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America's Unreported Economy: Measuring the Size, Growth and Determinants of Income Tax Evasion in the U.S.

Richard J. Cebula and Edgar L. Feige

Abstract

This study empirically investigates the extent of noncompliance with the tax code and examines the determinants of federal income tax evasion in the U.S. Employing a refined version of Feige's (1986; 1989) General Currency Ratio (GCR) model to estimate a time series of unreported income as our measure of tax evasion, we find that 18-23 % of total reportable income may not properly be reported to the IRS. This gives rise to a 2009 "tax gap" in the range of $390-$537 billion. As regards the determinants of tax noncompliance, we find that federal income tax evasion is an increasing function of the average effective federal income tax rate, the unemployment rate, the nominal interest rate, and per capita real GDP, and a decreasing function of the IRS audit rate. Despite important refinements of the traditional currency ratio approach for estimating the aggregate size and growth of unreported economies, we conclude that the sensitivity of the results to different benchmarks, imperfect data sources and alternative specifying assumptions precludes obtaining results of sufficient accuracy and reliability to serve as effective policy guides.

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America's Unreported Economy
Measuring the Size, Growth and Determinants of Income Tax Evasion in the U.S

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1. Introduction

Tax evasion, (the use of illegal means to avoid tax payments) effectively defrauds the government of legally due tax revenues, thereby increasing the nation's debt burden and reducing the government's ability to provide public services. Noncompliance with fiscal rules shifts real resources from honest taxpayers to dishonest evaders, and tax liabilities from present to future generations. Such inequities precipitate greater discontent with the government and further erode public revenues. In light of these consequences, economists strive to estimate the magnitude, composition, growth and determinants of tax evasion in the hope of implementing public polices likely to improve fiscal compliance.

In the U.S., tax evasion is accomplished by underreporting taxable income and/or overstating allowable deductions. Since such noncompliance is a punishable illegal behavior that individuals attempt to hide, directly measuring the magnitude of tax evasion is at best a difficult, imprecise and elusive task. Survey methods are unreliable because respondents understandably will not wish to admit to illegal behavior. Highly intensive audit procedures have been shown incapable of detecting large proportions of unreported incomes, particularly in the absence of rigorous information return requirements and/or income tax withholding at source.[3] Nevertheless, Slemrod (2007, p.26) contends that Internal Revenue Service (IRS) TCMP audits represent "the most careful and comprehensive estimates of the extent and nature of tax noncompliance anywhere in the world" and as such, aggregated TCMP measures of unreported income may provide the best available benchmark for estimating the magnitude of evasion in the U.S.

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[3] The IRS reported "that on average, for every dollar of income detected in (the Taxpayer Compliance Measurement Program) TCMP, another $2.28 went undetected." Internal Revenue Service (1988), p.A-31.

Estimating how evasion behavior changes over time is equally challenging, inevitably requiring highly simplifying assumptions. IRS projections of tax evasion over time rely on the restrictive assumption that "voluntary reporting percentages have remained at 1982 levels for each income, deduction, and credit item".[4] Alternatively, trends in aggregate unreported income may be inferred by postulating a relationship between the unobserved evasion behavior and some observed macro variable such as the public's use of currency.[5] Tracking observable aggregate currency usage as a proxy for unobserved tax evasion is justified because cash is the preferred medium of exchange for transactions that individuals wish to hide. Cash transactions do not leave a paper trail. This study employs a currency demand approach to estimate the temporal pattern of evasion while basing its estimate of the magnitude of evasion on an IRS audit based benchmark measure of unreported income. Times series estimates of the ratio of unreported to reported income are then employed to analyze the determinants of income tax evasion.

The rich theoretical literature on tax evasion [Allingham & Sandmo (1972), Yitzhaki (1974), Spicer & Lundsted (1976), Garcia (1978), Spicer & Thomas (1982), Carson (1984), Slemrod (1985), Baldry (1987), Falkinger (1988), Klepper, Nagin, & Spurr (1991), Thurman (1991), Alm, Jackson, & McKee (1992),Das-Gupta (1994), Pestieau, Possen, & Slutsky (1994), Yaniv (1994), Caballe & Panades (1997), Sandmo (2005)] has been comprehensively reviewed and analyzed by Cowell (1990), Andreoni, Erard, & Feinstein (1998), Slemrod (2007) and Slemrod and Weber (2011). The literature's theoretical models are inventive and mathematically elegant and can be employed to identify variables that are likely to affect tax compliance behavior. However, the plethora of behavioral assumptions and alternative model specifications often yield conflicting results regarding the expected signs and magnitudes of many of the key variables believed to effect tax evasion. Empirical analysis is required if these theoretical ambiguities are to be resolved.

Section 2 reviews how intensive TCMP audit studies can be aggregated to obtain estimates of unreported legal source income. This magnitude is combined with separate estimates of illegal source income to obtain a rough benchmark estimate of total unreported adjusted gross income for a

[4] Internal Revenue Service (1988).

[5] This follows Feige's (1979) suggestion to "look for the footprints unwittingly left behind by the irregular economy in the macroeconomic data that are routinely calculated for other purposes." P. 6.

particular year. Section 3 develops a refined version of Feige's (1986;1989) general currency ratio (GCR) model which links the unknown temporal pattern of noncompliance to observed currency usage on the assumption that currency is the preferred medium of exchange for conducting transactions that individuals wish to hide from the fiscal authority. The fourth section describes the determinants of tax evasion and the fifth presents our empirical results. The final section includes a summary of our findings and our conclusions.

