shows the correlation matrix for estimated net outflows derived from each of the indirect methods. The net outflow estimates from the different models appear to be more highly correlated than the share estimates, suggesting that the indirect methods may produce more accurate estimates of outflows than shares abroad.

Comparing direct and indirect estimates

Table 16 summarizes the cumulative net outflows for different periods as estimated by direct and indirect methods. For the period 1977-1994, cumulative outflows obtained with NRMs fall within the range produced by summing CMIR bulk shipments and unreported travel and remittance outflows. The two significant outliers are the CMIR estimates of the sum of reported bulk shipments and reported physically transported currency (CTN) and the MDM(S-PJ) estimate. The CTN estimate puts cumulative net outflow for the period at only $14.4 billion, while the MDM(S-PJ) estimates a cumulative outflow of $209.0 billion.

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26 Throughout the analysis, we assume that all US coin is held domestically.

Table 16: Cumulative Net Outflows of US Currency ($ billions)

	CSN	CTN	CSN + TR1	CSN + TR2	C/N	PCE	PDI	POP	MDM (S-PJ)
1977-1987	4.6	-36.9	23.5	14.8	16.8	35.5	37.2	36.7	90.9
1988-1994	79.4	51.2	85.2	72.0	113.1	67.0	51.5	74.5	118.1
1977-1994	84.0	14.4	108.7	86.8	129.9	102.4	88.7	111.2	209.0
1962-1994	NA	NA	NA	NA	122.2	103.9	93.5	108.8	235.0

Two hypotheses may explain the divergence between the indirect methods and the direct methods that include physically transported currency flows. The first stems from the possibility already mentioned of a downward compliance bias in reported CMIR outflows of physically transported currency. In such a case, physically transported outflows will be underestimated and so will the share of US currency held abroad. An alternative hypothesis is that physically transported net currency flows represent offsetting changes between domestic and overseas currency hoards that do not affect the total currency supply. Since each of the indirect methods is based on changes in the total currency supply, these methods would be incapable of reflecting currency hoard shifts from overseas to the US. While such hoard shifts do affect the

Table 17: Estimated Percentages of Currency Abroad: 1976 = 30%

Dec. 31	CMIR1*	CMIR2*	CSN	CTN	C/N	PCE	PDI	POP	MDM (S-PJ)
1976	30	30	30	30	30	30	30	30	30
1980	22	20	25	20	24	29	31	24	42
1985	6	2	18	-2	22	30	32	30	56
1990	14	8	26	3	27	35	37	37	66
1994	18	11	31	11	45	37	33	40	69

*CMIR1 = CCN+CSN+TR1 and CMIR2 = CCN+CSN+TR2

Table 18: Estimated Percentages of Currency Abroad: 1994 = 30%

Dec. 31	CMIR1*	CMIR2*	CSN	CTN	C/N	PCE	PDI	POP	MDM (S-PJ)
1976	79	106	21	110	-36	-3	17	-11	-133
1980	60	80	20	83	-25	6	22	-7	-83
1985	32	43	15	40	-11	15	26	9	-29
1990	32	35	24	31	6	25	33	23	10
1994	30	30	30	30	30	30	30	30	30

*CMIR1 = CCN+CSN+TR1 and CMIR2 = CCN+CSN+TR2

proportion of currency held abroad, they will not affect the total stock. If we accept this interpretation, indirect measures will overestimate the share of currency held abroad.

To test the sensitivity of the estimated percentage of US currency held overseas, we turn now to the implications of the alternative estimates of net outflows to different beginning and terminal assumptions about this percentage. Table 17 presents percentage estimates based on different net currency outflows and assuming that 30 percent of US currency was held abroad at the end of 1976. Table 18 presents percentage estimates that reflect the assumption that the terminal share of currency at the end of 1994 was 30 percent.

