[3]

The Underground Economy and the Currency Enigma

Edgar L. Feige*

Abstract

The size, growth and causes of the U.S. "underground economy" are re-examined in light of new estimates of foreign holdings of U.S. currency. World dollarization partially resolves the "currency enigma" which refers to the anomaly that roughly 80% of the U.S. currency supply is "missing" and an estimated ten trillion dollars of cash payments cannot be accounted for. U.S. currency used overseas creates a U.S. sized world wide unrecorded economy. Large and variable overseas currency holdings imply that all monetary aggregates must be redefined to include only domestically held currency stocks.

I. Introduction

Despite widespread predictions of the advent of the cashless society, and decades of cash saving financial innovations, *per capita* holdings of United States currency increased from $154 in 1961 to $1180 by 1993. Adjusting for inflation, real *per capita* currency increased by 55% and the proportion of the M1 money supply composed of currency rose from 20% to 29%. Federal Reserve surveys (Avery *et al.*, 1986, 1987) of currency usage by American households determined that adult U.S. residents admit to holding only 12% of the nation's currency in circulation outside the banking system. Allowing for U.S business holdings of currency, the whereabouts of perhaps as much as 80% of the nation's currency supply is presently unknown. These anomalous findings give rise to a "currency enigma" (Feige, 1990b) which consists of a stock and a flow component. Our inability to identify the holders and location of a large fraction of the U.S. currency stock gives rise to a $240 billion problem of "missing currency." This missing stock of currency in turn gives rise to a missing flow of payments for goods and services. If the missing currency turns over at the same rate as U.S. household currency

* Professor of Economics, Department of Economics, University of Wisconsin, Madison, Wisconsin, USA.

120 THE UNDERGROUND ECONOMY AND THE CURRENCY ENIGMA

turns over, it would effect a flow of "missing payments" totaling more than two and a half times recorded personal consumption expenditures in the U.S.

Two complementary hypotheses are put forward as possible explanations of the currency enigma. Some fraction of the missing currency may be held by U.S. residents to conduct unreported transactions in the U.S. underground economy. Another portion of the missing currency may be held abroad by foreigners who conduct transactions with U.S. dollars to effect payments in their own countries. This paper examines the extent to which the currency enigma can be resolved by appeal to both the underground economy hypothesis and the "foreign dollarization" hypothesis.

The first section of the paper reviews and updates our state of knowledge concerning the various "underground economies" in the United States[1] and their relationship to the currency enigma. The following section presents estimates of the amount of U.S. currency held abroad and examines the implications of foreign holdings for the size and growth of the U.S. underground economy. To anticipate the results, foreigners do appear to hold a surprisingly large fraction of U.S. currency, perhaps as much as 45%. The allocation of U.S. currency to foreign holders reduces currency based estimates of the domestic underground economy even as it raises estimates of the volume of largely unrecorded transactions undertaken abroad with U.S. currency. Refinements in monetary methods for estimating unreported income help to narrow the range of uncertainty concerning alternative estimates of the size and growth of unreported income. The new estimates of underground activity reveal that the relative size of the underground economy can be readily explained in terms of changing attitudes toward government and changing rates of taxation.

The large estimated foreign holdings of U.S. currency suggest that if monetary aggregates are to be used as indicators of domestic monetary policy, they must be properly adjusted to account for variations in overseas holdings of U.S. currency. The final section therefore includes estimates of the *domestic* monetary base and the *domestic* M1 money supply, both of which are believed to be more reliable indicators of the stance of domestic monetary policy than conventional monetary aggregates.

II. Updated Estimates of Unreported Income in the U.S.

Earlier empirical efforts to measure the size and growth of underground activities revealed that underground economies were large enough to be of economic significance and had grown considerably during the latter half of the 1960s and throughout much of the decade of the 1970s. Costly regulation, rising tax rates and a growing distrust of government were sighted as the primary causes of increased underground activity. The conservative politics of the 1980s sought to reverse these trends by reducing government regulations, decreasing the burden of taxation and restoring a greater sense of trust and confidence in the government by reforming the tax system and reducing wasteful

EDGAR L. FEIGE   121

government expenditures. One of the questions we seek to examine is whether these efforts had any effect on reducing the size and growth of the underground economy.

Various descriptive statistics have been mentioned as possible indicators of underground activities. These include: (i) *per capita* currency holdings; (ii) the increasing share of large denomination bills; (iii) the adjusted gross income (AGI) gap discrepancy measure produced by the Bureau of Economic Analysis (BEA); (iv) audit based discrepancy measures of unreported taxable income produced by the Internal Revenue Service (IRS) and (v) estimates of unreported income derived from various specifications of currency ratio models. These are reviewed and updated.