2. Measuring Tax Evasion

The first, and often most difficult problem encountered in any empirical attempt to analyze the determinants of tax evasion is to define and estimate noncompliance. Tax evasion activities give rise to the "unreported economy"[6] whose magnitude is measured by "unreported income" (*Yu*). "Unreported" income is the difference between the total amount of income (Y_T) that should be reported to the tax authority under full compliance with the tax code and the amount actually reported (Y_o). (Y_T) is typically unobserved whereas the income actually reported (Y_o) corresponds to Adjusted Gross Income (AGI). The total amount of income that should be reported to the fiscal authority (Y_T) includes income earned in both the legal and the "illegal" economy[7]. Illegal income earned in the production and distribution of prohibited goods and services, is nonetheless taxable under the U.S. fiscal code. Our first task then is to obtain the best available aggregate measure of unreported legal plus illegal source income.

Andreoni, Erard, & Feinstein (1998, p. 836) suggest that "the most reliable information about noncompliance is based on actual tax return information that has been thoroughly examined by auditors" as part of the IRS (TCMP) which attempts to measure "unreported" income[8] and the national "tax gap".[9] The last TCMP audit undertaken by the IRS was for the tax

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[6] The unreported economy as defined by Feige (1990) "consists of those economic activities that circumvent or evade the institutionally established fiscal rules as codified in the tax code."

[7] The illegal economy as defined by Feige (1990) "consists of the income produced by those activities pursued in violation of legal statues defining the scope of legitimate forms of commerce."

[8] Feige (1989, p. 33-35) describes the IRS TCMP procedures for estimating unreported income and some of the shortcomings of the approach. Feldman and Slemrod (2007) note that, "there are sources of income that even the most intensive audit would have difficulty in detecting, such as cash transactions."

[9] The IRS defines the" tax gap" as "the difference between what taxpayers should have paid and what they actually paid on a timely basis." The tax gap has three components –non-filing; underreporting of taxes owed and underpayment of taxes. It should be noted that the current IRS estimates of the tax gap do not include estimates for tax liabilities incurred from illegal activities since the IRS has not published measures the size of illegal activities

year 1988.[10] In 1988 the IRS estimated that $449.1 billion of legal source income was unreported as a result of misreporting on filed returns and delinquencies of non-filers.[11] The IRS did not provide an estimate of illegal unreported income for 1988; however it did publish an estimate of $34.2 billion of illegal source income from drugs, illegal gambling and prostitution for the year 1981.[12] Assuming that the ratio of illegal to legal unreported income in 1981 remained roughly constant over time, we infer unreported illegal income for the year 1988 and then utilize the estimated sum of legal and illegal unreported income relative to reported AGI as a "benchmark" approximation of the relative magnitude of tax evasion in 1988. Our second benchmark employs an estimate of unreported income based on the most recent IRS estimate of the gross tax gap which amounted to $345 billion in 2001.[13] Given these benchmarks, we then proceed to construct time series estimates of the relative size of the unreported economy employing a refined version of the General Currency Ratio (GCR) model.

3. The General Currency Ratio (GCR) Model

The most common method for estimating the relative size and growth of the unreported economy (*Yu/Yo*) relies on a restrictive variant of the general currency ratio (GCR) model described in Feige (1986; 1989).[14] The most restrictive specification of the GCR model employed by (Cagan, 1958; Gutmann, 1977), known as the "simple currency ratio" (C/D) model assumes that:

a) the entire stock of currency is held domestically;

b) that currency is the exclusive medium of exchange for unreported transactions;

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since 1981.

[10] These TCMP "audits from hell" were politically deemed to be overly intrusive and were discontinued. A less intrusive substitute for TCMP known as the National Research Program (NPR) was instituted in the 1990's to estimate noncompliance.

[11] Internal Revenue Service (1988), Table D-17

[12] Internal Revenue Service (1983), Table VI-2

[13] Unreported income is estimated as the gross tax gap divided by the National Bureau of Economic Research estimate of the marginal tax rate. See: http://www.nber.org/~taxsim/ally/ally.html . This method is likely to overstate legal source unreported income but does not include an estimate for illegal source income.

[14] Often referred to as the "currency demand approach," the GCR model is fully described in Appendix A along with the typical restrictive assumptions employed to obtain estimates of the relative size of the unreported economy. The relative size of the "unreported economy" is typically measured as $Yu/Yo=\alpha$. The "noncompliance rate" (η) is then measured as $Yu/(Yu+Yo) = \alpha/(1+\alpha)$.

c) that the amount of unreported income produced by a dollar of currency transacted in the unreported sector is the same as the amount of reported income produced by a dollar of currency transacted in the reported economy, that is , that the income velocities of the reported and unreported sectors are identical;

d) that the ratio of currency to checkable deposits remains constant except for changes induced by the growth in unreported income.

e) that in some benchmark year (typically 1940) unreported income was zero.