The starting assumption that 30 percent of US currency was abroad in 1976 leaves us with a range of estimates of 11 to 69 percent for the current situation. All estimated percentages except the CTN result are within the permissible 0-100 range. However, when a terminal share of 30 percent abroad is assumed, only CMIR1, CSN, and PDI yield estimates within the permissible range. What these simulations reveal is that the alternative estimates have a "knife edge" characteristic in the sense that plausible temporal estimates exist only for narrow ranges of terminal conditions. The full CMIR direct estimates give plausible results only for terminal conditions in the 20 to 25 percent range, whereas the NRMs give plausible estimates for terminal conditions between 35 and 50 percent. The MDM(S-PJ) yields plausible results only for terminal conditions in the range of 60 to 80 percent.

Composite estimates

Given the diversity of indicators of unknown net flows of currency overseas, we will now combine these measures to obtain a single estimate based on all available information. One approach here is to use a factor analysis model to estimate the common signal or latent variable (L_t) associated with different indicators of net overseas currency flow (M_{it}). In the factor model

$$(14)\quad M_{it} = \delta_i L_t + \varepsilon_{it}, (i = 1, 2, \ldots N)$$

each of the M_i indicators of net outflow[27] is linearly related to the latent common factor (L_t). The δ_is represent the factor loadings and the ε_{it} are the temporal measurement errors in each of the N measures of net currency outflow. The latent factor L_t is computed as a weighted average of the observed indicators with the weights constrained to sum to unity.

Since different estimates of net outflows are available for different time periods and different frequencies, we estimated several factor models for both annual and quarterly frequencies to test the stability of our results. The variables used and periods covered by these estimates are described in Table 19.

Figure 8 shows maximum likelihood estimates of annualized net outflows as derived from each of the foregoing factor models. The

Table 19: Factor Model Specifications

Factor Model	Period	Variables
Annual Model AF(1)	1962-1994	NRM(PCE); NRM(PDI); NRM(POP); MDM(C/N); MDM(S); TR2
Quarterly Model QF(1)	1961:1-1994:4	NRM(PCE); NRM(PDI); NRM(POP); MDM(C/N)
Quarterly Model QF(2)	1977:1 - 1994:1	CCN; CSN; NYN; NRM(PCE); NRM(PDI); NRM(POP); MDM(C/N)

27 A general discussion of factor analysis models can be found in Mulaik (1972). Bollen (1989) contains a review of factor analysis in the context of latent variables.