The decade of the 1980s was characterized by financial innovations that were widely believed to hasten the arrival of the "cashless society." Cash substitutes in the form of credit and debit cards reduced the need for cash inventories as did the proliferation of automatic teller machines. Yet by 1993, the stock of U.S. currency in circulation outside the banking system was sufficient to provide the average American adult with a cash inventory of nearly $1,500, representing a 30% real increase over comparable cash holdings in 1980. By 1993, $100 dollar denomination bills made up 54% of the value of the outstanding stock of currency. The comparable share of $100 bills had been 24% in 1970 and 39% in 1980. Since currency is often identified as the preferred medium of exchange for illegal and unreported economic activities, one explanation of the unexpected increases in *per capita* currency holdings and in the rising share of large denomination bills is growth in the underground economy. An alternative explanation is a growing share of overseas holdings of U.S. currency, namely "currency substitution" and the dollarization of foreign countries .
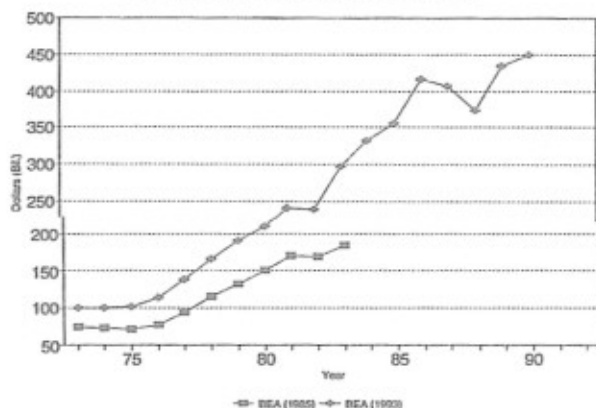
Discrepancy Measures

The U.S. Government produces two discrepancy measures that are often cited as indicators of underground activity. The first of these, compiled by the Bureau of Economic Analysis (BEA) calculates the discrepancy between adjusted gross income (AGI) as reported to the Internal Revenue Service (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 several qualifications, (Carson, 1984, Feige, 1989) the AGI gap can be interpreted as a lower bound measure of noncompliance in the reporting of taxable income.

Figure 1 displays the AGI gap estimates published by the BEA in 1985 and the most recently revised estimates. The latest government figures reveal that the earlier gap estimates had been much too low, requiring upward revision of $115 billion in 1983. By 1990, the AGI gap had risen to $450 billion. As a percentage of AGI, the gap reached its peak of 16.8% in 1986 and then fell to an estimated 13.1% of AGI in 1990.

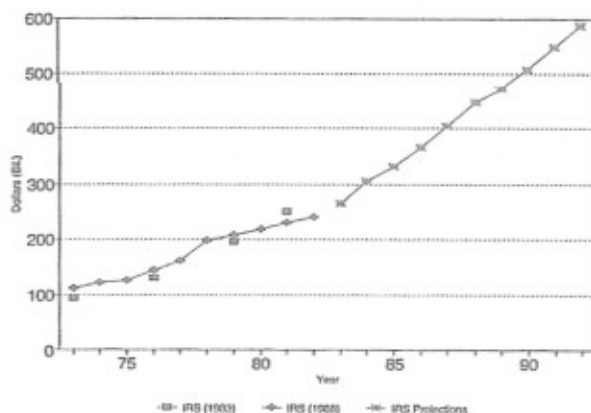122 THE UNDERGROUND ECONOMY AND THE CURRENCY ENIGMA

An alternative discrepancy estimate of unreported income is prepared by the (IRS) on the basis of their Taxpayer Compliance Measurement Program (TCMP). The original (IRS, 1983) estimates of unreported legal source income as well as the latest revised

Figure 1: Adjusted Gross Income (AGI) Gap
Bureau of Economic Analysis Estimates

estimates (IRS, 1988) are presented in Figure 2. The most recent IRS estimates include results based on their audits of tax returns in the years 1973, 1976, 1979 and 1982.[3] In each of those years, a sample of roughly 55,000 tax filers was subjected to examination

Figure 2: Unreported Legal Source Income
Internal Revenue Service Estimates

by IRS auditors who attempted to determine the amounts of income that should have been reported and the amounts that were unreported. Final estimates of unreported income of filers and non filers for those years were obtained by combining information from audits, information returns, and special surveys. The IRS estimates for the period

1985-1992 are projections based on Office of Management and Budget forecasts of personal income combined with an assumption of constant rates of non compliance between 1982 and 1992.[4]

Whereas the earlier IRS studies reported estimates of both legal and illegal source unreported income, the most recent study is limited to estimates of unreported legal source income. The (IRS, 1983) study estimated that in 1981, illegal source income amounted to $34.2 billion, or roughly 15% of the revised legal source estimate for 1981. If illegal income remained at roughly the same percentage of legal income, it would add an additional $88 billion of unreported illegal source income to the estimate of $585 billion of unreported legal source income for 1992.[5] The IRS estimates that the "tax gap" resulting from unreported income on the personal and corporate income tax amounted to roughly $130 billion in 1992.