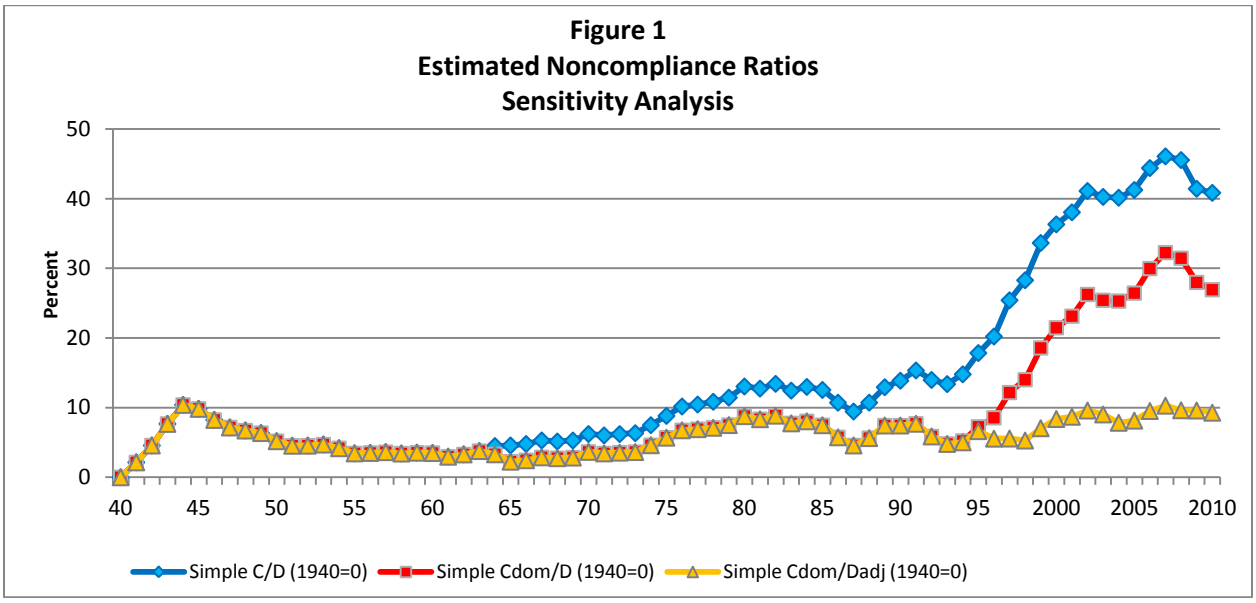
As described in Appendix A, these restrictions imply that the relative size of the unreported economy (α) can be estimated as follows:

$$(1)\ \alpha_t = \frac{Y_{ut}}{Y_{0t}} = \frac{C_t - k_0 D_t}{(k_0+1)D_t}$$

where, *C*=currency, *D*=checkable deposits and $ko=(C/D)_{1940}$, for all t.

This simple currency ratio model has obvious strengths and weaknesses. Its critics rightly cite the simplicity and restrictiveness of the assumptions typically required to obtain estimates of the unreported economy. Yet the model's simplicity is also its strength since the model is transparent, easily replicable and therefore readily subject to sensitivity testing. In the analysis that follows, we examine the implications of relaxing each of the restrictive assumptions in order to determine how their relaxation affects both the magnitude and the temporal pattern of noncompliance in the U.S. To anticipate our results, we find that both the magnitude and temporal profile of evasion behaviors are significantly affected by a relaxation of the restrictive assumptions.

Figure 1 displays the temporal pattern of the estimated noncompliance rate [η = (α/1+α)] derived from the highly restrictive simple C/D model (1940=0) whose solution is given by equation (1). The noncompliance rate, assumed to be zero in 1940, rises to a peak of 10 percent by the end of World War II, declines until the early 1960's and then gradually trends upward until the early 1990's when it rises implausibly to peak at roughly 46 percent in 2007.



Our first modification of the simple model is to relax assumption (a), recognizing that varying quantities of U.S. currency are held abroad. We employ Feige's (2012) new temporal estimates of overseas currency holdings to generate a time series of domestic currency (C_{dom}) which is then used instead of total currency. When the noncompliance rate is re-estimated by the simple C/D model with domestic currency (C_{dom}) substituted for total amount of currency (C) in equation (1), we find a significant reduction in magnitude of estimated noncompliance after the mid 1960's but the implausible increase in noncompliance after 1995 is still apparent. (See Figure 1)

The second modification to the currency ratio model involves a relaxation of assumption (d), requiring us to account for technological innovations in the financial industry that significantly reduced the volume of "checkable deposits" (D) and hence raised the C_{dom} /D ratio in a manner unrelated to tax evasion behaviors.[15] When banks began to offer retail sweep programs, checkable deposits were swept into money market deposit accounts, enabling banks to profitably reduce the level of demand deposits subject to reserve requirements. In 1994 these "sweeps" amounted to only $7.5 billion dollars but have subsequently increased to $800 billion in 2010. By adjusting for these "sweeps" in our definition of checkable deposits (D_{adj}), we explicitly account for an important factor affecting the conventional C/D ratio which is unrelated

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

to developments in the unreported economy.[16] Figure 1 shows that both the magnitude and temporal pattern of estimated noncompliance changes dramatically once we account for changes in domestic currency holdings and for financial innovations affecting checkable deposits which are unrelated to evasion behaviors. In short, assumptions (a) and (d) are indeed overly restrictive and the noncompliance estimates are highly sensitive to their relaxation.

We can now further refine the GCR model described in Appendix A by relaxing additional restrictive assumptions. As shown in the appendix, the GCR model has the general solution:

$$(2)\ Y_{ut} = \frac{1}{\beta} Y_{ot} \frac{(ku+1)(C_t - ko\ D_t)}{(ko+1)(ku\ D_t - C_t)}$$

where, β is the ratio of the income velocity in the reported sector to the income velocity in the unreported sector; and k_o and k_u respectively represent the currency/deposit ratios in the reported and unreported sectors.

Recall that assumption (e) [that unreported income in 1940 was zero] was necessary to obtain an empirical benchmark estimate of the parameter k_o. We can now relax (e) and instead employ an independent audit based IRS estimate of unreported income for a year in which such a benchmark is available.[17] As described in Section 2 above, two benchmark years were chosen, the 1988 TCMP estimate and 2001 NPR based estimate.