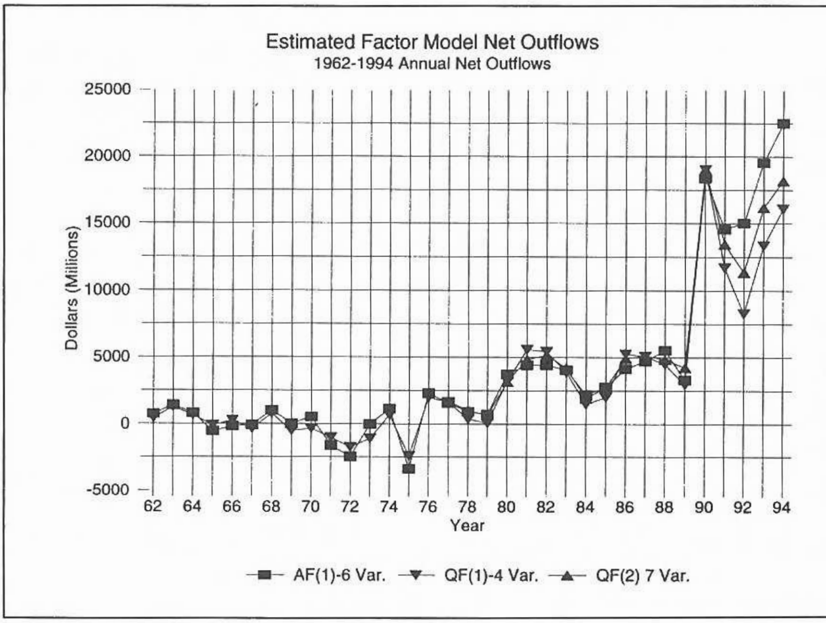

Figure 8

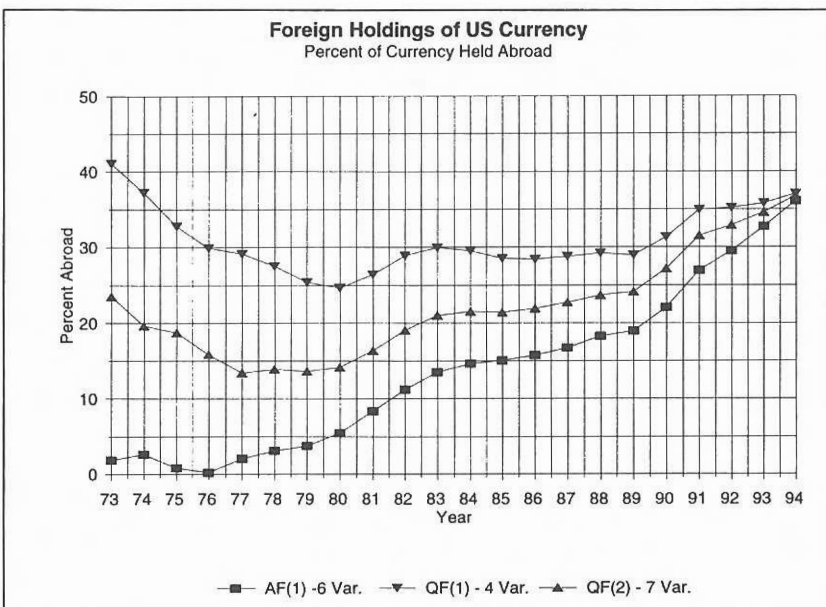

Figure 9

temporal patterns are broadly similar in all estimates, which suggests a rising level of net outflows during the decade of the 1980s and a significant upward shift in net outflows during the early '90s associated with increased use of US currency as a co-circulating medium of exchange in Eastern Europe and the newly independent republics of the former Soviet Union. The seven-variable annual factor model AF(1) produces the highest estimated net outflows for recent years, while the four-variable quarterly model QF(1) produces the lower-bound net outflow estimates.

Simulations employing the factor model outflows for different beginning and terminal values reveal that the most plausible estimate of the share of US notes presently held abroad is roughly 40 percent, which implies that something like 36 percent of all US currency (notes plus coin) is held abroad. Using this current value, Figure 9 displays the implied time series of the share of currency held overseas between 1973 and 1994 for each of the factor model net outflow estimates.

Implications for the domestic unreported economy

These provisional estimates of overseas dollar holdings suggest that earlier currency ratio model estimates of the unreported economy were erroneous in assuming that the entire stock of US currency was held domestically. We are now able to reestimate the currency ratio models with our new alternative estimates of the domestic US currency stock.

Figure 10 displays estimates of total unreported income obtained from a GCR model using alternative factor model estimates of the domestic US currency stock. Figure 11 shows GCR estimates of unreported income as a percentage of AGI.

Total unreported income appears to have grown secularly until 1985, declined briefly around the time of the 1986 tax reform, and then peaked in 1991. The temporal pattern of the alternative GCR estimates of unreported income as a percentage of AGI tell essentially the same story. Unreported income appears to have grown rapidly from 1966 and peaked as a percentage of AGI in 1980. The percentage of unreported income then declined until 1987, rose again until 1991, and fell again to a level approximating levels last observed in the early 1970s.