Currency Ratio Models

The most common method for 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 (Cagan, 1958; Gutmann, 1977) of the currency ratio model assumes that currency is the exclusive medium of exchange for unreported transactions; that the ratio of currency to checkable deposits is only affected by the growth of unreported domestic transactions; that the income velocity of reported and unreported transactions are identical and that in some base period, unreported income was zero so that the observed currency deposit ratio serves as a proxy for the desired currency ratio in the official economy.[6]

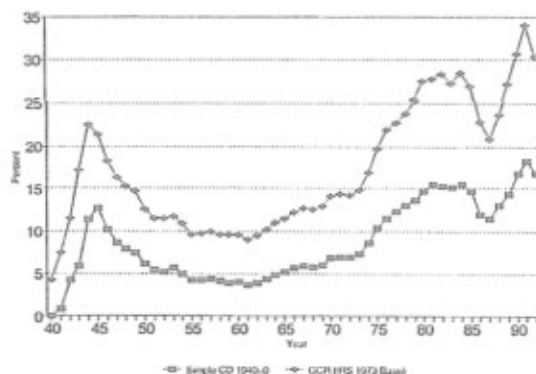Figure 3: Unreported Income as Percent of AGI
Currency Ratio Models

Figure 3 displays estimated unreported income as a percent of recorded AGI as obtained from the simple currency ratio model under the assumption that in 1940 there
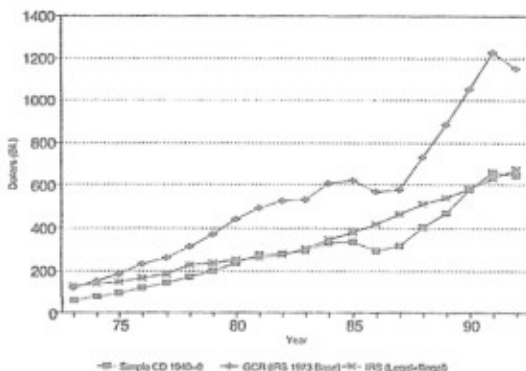
124 THE UNDERGROUND ECONOMY AND THE CURRENCY ENIGMA

was no unreported income. As has been noted in earlier studies, the ratio of unreported income rose sharply during World War II and then declined and remained relatively stable until the early 1960s. Unreported income then grew from less than 5% of AGI in 1960 to 15% by 1980. The percentage of unreported income reached a plateau during the early 1980s and actually declined around the time of the 1986 tax reform act. The percent of unreported income then rose steeply between 1987 and 1991.

Figure 3 also presents the results of a more general specification of the currency ratio model.[7] The general currency ratio model (GCR) employs the IRS estimate of unreported income for 1973 as an appropriate benchmark and assumes that 75% of unreported income transactions are effected by currency and that the remaining 25% are effected by checkable deposits. The resulting estimates display a time path similar to that of the more restrictive estimates however, the percent of unreported activities is considerably higher in all periods.

Figure 4 displays three measures of unreported income from both legal and illegal sources for the period from 1972 to 1992.[8] The IRS projections are remarkably similar to those obtained by the simple currency ratio model. By 1991, total unreported income

Figure 4: Estimated Total Unreported Income
Currency Ratio Models and IRS Estimate

amounted to roughly $650 billion or 17% of reported AGI. Assuming that this unreported income had been subject to a marginal income tax rate of 20%, $130 billion of tax revenues would have escaped government collection, roughly 62% of the federal budget deficit. The GCR results imply that unreported income grew gradually during the first half of the 1980s, declined in the mid 80s and then resumed its growth until the early 1990s. The estimates suggest that unreported income doubled during the last half of the decade and exceeded $1 trillion during the early 1990s.

All of the currency ratio model estimates are predicated on the assumption that U.S. currency is exclusively used to effect domestic transactions in either the official or the underground economy. There is however a growing body of anecdotal evidence sugges-

ting that U.S. currency also circulates as a medium of exchange in foreign countries. If a large and perhaps variable fraction of U.S. currency is held outside of the U.S. this would tend to overstate the size of the domestic underground economy as estimated by conventional currency ratio models.

Federal Reserve (Avery *et al.*, 1986, 1987) Surveys of Currency and Transaction Account Usage (SCTAU) reinforce the notion that a substantial portion of U.S. currency holdings can not be accounted for by the behavior of U.S. households. In both 1984 and 1986, SCTAU determined that U.S. households admitted to holding at most 12% of the nation's currency supply. Since business firms are very concerned with efficient cash management in order to minimize interest losses associated with cash inventories, it is most likely that U.S. firms hold considerably smaller cash inventories than households. The scant evidence on U.S. currency holdings by business firms (Anderson, 1977; Sumner, 1990) suggests that domestic firms hold less than 3% of currency in circulation. The amount of currency required to sustain the estimated volume of underground transactions is obtained by assuming that 75% of unreported transactions are effected by cash and by then dividing the resulting unreported cash payments by an estimate of currency turnover, namely the velocity of currency.[9] The velocity of U.S. currency is estimated to be roughly fifty turnovers per year. Employing the estimate of unreported legal and illegal source income derived from the IRS discrepancy measure for 1992 suggests that roughly 4% of currency in circulation with the public is employed for underground transactions.