Figure 2 displays the sensitivity of the temporal pattern of noncompliance when the 1940 benchmark is replaced by the 1988 and 2001 benchmarks.[18] The new audit based benchmarks raise the initial 1940 noncompliance rate from zero to 9-11 percent and noncompliance rates now peak at 19-20 percent by the end of World War 11. The 1980's and 1990's displayed considerable fluctuations which Cebula (2001; 2004) and Cebula, Coombs & Yang (2009) showed could be attributed to variations in tax rates, the public's dissatisfaction with government, and audit rates. By 2010, the audit based noncompliance rate estimates are 18-19

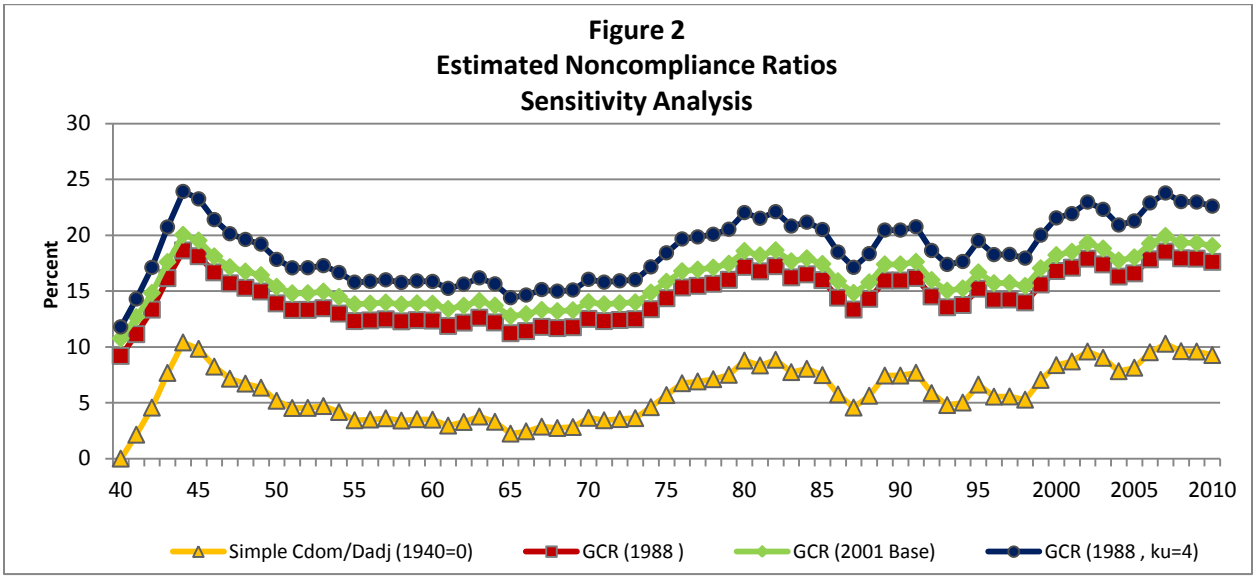
[16] The growth of plastic payment alternatives would also be expected to reduce the currency/deposit ratio over time. Failure to specifically account for this trend leads to an underestimate of the true noncompliance rate over time.

[17] Appendix A, equation (A: 10) shows the derivation of the new benchmark.

[18] The 1988 benchmark includes TCMP estimates of unreported legal source income and projected unreported illegal source income. The 2010 benchmark excludes unreported illegal source income but may overstate unreported legal source income because it is based on the gross tax gap.

percent, roughly double those produced by the 1940 base year model. Despite these significant differences in magnitudes, the temporal patterns of the alternative estimates are similar.

A further refinement of the GCR model involves a relaxation of assumption (b) namely, that currency is the exclusive medium of exchange used for unreported transactions. This



assumption is likely to be violated since tax evasion includes the underreporting of income from income source categories for which payments are typically made by check.[19] In particular, underreporting of interest, dividends, state tax refunds, capital gains, taxable unemployment benefits, pensions and annuities, estates and trusts and taxable social security are all likely to be income sources largely paid by check. The 1988 TCMP audit reveals that the sum of unreported filer income in all of the above categories amounted to 18 percent of total unreported filer income.[20] If we assume that 20 percent of unreported income transactions are paid by check and 80 percent by cash, the currency deposit ratio in the unreported economy (k_u) = 4. As displayed in Figure (2), a relaxation of the assumption that all unreported incomes are paid in cash leads to a substantially higher estimate of the noncompliance rate, but leaves the temporal pattern of noncompliance essentially unchanged.

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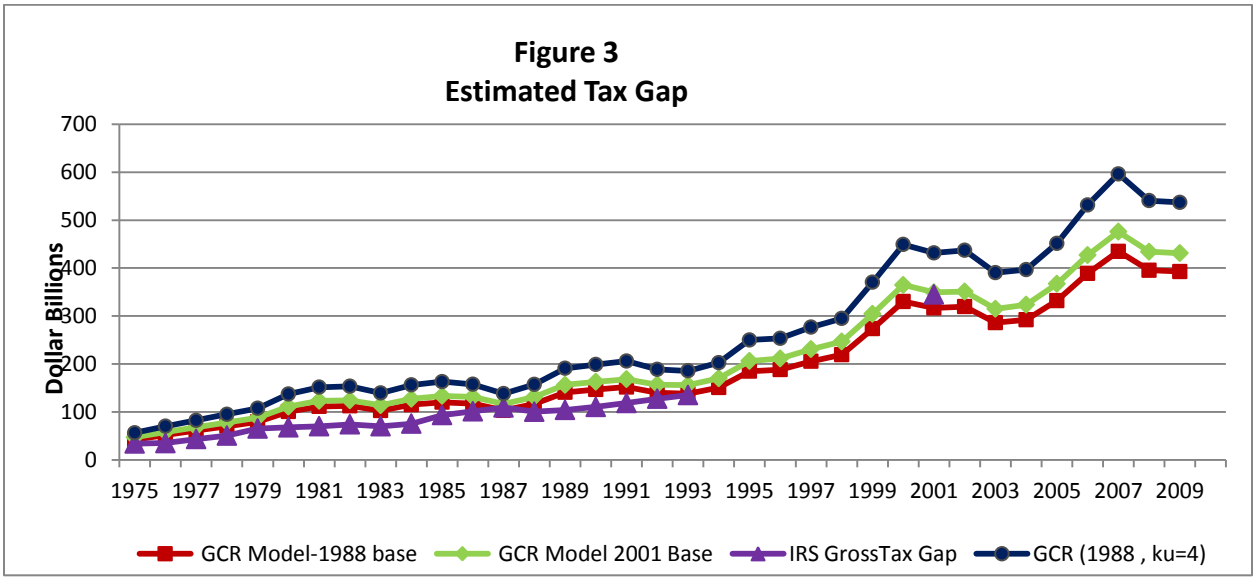
[19] The Internal Revenue Service (1979) citing underreporting of interest and dividend payments observes that "the unreported income problem extends beyond incomes paid in currency." P.13