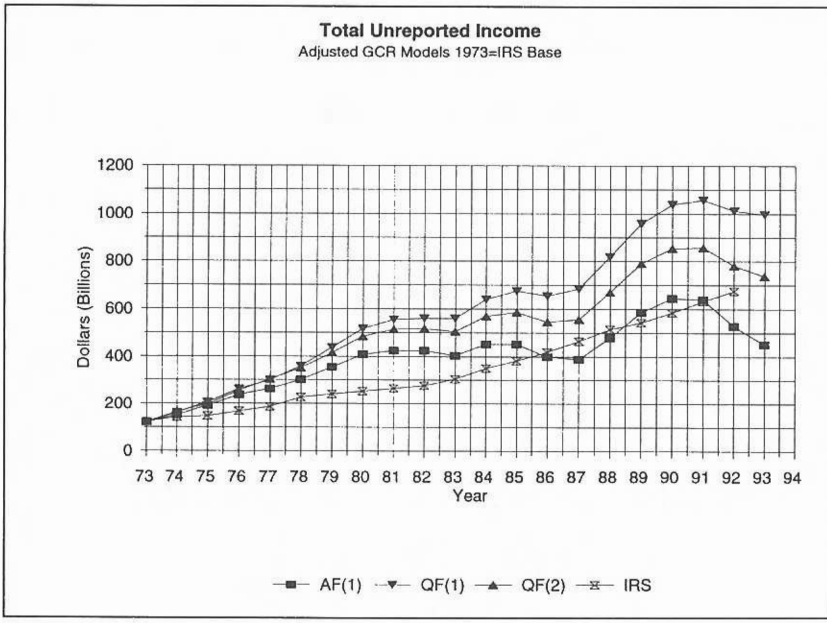

Figure 10

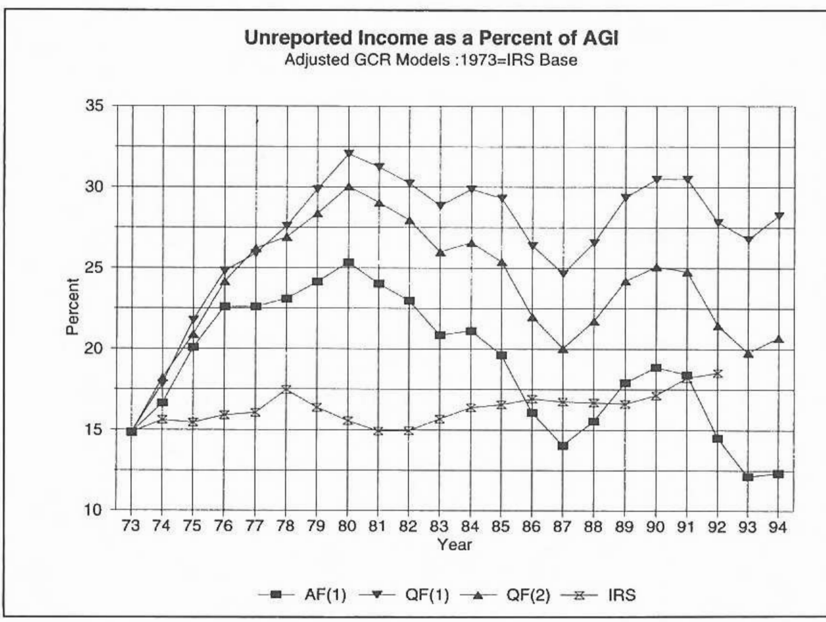

Figure 11

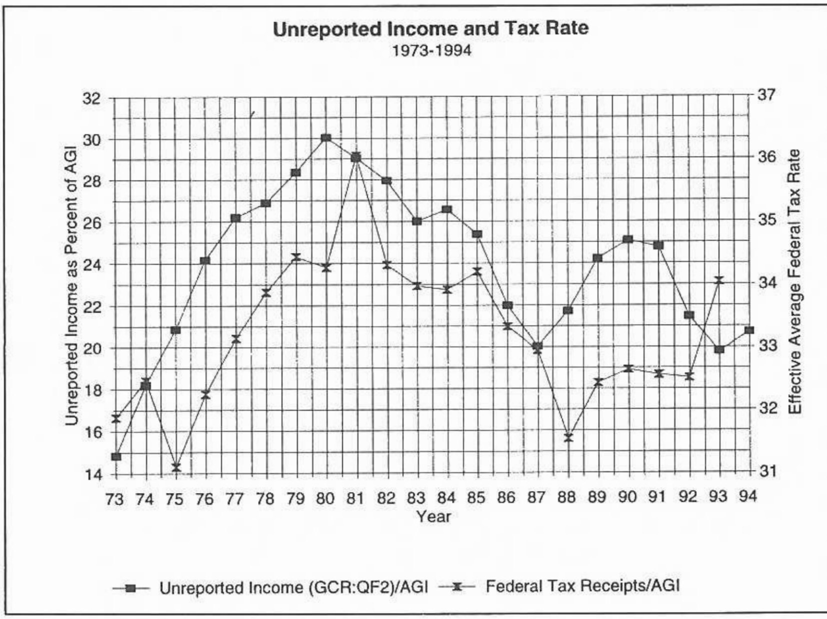

Figure 12

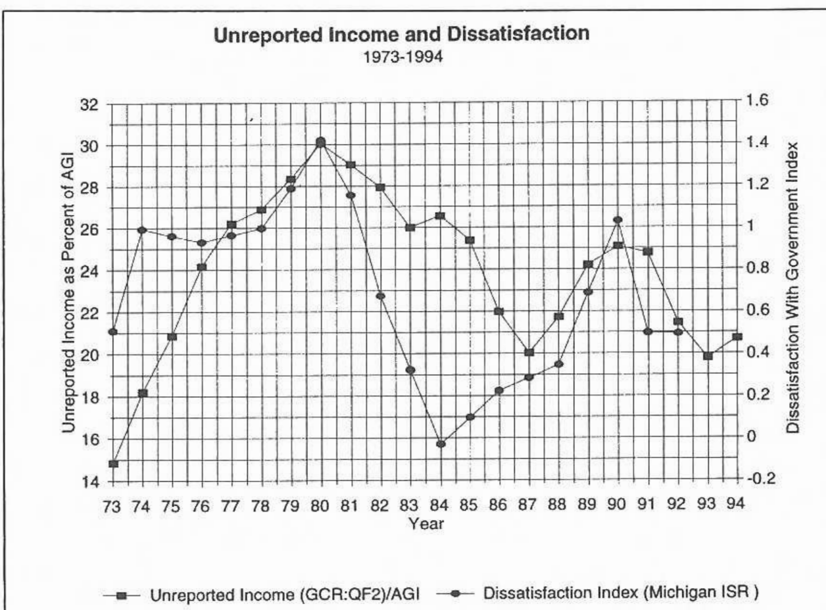

Figure 13

Of the three factor model estimates of the domestic currency supply, the QF(2) may be the most reliable, being based on quarterly frequencies and the largest amount of direct and indirect information concerning net currency outflows. Employing the QF(2) estimates in the GCR model suggests that total unreported income in 1994 was roughly $700 billion, or approximately 20 percent of AGI.

The main conclusion to be drawn from these revised estimates of unreported activity is that once account is taken of foreign US currency holdings, the range of uncertainty about the magnitude of unreported income is substantially reduced. The difference between the unadjusted GCR estimates of unreported income and the IRS estimates for 1992 amounted to more than $400 billion. The revised estimates in Figure 10 reveal that the difference between the IRS and the QF(2) estimates is now reduced to roughly $100 billion.

Figure 11 reveals that unreported income as a percentage of AGI varies considerably over time. The two most plausible explanations for these fluctuations are changes in average tax rates and variations in levels of dissatisfaction with government.

Figure 12 shows the relationship between the QF(2) revised estimates of unreported income as a percentage of AGI and the average effective federal tax rate, and Figure 13 displays the relationship between unreported income and an index of dissatisfaction with government.[28] As we can see in the first of these figures, tax evasion does appear to rise in response to higher average taxes and fall when incentives to cheat are reduced by lower rates. Similarly, Figure 13 confirms the expected relationship between tax evasion and level of dissatisfaction with government. The dramatic fall in the level of dissatisfaction with government between 1980 and 1984 coincided with a drop in the relative level of tax evasion. Conversely, increases in the level of dissatisfaction

28 The average effective federal tax rate is simply the sum of federal government tax receipts divided by AGI. The dissatisfaction with government index is constructed as an equally weighted average of three normalized indices representing answers to the University of Michigan's Institute for Social Research (ISR) surveys on whether government officials can be trusted, whether they are crooked, and whether the government is wasting taxpayers' money. I am indebted to the ISR for providing the underlying data.

with government observed in the later 1980s are associated with a relative surge in evasion. It seems that when taxpayers perceive their public representatives as dishonest and see benefits from their tax dollars decline, they are more likely to engage in tax evasion.