On the basis of the foregoing estimates, it appears that we can only account for less than 20% of the U.S. currency stock held outside of the banking system. This anomaly gives rise to the stock component of the "currency enigma", namely that as much as 80% of the circulating medium of exchange can not be accounted for and must therefore be classified as "missing." A similar problem arises with attempts to allocate the flow of payments sustained by the outstanding currency stock to different sectors of the economy. The admitted household holdings of 12% of U.S. currency circulating outside of the banking system gave rise to an estimated volume of cash payments of $1.7 trillion in 1992, roughly 41% of recorded personal consumption expenditures. Estimated cash holdings of business firms analogously gave rise to some $400 billion of intermediate payments, amounting to roughly 7% of total intermediate payments. An additional $500 billion of cash payments was allocated to underground transactions. If the stock of the remaining "missing" currency circulated at the same rate as currency held by U.S. households, it would give rise to an additional $11 trillion of unaccounted for cash payments. One possible explanation of these monetary anomalies is that a substantial fraction of U.S. currency is held abroad by residents of other nations. Anecdotal reports of U.S. currency circulating in parts of Latin America, the Middle East and Eastern Europe are widespread, as are suggestions that foreign demand for U.S. currency can fluctuate quite dramatically. Both the size and variability of foreign holdings of U.S. currency have important implications for the measurement of the domestic underground economy and for the conduct of monetary policy.

126 THE UNDERGROUND ECONOMY AND THE CURRENCY ENIGMA

III. Estimating Foreign Holdings of U.S. Currency

Several different approaches are presently being explored to estimate both the stock of foreign holdings of U.S. currency and the migration of currency into and out of the country.[10] The most general and ambitious "demographic approach" would require a census of the currency population and the construction of currency life tables and migration matrices analogous to those created for human populations.[11] In the absence of a location specific enumeration of currency holdings similar to a population census, it is necessary to rely on more indirect methods of estimating foreign holdings of U.S. currency.

One such approach treats the unobserved foreign demand for U.S currency as a missing variable from an econometric specification of the currency demand function.[12] If the currency demand equation is initially estimated during a period when foreign demands (net inflows and outflows of currency) are relatively minor random occurrences, the equation is essentially well specified. However, if the currency equation is then simulated to produce out of sample forecasts into a period where foreign demand is significant, the forecast errors can be expected to bear a systematic relationship to the unobserved net inflows or outflows of U.S currency. A second approach developed by Porter (1993) relies on relative variations in cross-country seasonal patterns of currency holdings. Porter attempts to estimate the proportion of U.S. currency held abroad by a temporal comparison of the relative seasonal variations in the U.S currency stock compared with that of Canada under the assumptions that: (i) the seasonal variations in domestic U.S currency holdings have the same amplitude as the seasonal variations in Canadian currency holdings, (ii) that there is no seasonal pattern in foreign holdings of U.S. currency and (iii) that virtually all of the Canadian currency supply is held in Canada.
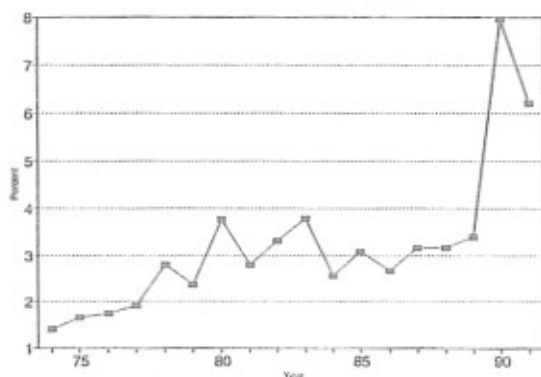
A third approach employed in this paper uses direct information on denomination specific currency stocks and flows obtained from the FR160 data system.[13] Monthly FR160 reports prepared by each of the thirty seven Federal Reserve Banks (FRB) are complied at the Board of Governors and used to oversee and administer the currency circulation system. The reports contain denomination specific information on the amounts of currency on hand at the beginning and end of each month as well as the inflow of currency received from circulation and the outflow of currency paid into circulation. The difference between the amount of currency paid into circulation by a particular FRB and the amount received from circulation by that FRB is referred to as the FRB net outflow. The FRB net outflow reflects the increase in the stock of currency held by the public in that Federal Reserve zone plus net outflows of currency from that zone.

Foreign demand for U.S. currency is satisfied by overseas currency exchange bureaus and banking institutions who in turn obtain the required currency from U.S. commercial banks that specialize in shipments of U.S. currency. The New York Federal Reserve Bank has traditionally been the primary supplier of U.S. currency to those

commercial banks that export currency to the rest of the world. Currency specialists who engage in these transactions report that virtually all such commercial bank shipments of U.S. currency overseas is in the form of $100 bills. During the period 1923-1941, the Federal Reserve routinely published data on shipments and receipts of U.S. paper currency to and from Europe.[14] Although these data are no longer published, the FR160 data base pertaining to the New York Federal Reserve Bank's net outflow of $100 can be used as a provisional estimate of net currency shipments abroad.[15]

Figure 5 presents annual estimates of the percentage of U.S. currency flowing abroad between 1974 and 1991 derived from the FR160 data base. Net outflows of