[20] Internal Revenue Service (1988), Table A-50.

Finally, it is possible to relax assumption (c), namely, that the income velocities in the unreported and reported sectors are identical. As shown by equation (2) the magnitude of unreported income is directly proportional to the reciprocal of the velocity ratio β. The most plausible scenario is that unreported incomes generated by cash payments are concentrated in the service sectors, which require fewer intermediate transactions. Therefore, β is likely to be less than one and the noncompliance rates exhibited in Figures 1 and 2 are likely to be underestimated.

The implications of the GCR model estimates of unreported income for the magnitude and temporal pattern of the estimated tax gap are displayed in Figure 3, which also includes the available IRS tax gap estimates. Since 2001, the tax gap appears to have peaked in 2007 at between $435-596 billion and in 2009 the gap decreased and is estimated to lie in the $390 - $537 billion dollar range.[21]



Recent attention has been focused on an additional tax gap resulting from an estimated $5 trillion in assets held in offshore tax havens. The IRS reports that the annual revenue loss to the

[21] The tax gap estimates reported diverge from those reported in earlier versions of this paper due to a recent revision of the marginal federal tax rate as estimated by the National Bureau of Economic Research.

U.S. from these tax havens is in excess of $70 billion per year.[22] Taking account of the tax gap resulting from these overseas tax havens, overall tax evasion may cost the U.S. government between $500 -$600 billion per year in lost revenues.

4. Modeling the Determinants of Noncompliance

Given our empirical estimates of the temporal path of the unreported economy, we now specify a model of noncompliance which we will estimate empirically. In this study, the relative probability that the representative economic agent will not report his/her taxable income to the IRS is treated as an increasing function of the expected gross benefits to the agent of not reporting income, *eb*, and as a decreasing function of the expected gross costs to the agent of not reporting income, *ec*. Thus, the ratio of the probability of not reporting income to the IRS, *pnr*, to the probability of reporting income to the IRS, *(1-pnr)*, is described for the representative economic agent by:

$$(3)\ pnr/(1\text{-}pnr) = j(eb, ec),\ j_{eb} > 0, j_{ec} < 0$$

Expressing probabilities in relative terms such as shown in equation (3) possesses the virtue that it reflects the form of the tax evasion data described above, namely as the ratio of unreported to reported income.

The expected benefits from tax evasion are hypothesized to depend positively on the average effective tax rate (AET), the aggregate unemployment rate (UN), real income (INC), dissatisfaction with government (DIS), the interest rate (i), and negatively on a dummy variable representing the 1986 Tax reform act (TRA) such that:

$$(4)\ eb = g(AET, UN, INC, DIS, i\ TRA),$$
$$g_{AET} > 0,\ g_{UN} > 0,\ g_{INC} > 0,\ g_{DIS} > 0,\ g_{i3note} > 0,\ g_{TRA} < 0,$$

Cagan (1958), Bawley (1982), Tanzi (1982; 1983), Clotfelter (1983), and Feige (1994), all put forward the hypothesis that the expected benefits from not reporting income to the IRS are an

[22] http://www.irs.gov/businesses/small/article/0,,id=106568,00.html

increasing function of the federal income tax rate. To reflect the federal income tax rate, most previous studies using official data for the U.S. have adopted either of two alternative measures: an average effective federal income tax rate (*AET*) or the maximum marginal federal income tax rate (*MAXT*). We employ the *AET* measure because this tax rate is likely to be a more representative measure of the income tax rate for a larger portion of the taxpaying public than *MAXT*.

Following Alm & Yunus (2009), we expect a higher unemployment rate (*UN*) to be associated with a greater degree of income tax evasion, as unemployed workers (participate) in the "unreported economy". Moreover, employed workers, fearing future job losses, may also under-report income as a means of hedging against expected future unemployment. We also expect tax evasion to be positively related to real income (INC) since higher income individuals are more likely to report income on Schedule C for which there are no information reporting or withholding requirements (Ali, Cecil & Knoblett, 2001)

Noncompliance with the tax code is also believed to be related to the public's dissatisfaction with the government (*DIS*). Taxes are more willingly paid when taxpayers believe that tax revenues are being wisely employed to provide public services. Conversely, as the public's distrust of the government grows, so does noncompliance. The variable (*DIS)* is an index of public dissatisfaction with the government, constructed from survey data collected by the University of Michigan Institute for Social Research, (2009). The DIS index is based on responses to three survey questions measuring : (a) the degree to which the public distrusts public officials (other than the President) to fulfill their job obligations; (b) the degree to which the public regards government officials as dishonest; and (c) the degree to which the public believes that government officials waste tax dollars. The value of the index ranges from -1.5 to + 1.5, with a higher index value signifying a greater degree of dissatisfaction with government.