The finding that a substantial portion of US currency is held overseas provides a partial resolution of the currency enigma. It will be recalled that Federal Reserve surveys showed that US households admit to holding only 12 percent of the nation's currency, firms account for roughly 3 percent, and the unreported economy employs about 4 percent. We now find that another 35 to 40 percent is held abroad and believe that the percentage held domestically is larger than admitted.

Porter and Judson (1995), who place considerable emphasis on the MDM(S-PJ) and MDM(SR) results, have suggested that as much as 50 to 70 percent of US currency is held abroad. We are more inclined to believe that surveys of currency usage are subject to self-selection and underreporting biases which result in a substantial understatement of the actual amount of currency held at home. Whether these domestic cash hoards are derived from underground activities that we continue to underestimate or from legitimate activities that are simply underrecorded in our NIPA accounts remains to be resolved.

Our overseas finding raises another monetary puzzle. Are foreign holdings of US currency being used solely as a store of value or do they function as a co-circulating medium of exchange? An investigation of the age and quality of a large sample of individual banknotes (Feige, 1994b) suggests that the age/quality distributions of domestically circulating notes and notes returning to the US from abroad are quite similar. This suggests that the average velocity of domestically held currency is not that different from the velocity of currency held abroad. If foreign US currency holdings circulated at the same rate as US household holdings, they would generate a flow of annual cash payments approaching the size of the United States GDP.

Thus, the partial resolution of the currency enigma for the US merely creates another monetary anomaly for the rest of the world. The world economy appears to subsume a US-sized unrecorded economy which employs US currency as its medium of exchange. This global currency enigma deepens when we consider that our revised estimates of US per-capita currency holdings are still modest compared with the per-capita currency holdings of other developed European and Asian nations. The missing currency problem is not limited to the US dollar: it extends to other major currencies, most importantly the German mark and the Japanese yen.

Conclusion

In an effort to mitigate uncertainty about the size of the domestic underground economy, we have examined a variety of measures of net US currency outflows to determine what percentage of US currency is held abroad and thus the amount of US currency circulating in the domestic economy. While alternative methods of estimating overseas US currency holdings still yield a wide range, we conclude that the most plausible estimates are in the range of 25 to 45 percent. Given the importance of forming a more accurate estimate of the domestic US money supply, both for the purpose of gauging the size of the domestic underground economy and for more refined monetary policy analysis, it seems necessary to continue research into the matter of the precise amount of US currency held domestically and overseas.

The introduction in 1996 of a newly designed US currency series with modern counterfeit protection provides a unique opportunity to establish a currency census system which, like the population census, would aim at precision concerning amounts of US currency circulating domestically and overseas. A currency census system would not require the burden of human reporting: all necessary information on banknote life cycles could be electronically captured as notes are routinely and anonymously processed by high-speed sorting machines at the times of their issue and return to the Federal Reserve banks. A currency census system would fully preserve the anonymity of currency use by individuals and firms while maintaining automated records of a note's age, quality, birthplace, location, and final redemption. Such a system would provide the data required to construct currency migration matrices and all other demographic characteristics of the note population.[29] In short, the establishment of a currency census system would provide us with reliable estimates of the domestic money supply and so enhance our ability to conduct domestic monetary policy.

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29 The application of demographic theory and methods to currency populations is developed in Feige (1990b), which includes estimates of age-specific currency mortality and survival rates. Feige (1994b) presents a full demographic model describing the life cycle of the individual note and the dynamics of note populations and cohorts.

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