Figure 5: Estimated Net Outflows of U.S. Currency
Percent of U.S. Currency Supply

currency rose gradually from slightly over one percent of outstanding currency in 1974 to a peak of eight percent in 1990. The estimates reveal that net currency outflows can be both large and variable. The FR160 net outflow series can be benchmarked to Porter's 1973 estimate of the percent of U.S. currency abroad in order to obtain a time series of the percent of the U.S. currency stock held overseas. Figure 6 reveals that the estimated percentage of foreign holdings of U.S. currency declined from the 36% benchmark for 1974 to 30% in 1980 before rising to almost 43% by 1992. In order to further test the veracity of the FR160 estimates of net outflows of U.S.currency, they are compared with out of sample forecast errors obtained from a currency demand equation that has been estimated and used by the staff of the Federal Reserve.[16]

The results presented in Figure 7 display the close correspondence of both levels and changes between the currency equation forecast errors and the FR160 based estimates of net currency outflows. The correlation coefficient between the two series is .79. The comparable correlation coefficient between Porter's seasonal model estimates of net outflows and the currency demand function residuals is only .62. Since the FR160 based estimates of net outflows bear a closer relationship to both the currency residuals and the Federal Reserve's confidential shipments series[17], we use the FR160 flow

128 THE UNDERGROUND ECONOMY AND THE CURRENCY ENIGMA

Figure 6: Foreign Holdings of U.S. Currency
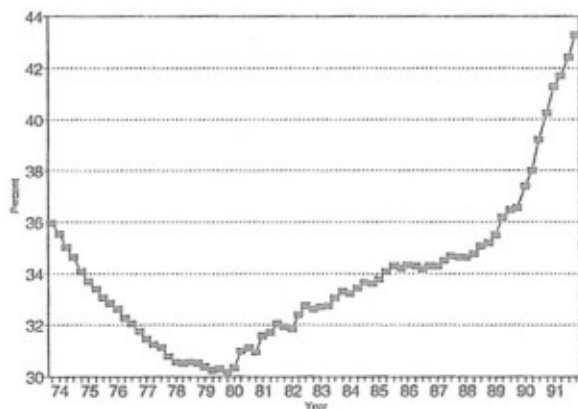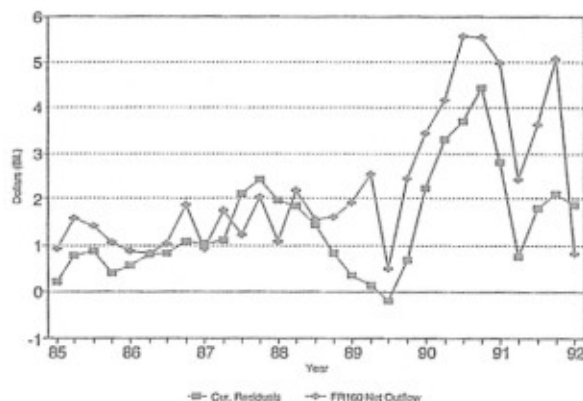Percent of Outstanding Currency Stock

Figure 7: Currency Residual and FR160 Net Outflow
Quarterly Out of Sample Forcast Errors

estimates in conjunction with the 1973 benchmark to estimate the percentage of U.S. currency held overseas.

IV. Implications of Foreign Held Currency
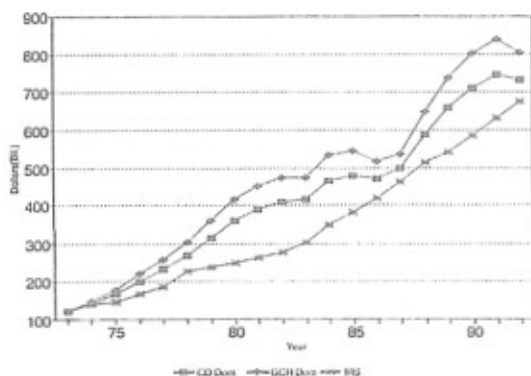
The Underground Economy

The sizable estimates of foreign holdings of U.S. currency suggest that conventional currency ratio models for estimating the underground economy are mis-specified

in so far as they erroneously assume that the entire stock of outstanding currency is held domestically. Given our independent estimates of foreign holdings of U.S. currency, it is possible to re-estimate the currency ratio models using only estimated *domestic* holdings of the U.S. currency stock. Figure 8 displays the revised estimates of unreported income.

Figure 8: Revised Total Unreported Income
Adjusted Currency Ratio Models and IRS

The main conclusion to be drawn from the revised estimates of unreported income is that once account is taken of foreign holdings of U.S. currency, the range of uncertainty concerning the magnitude of unreported income is substantially reduced. For 1992, the discrepancy between the GCR estimate and the IRS estimate of total unreported income is reduced by $350 billion representing a reduction in the range of error from 71% to 19%. The revised estimates suggest that in 1992, roughly 18-21 percent of AGI is not reported to the tax authorities representing total unreported income ranging between $675-806 billion.