The expected benefits of tax evasion are also believed to increase as the opportunity costs of tax compliance increase. As interest rates increase, any unreported income will yield a higher return than before. Accordingly, the higher the interest rate yield on, say, three year U.S. Treasury notes (i*)*, the greater the expected benefit of tax evasion.

Finally we postulate that the expected benefits of evasion were reduced during the first years of the implementation of the Tax Reform Act of 1986 (*TRA*). Musgrave (1987, p. 59) described the TRA as "the most sweeping reform since the early 1940." The *TRA* introduced a

number of reforms described in Barth (1991), Barth & Brumbaugh (1992), Ott & Vegari (2003), and Sanger, Sirmans, & Turnbull (1990). Ott & Vegari (2003) noted that the TRA broadened the tax base by reducing itemized deductions, and once fully effective in 1988, replaced the fourteen bracket tax schedule with two tax brackets set at 15 and 28 percent. Musgrave further observes that prior to the *TRA*, the income tax base had been eroding. Musgrave was particularly dismayed by the widening of tax loopholes and the emergence of high income tax shelters that had "…gained momentum in recent years and undermined the public's faith in the income tax." Musgrave asserted that the *TRA* "…reversed these trends, a major accomplishment that all reformers will welcome." To the extent that taxpayers regarded the *TRA* favorably, we would expect that compliance rates would improve at least temporarily. Cebula, Coombs & Yang, 2009 found that studies of aggregate personal income tax evasion in the U.S. risk the problem of omitted-variable bias if they fail to somehow account for the Tax Reform Act of 1986.

The expected gross costs of not reporting income to the IRS are hypothesized[23] to be an increasing function of the likelihood of being audited (AUDIT) as measured by the percentage of filed federal income tax returns that are formally audited by IRS examiners.

$$(5) \quad ec = h(AUDIT), \; h_{AUDIT} > 0$$

This study adopts the probability of a formal audit as a measure of risk to the would-be tax evader. Unfortunately, insofar as IRS tax penalty data are unavailable for the full period covered by this study, we employ the IRS audit rate as the exclusive factor reflecting tax evasion risks. Substituting from (4) and (5) into (3) yields:

$$(6) \quad pnr/(1\text{-}pnr) = j(AET, TRA, UN, INC, DIS, i, AUDIT)$$

$$j_{AET} > 0, \; , j_{UN} > 0, j_{INC} > 0, j_{DIS} > 0, j_{i,} > 0, j_{TRA} < 0, \; j_{AUDIT} < 0$$

Let Y_T represent the total amount of adjusted gross income that should be reported to the IRS under full compliance with the tax code such that:

[23] See Friedland, (1982); De Juan,(1989); Pestieau, Possen & Slutsky, (1994); Erard & Feinstein, (1994) and Caballe & Panades, (1997).

(7) $Y_T = U_{AGI} + R_{AGI} = (pnr)^* Y_T + (1\text{-}pnr)^* Y_T$

where U_{AGI} *is* unreported adjusted gross income and R_{AGI} is reported adjusted gross income. It follows that:

(8) $U_{AGI}/R_{AGI} = (pnr)^* Y_T / (1\text{-}pnr)^* Y_T = (pnr)/(1\text{-}pnr) = j(AET, UN, INC, DIS, i, TRA, AUDIT)$

$j_{AET} > 0, j_{UN} > 0, j_{INC} > 0, j_{DIS} > 0, j_i > 0, j_{TRA} < 0, , j_{AUDIT} < 0$.

5. Empirical Results

Based on the framework provided in (8) above, we estimate the following reduced-form equation:

(9) $(U_{AGI}/R_{AGI})_t = a_0 + a_1 AET_{t-1} + a_2 TRA_t + a_3 UN_{t-1} + a_4 INC_{t-1} + a_5 DIS_{t-1}$
$+ a_6 AUDIT_{t-1} + a_7 i_{t-1} + a_8 TREND + u$

where:

$(U_{AGI}/R_{AGI})_t$ = the ratio of the unreported to reported adjusted gross income in year t expressed as a percent;

a_0 = constant term;

AET_{t-1} = the average effective federal income tax rate in year *t-1*, expressed as a percent;

TRA_t= a binary (dummy) variable: TRA_t=1 for the years 1986, 1987 and TRA_t =0 otherwise;

UN_{t-1}= percentage unemployment rate of the civilian labor force in year t-1;

INC_{t-1} = per capita real GDP in year t-1 (expressed in year 2000 dollars);

DIS_{t-1} = the mean value of the public dissatisfaction with government index, year t-1,

$AUDIT_{t-1}$= the percentage of filed federal personal income tax returns in year t-1 that was subjected to a formal IRS audit involving IRS examiners;

i_{t-1} = the average interest rate yield in year t-1 on three year U.S. treasury notes, expressed as a percent per annum;

TREND = a linear trend variable; and

u = stochastic error term.

The reduced form (9) is estimated for the entire period of observation 1960 through 2008. In the interest of testing for robustness and consistency of results, as well as in the quest for potential additional insights, we also estimate (9) for the sub periods, 1970-2008 and 1980-2008. The data are annual. The explanatory variables, except for the binary *TRA* variable, are lagged in order to avoid endogeneity problems.[24]

Three least squares regression estimates of equation (9) are provided in Table 1. In these estimates, all of the estimated coefficients on the explanatory variables exhibit the expected signs. Furthermore, thirteen of these estimated coefficients are statistically significant at the 1% level, one is statistically significant at the 2.5%, three are statistically significant at the five percent level, and two are statistically significant at the 10% level. Only the coefficients for the *DIS* variable fail to be statistically significant at the five percent level.