Figure 9a displays the revised estimates of unreported income as a percentage of AGI derived from the GCR model after taking account of foreign holdings of U.S. currency. As before, the unreported economy as a percent of AGI is seen to rise steeply between 1961 and 1980, then decline until 1987 before once again drifting upward. The distinctive temporal pattern of the unreported economy mimics the patterns of two variables often cited as possible causes of underground activity. Figure 9b displays the effective average tax rate and Figure 9c displays an index of dissatisfaction with the government.[18]

A simple linear regression including a constant and one period lagged values of the dissatisfaction index and tax rate variables explains 89% of the variation in unreported income.[19] The results suggest that the increasing dissatisfaction with the government which arose as the result of the Viet Nam War and the subsequent Watergate episode and sharply rising tax rates, significantly eroded voluntary compliance with fiscal

Figure 9a: Unreported Income as a Percent of AGI
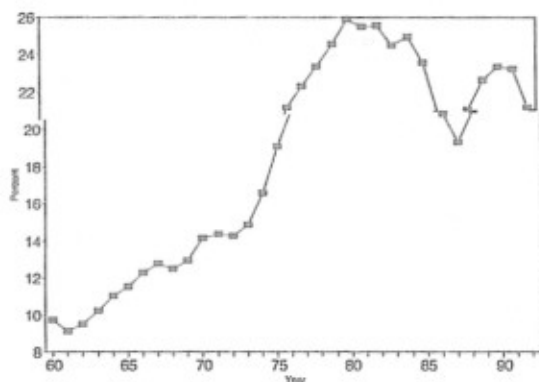Revised Domestic Currency GCR Model

Figure 9b: Effective Average Tax Rate
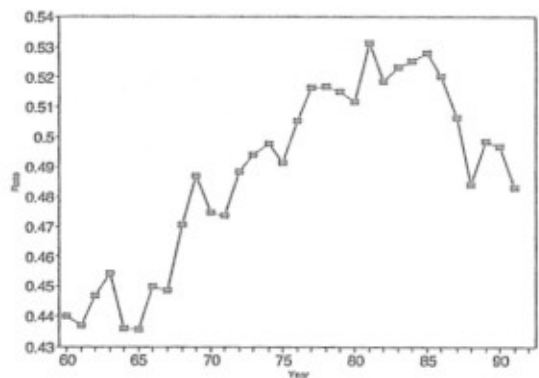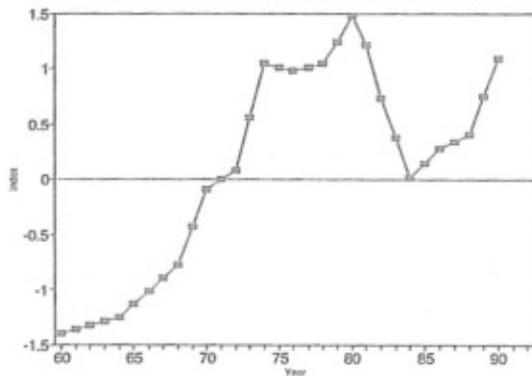Total Tax Receipts Per Dollar of AGI

Figure 9c: Dissatisfaction with Government
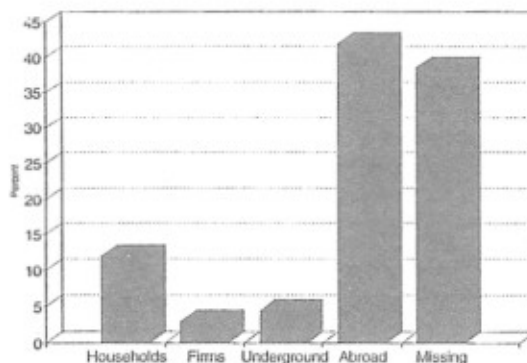Index Derived From Michigan ISR Data

regulations. Conversely, during the early years of the Carter administration and those of the Reagan administration, public attitudes toward government improved and correspondingly, tax evasion fell. Lower tax rates reduced incentives to participate in underground activities and correspondingly increased incentives to engage in taxable economic activity. As a result, relative unreported activities fell sharply.

The Currency Enigma

The finding that a substantial portion of U.S. currency is held abroad provides a partial resolution of the problem of missing currency. Figure 10 displays our provisional allocation of U.S. currency taking account of both the revised estimates of the underground economy and the estimates of U.S. currency held by foreigners.[20] U.S. households admit to holding 12% of the total supply of currency circulating outside the

Figure 10: Allocation of U.S. Currency Holdings
Provisional Estimates for 1992

banking system. Firms account for roughly 3%, the unreported economy employs roughly 4%, foreign holdings amount to 42%, leaving some 39% still missing.