As displayed in Table 1, the coefficient on the tax variable (*AET*) is positive in all three estimates and statistically significant. As expected, the higher the average effective federal income tax rate, the greater the extent of income tax evasion. This finding is consistent with most previous studies of income tax evasion using official data (Ali, Ceceil & Knoblett, 2001; Cebula, 2001, 2004; Clotfelter, 1983; Feige, 1994, 1996,1997; Klepper, Nagin and Spurr, 1991; Tanzi, 1982, 1983].

Consistent with the arguments in Musgrave (1987) and findings in Cebula, Coombs & Yang (2009), the TRA coefficients are negative and statistically significant at the 1% level. The implementation of the Tax Reform Act of 1986 is shown to have reduced federal personal income tax evasion in the U.S., albeit only briefly. The estimated coefficients on the unemployment variable are all positive, as hypothesized, and statistically significant at the 1% level in all cases (1960-2008, 1970-2008, and 1980-2008). Thus, there is strong evidence that the higher the unemployment rate,

[24]The AET is the federal average tax rate from the NBER TAXSIM model. The *AUDIT* data were obtained from the Government Accounting Office (1996: Table I.1), and the U.S. Census Bureau (1994: Table 519, 1998: Table 550, 1999: Table 556, 2001: Table 546, 2010: Table 469). The *TRA* variable is a dummy variable; the Tax Reform Act of 1986 was actually signed into law by President Reagan in October of 1986. The data for the variables *UN, INC,* and *i* were obtained from the Council of Economic Advisors (2009, Tables B-42, B-41, B-73). The *DIS* data were obtained from the University of Michigan Institute for Social Research (2009).The series adopted to measure income tax evasion, in this case represented by the variable $U_{AGI}/R_{AGI} = Yu/Yo$] were obtained from Feige (2012), as described in Section 2. For the interested reader, descriptive statistics for each of the variables in each of the three study periods are found in Appendix B: Table B:1, and the actual U_{AGI}/R_{AGI} data are provided in Table B:2.

the greater the extent of income tax evasion. This finding is compatible with the recent findings in Alm & Yunus (2009).

Table 1. Empirical Estimates (Dependent Variable: (U_{AGI}/R_{AGI})

Variable\Estimation	1960-2008	1970-2008	1980-2008
a_0	-55.36	-53.9	-49.2
AET	0.43**	0.56***	0.42*
	(2.58)	(3.06)	(2.22)
TRA	-3.56***	-3.65***	-3.59***
	(-6.39)	(-6.51)	(-6.96)
UN	1.77***	1.79***	1.59***
	(10.36)	(10.24)	(7.64)
INC	0.0039***	0.0039***	0.0038***
	(12.64)	(12.64)	(11.27)
DIS	0.192	0.345#	0.172
	(1.09)	(1.72)	(0.72)
AUDIT	-0.73#	-0.968*	-1.24*
	(-1.69)	(-2.07)	(-2.12)
i	0.388***	0.365***	0.446***
	(5.08)	(4.68)	(4.47)
TREND	-1.83***	-1.86***	-1.80***
	(-11.71)	(-11.73)	(-9.82)
R^2	0.91	0.86	0.81
AdjR^2	0.88	0.82	0.74
DW	1.73	1.77	1.80

***indicates statistical significance at the 1% level; **indicates statistical significance at the 2.5% level; *indicates statistical significance at the 5% level; and #indicates statistical significance at the 10% level. Terms in parentheses are t-values. The least squares estimates are fully-modified OLS [FMOLS] estimates.

Next, the estimated coefficients on the per capita real GDP variable *(INC*) are all positive and statistically significant at the 1% level for the three periods. The higher the real income level

(*INC*), the greater the degree to which tax evasion is expected to occur, *ceteris paribus*. The estimated coefficients on the public dissatisfaction with government variable, *DIS*, are all positive, as expected; however, only one of these coefficients is statistically significant at even the 10% level (that for the 1970-2008 period). Thus, it appears that this variable may have exercised only a very modest (if not negligible) impact on the aggregate degree of federal personal income tax evasion over the study period. The estimated coefficients of the AUDIT variable exhibit the expected negatives signs and are also statistically significant. Thus the likelihood of an audit appears to act as a deterrent to evasion and hence serves as a viable policy tool with which to combat personal income tax evasion. Finally, we find that a higher interest rate appears to encourage greater income tax evasion, by raising the opportunity costs of personal income tax compliance.

In closing, we note that the coefficients of determination are relatively similar in magnitude in all three estimates, with the inference being that the model explains roughly five-sixths of the variation in income tax evasion. Furthermore, there is no autocorrelation in the estimates and as displayed in the correlation matrix of Table B:3 (Appendix B) , no serious multicollinearity among the variables in the model. Only two zero-order correlation coefficients barely exceed 0.5 in absolute value, and in these cases, the coefficients for the variables involved (*UN*, *INC*, and *i*) are all highly statistically significant.

6. Summary and Conclusions

This empirical study employs a refined version of Feige's (1986; 1989) general currency ratio model (GCR) in an effort to obtain time series estimates of U.S. unreported aggregate adjusted gross income for the period 1940-2010. These time series estimates of unreported income are then employed in a regression analysis to evaluate the relationship between tax evasion and its presumed determinants, tax rates, income, unemployment, interest rates, audit rates and public attitudes toward the government. We find that the average tax rate, real income, the interest rate and the unemployment rate have the expected positive relationship with unreported income whereas the audit rate appears to deter tax evasion. The 1986 Tax reform Act appears to have had a short run effect reducing evasion whereas a variable reflecting dissatisfaction with the government has a positive but statistically insignificant effect on evasion behavior.