If 42% of the stock of U.S. currency is currently overseas, is it being used as a parallel transactions medium of exchange or is it hoarded as a store of value? Preliminary evidence based on an investigation of the age and quality of some 200,000 individual notes suggests that the age/quality distributions of domestically circulating notes and notes returning to the U.S. from abroad are quite similar. These findings suggest that the velocity of domestically held currency is on average not that different from the velocity of currency held abroad. If foreigner's holdings of U.S. currency circulate at the same rate as U.S. household holdings, they would generate a flow of annual cash payments approaching the size of the GDP of the U.S. Thus, the partial resolution of the currency enigma for the U.S. merely creates another monetary anomaly for the rest of the world. The world economy appears to subsume a U.S. sized
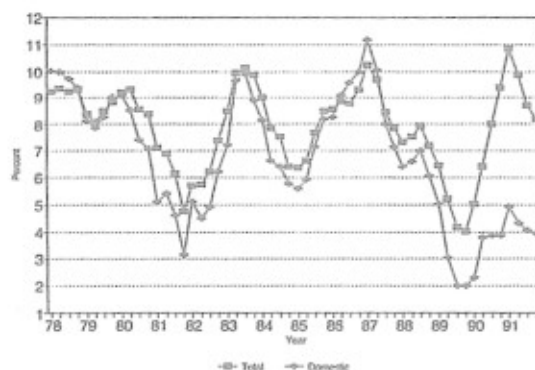
132 THE UNDERGROUND ECONOMY AND THE CURRENCY ENIGMA

unrecorded economy which employs U.S.currency as its medium of exchange. The world's currency enigma deepens when one considers that U.S. per capita currency holdings are modest compared with the per capita currency holdings of other developed European and Asian nations. The U.S. missing currency problem may be small compared to the problem of missing currency for other nations.

Monetary Policy

Monetary authorities naturally monitor and at times attempt to control monetary aggregates in order to stabilize or to stimulate domestic economic activity. If a sizable and variable fraction of currency is held abroad, reliance on conventional monetary aggregates which include total currency in circulation would clearly be misleading.[21] The appropriate monetary aggregates to monitor would be the *domestic* monetary base and the *domestic* money supply rather than the total monetary base and total money supply. Figure 11 compares the growth rates of the total and domestic monetary base

Figure 11: Total and Domestic Monetary Base
Growth Rates

(MB) estimated for the U.S. and Figure 12 compares the corresponding growth rates for total and domestic M1. Figure 11 reveals that the growth rates of the total and domestic MB moved together between 1978 and 1988 but began to diverge quite seriously in mid 1989. The series for M1 display a similar but less severe divergence. By 1991, the growth rate of the total base appeared to be growing 11% but the actual domestic base was only growing at 5%. Similarly, the total M1 growth rate was almost double the domestic M1 growth rate in 1991.
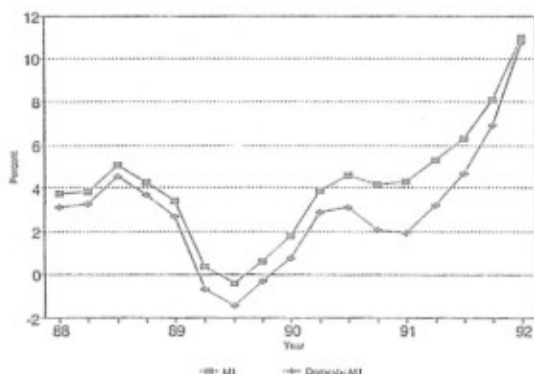
The results suggest that unrecognized large outflows of currency in 1990 and 1991 made monetary policy appear to be more stimulative than was in fact the case. The slower growth rates of the domestic monetary aggregates prior to the presidential

elections kept the economy from expanding as rapidly as might have been intended by policy makers who were following total monetary aggregates. Improved knowledge of

Figure 12: Growth Rates of Monetary Aggregates
M1 and Domestic M1

net outflows of U.S. currency permit policy makers to measure and track more appropriate domestic monetary aggregates such as the domestic monetary base and the domestic money supply.

Notes

1. The taxonomy of "underground economies" which identifies the interrelationships between the illegal, unreported, unrecorded and informal economies is discussed in Feige (1989;1990a). Throughout the paper, we employ the institutional based definitions from Feige (1990a) which appear below:

"As a general proposition, an economic agent is regarded a member of the 'formal' sector of any economy when his actions adhere to, or are protected by the established institutional rules of the game. Adherence to the established rules constitutes participation in the formal or above ground economy, whereas, non compliance, or circumvention of the established rules, or exclusion from the protection of those rules, constitutes participation in an informal or underground economy. Since there are a variety of institutions (different sets of rules covering a wide spectrum of economic behaviors) there are also a variety of informal sectors. The characteristics of each distinct informal economy are determined by the particular set of institutional rules that its members circumvent."

1) The *illegal* economy consists of the income produced by those economic activities pursued in violation of legal statutes defining the scope of legitimate forms of commerce.

2) The *unreported* economy consists of those economic activities that circumvent or evade the institutionally established fiscal rules as codified in the tax code. A summary measure of the unreported economy is the amount of income that should be reported to the tax authority but is not so reported.

3) The *unrecorded* economy consists of those economic activities that circumvent the institutional rules that define the reporting requirements of government statistical agencies.

4) The *informal* economy comprises those economic activities that circumvent the costs and are excluded from the benefits and rights incorporated in the laws and administrative rules covering property relationships, commercial licensing, labor contracts, torts, financial credit and social security systems.

134 THE UNDERGROUND ECONOMY AND THE CURRENCY ENIGMA

2. The AGI gap tends to understate total unreported income insofar as it takes no account of under reporting of other types of taxes nor does it capture unreported illegal income since the latter is not typically included in NIPA estimates of personal income. Moreover, to the extent that the NIPA measure of personal income is understated as a result of other unrecorded income, the AGI gap will correspondingly understate unreported income.

3. The methodology employed by the IRS is reviewed in Feige (1989). A more detailed explanation of the IRS methodology is found in several hundred pages of supporting appendices to Publication 7285 (IRS, 1988).

4. The OMB personal income projections employed by the IRS study are found in (IRS, 1988) P.A-79. Comparisons between the OMB projections and actual personal income suggest that in all years, the OMB forecasts underestimate actual personal income. The underestimates range from roughly 2% in 1985 to 4.8% in 1990. The projections assume that taxpayer behavior was unaffected by the tax reforms enacted in 1986.

5. 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. These are reported in Appendix E (IRS, 1988).

6. As described in Feige (1989) the foregoing restrictions imply that the ratio of unreported (Yu) to reported income (Yo) can be estimated as follows:

$$Yu/Yo = (C - koD)/(ko + 1) D,$$

where

   C = Currency
   D = Checkable Deposits
   $ko = Co/Do$.

7. The GCR model permits a relaxation of several of the assumptions employed in the simple currency ratio model. In particular, currency needs no longer be the exclusive medium of exchange in unreported transactions and any year for which an independent estimate of unreported income is available can serve as a benchmark. 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 in the reported economies.

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

9. The methodology for estimating the velocity (turnover) of currency is described in Feige (1990b). The estimates require calculations of the average lifetime of each note denomination. These are derived from FR160 data on currency issues (births) and redemptions (deaths). The estimates employed here are averages of share weighted denomination specific velocities.

10. The research reported here is one of several approaches undertaken as part of a broader joint research effort with Richard Porter and Jeff Hallman of the Board of Governors of the Federal Reserve System on estimating foreign holdings of U.S Currency.

11. 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 .

12. This approach was suggested by Milton Friedman in private correspondence.

13. The historical background and evolution of the FR160 reports from their inception in July, 1920 to the present is contained in the Board of Governors of the Federal Reserve System, technical memorandum #91 "Processing Procedures for the Cash Series," November, 1988.

14. The shipments and receipts data are published in Table No. 113 in *Banking and Monetary Statistics: 1914-1941*, Board of Governors of the Federal Reserve System. These data were derived from reports of large New York City Banks. The Federal Reserve recently started to collect data on international currency shipments and receipts on an informal confidential basis from a number of commercial banks that play an important role in currency exports and imports. These confidential data are presently regarded as one of the

best available sources of information pertaining to currency flows abroad, but they are not in the public domain.

15. The FR160 data are likely to overstate net shipments abroad to the extent that net increases in the demand for $100 bills in the New York District are not met by inflows of currency by tourists from other Federal Reserve districts. They understate net shipments abroad to the extent that U.S. net currency flows can take place through other channels and with smaller denominations. A broader research effort is now underway to refine estimates based on the FR160 data. Refinements involve obtaining appropriate weights for data from other Federal Reserve Districts and for smaller denominations. In order to check the veracity of the estimated net currency outflows reported in this paper, my series, derived from the FR160 data system was forwarded to the Federal Reserve which compared it to its own internal time series estimates. A similar comparison was made for Porter's estimates of net currency outflows based on his seasonal model. The correlation coefficient between the FR160 quarterly series and the Federal Reserve's internal series was reported to be .98. The corresponding correlation coefficient between Porter's net outflow series and the Federal Reserve internal series was .67. The Porter series employed in this paper are based on the methods reported in Porter (1993) but include updates and refinements made by Porter. I am indebted to Richard Porter for providing me with his data and the correlation results reported here.

16. The specification of the currency demand equation is reported in Moore *et al.* (1990). Richard Porter refit the currency demand model through 1984: Q4 and then simulated out of sample forecasts between 1985 and 1992. The yearly increments to the cumulative forecast errors should reflect annual net currency outflows. I am indebted to Porter for supplying me with these forecast errors.

17. See note 16.

18. The average tax rate is simply the sum of total government tax receipts divided by AGI. The dissatisfaction index is constructed as an equally weighted average of three normalized indices representing answers to the University of Michigan's Institute for Social Research surveys concerning whether government officials can be trusted, whether they are crooked and whether the government wastes money. I am indebted to the ISR for providing the underlining data.

19. The estimated regression is:

$$[Yu/AGI]_t = -22.62 + 3.05\,D_{t-1} + 83.29\,T_{t-1} \qquad R^2 = .89$$
$$ (1.99) \quad (0.76) \qquad (22.30) \qquad \text{DF} = 28.$$

20. The estimated holdings of U.S currency required for domestic underground activities are obtained from the GCR model estimates of unreported income displayed in Figure 8.

21. German monetarists have been surprised to find that domestic economic activitiy has failed to respond to monetary stimulation as readily as in the past. One possible explanation is that a large and growing fraction of the German currency supply is now held outside of Germany. In 1992, German per capita currency holdings approached $1,800 compared to $1,100 for U.S. per capita holdings.

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136 THE UNDERGROUND ECONOMY AND THE CURRENCY ENIGMA

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