Our paper contributes to literature that employs variants of the popular currency ratio

models to estimate the magnitude and temporal path of the unreported economy. We refine the methodology of currency demand approaches by addressing each of the typical germane critiques of the restrictive GCR model and examine the sensitivity of both the magnitude and growth of unreported income estimates to a relaxation of numerous restrictive assumptions. First, we modify the currency ratio model by employing domestically held currency as the appropriate cash variable rather than total currency. Domestic cash holdings are derived from Feige's 2012 new estimates of the amount of U.S. currency held abroad. We find that accounting for overseas currency significantly affects both the magnitude and temporal path of estimates of unreported income.

Garcia (1978) critiqued the currency ratio model for assuming that the ratio of currency to demand deposits was only affected by changes in tax evasion whereas financial innovations independent of noncompliance behaviors could significantly reduce demand deposit holdings and hence increase the observed currency ratio. We therefore relax this restrictive assumption by adjusting the checking deposit variable to take account of the major financial innovation of "sweeps", thereby accounting for a financial innovation that increased the observed the currency ratio for reasons unrelated to changes in evasion behavior. We find that a failure to take account of this innovation would lead to a significant overstatement of both the magnitude and the growth of unreported income over time. Conversely, we note that the failure to take further account of the secular upward trend in credit and debit card use will lead to an underestimate of unreported income and an underestimate of its growth over time.[25]

The GCR model is further refined by eliminating the arbitrary assumption that in some year (typically 1940) tax evasion was nonexistent and instead we benchmark the model to an audit based estimate of the size of legal and illegal unreported income. The model is further modified to take account of the fact that currency is not the exclusive medium of exchange for transactions involving unreported incomes. Examination of specific categories of unreported income reveals that checks are used for payment for roughly 20 percent of aggregate unreported income. This modification is again shown to significantly raise the estimates of unreported income, albeit, not having much effect on the temporal path of tax evasion. Similarly, we demonstrate that a relaxation of the typical assumption of equal income velocities in the recorded and unrecorded sectors will likely increase

[25] Note that the use of plastic payment methods reduces the demand for cash while increasing the demand for checking deposits, hence reducing the observed currency ratio over time.

estimates of tax evasion behavior without affecting the temporal path.

The new estimates of noncompliance from the refined GCR model suggest that in 2009 roughly 18-23 [26] percent of total reportable income was not properly reported to the IRS. The estimated $1.8 -2.4 trillion of unreported income gives rise to an annual tax gap currently estimated to be $390 - $537 billion. The regression analysis gives intuitively plausible results concerning the determinants of evasion behavior. Although the foregoing estimates benefit from significant refinements of the currency ratio models widely in use[27], the sensitivity of the results to alternative specifying assumptions, benchmarks, and data revisions concerning overseas currency leads us inextricably to the uncomfortable conclusion that the current state of our science is still incapable of producing sufficiently precise and reliable estimates of the magnitude and growth of unreported economies to serve as a dependable guide for public policy.[28]

[26] The lower estimate is based on GCR (1988) while upper is based on GCR (1988) Ku=4).

[27] It should be noted that the widely cited and severely critiqued (Breusch, 2005, a, b, c; 2006) MIMIC model estimates are all presumably based on some highly simplified, albeit undocumented, currency demand approach.

[28] Similar concerns are expressed in Feige and Urban (2008) in their investigation of estimates of the "unrecorded" economy in transition countries.

REFERENCES

Ali, M.M., Cecil, H.W., Knoblett J.A., (2001), "The Effects of Tax Rates and Enforcement Policies on Taxpayer Compliance: A Study of Self-Employed Taxpayers," *Atlantic Economic Journal*, vol. 29 (2), pp. 186-202.

Allingham, M.G., Sandmo, A., (1972), "Income Tax Evasion," *Journal of Public Economics*, vol. 1 (3), pp. 323-38.

Alm, J., Yunus, M., (2009). "Spatiality and Persistence in U.S. Individual Income Tax Compliance," *National Tax Journal*, vol. 62 (1), pp. 101-24.

Alm, J., Jackson, B., McKee, M., (1992), "Institutional Uncertainty and Taxpayer Compliance," *American Economic Review*, vol. 82 (4), pp. 1018-26.

Andreoni, J., Erard, B., Feinstein, J., (1998). "Tax Compliance," *Journal of Economic Literature*, vol. 36 (2), pp. 818-60.

Baldry, J.C., (1987), "Income Tax Evasion and the Tax Schedule: Some Experimental Results," *Public Finance/Finances Publiques*, vol. 42 (2), pp. 357-83.

Barth, J.R., (1991), *The Great Savings and Loan Debacle.* Washington, D.C.: American Enterprise Institute.

Barth, J.R., Brumbaugh, R.D., (1992), *The Reform of Federal Deposit Insurance*. New York: Harper Business.

Bawley, D., (1982), *The Subterranean Economy.* New York: McGraw-Hill.

Breusch, T. (2005a), "Australia's Cash Economy: Are the Estimates Credible?" *The Economic Record*, 81, pp. 394–403.

Breusch, T. (2005b): "Fragility of Tanzi's method of estimating the underground economy," The School of Economics, The Australian National University.

Breusch, T. (2005c). "Estimating the Underground Economy using MIMIC Models," The School of Economics, The Australian National University.

Breusch,T, (2006),"Size, Causes, and Consequences of the Underground Economy: An International Perspective, Edited by C. Bajada and F. Schneider," *The Economic Record*, The Economic Society of Australia, vol. 82(259), pages 492-494, December.

Caballe, J., Panades, J., (1997), "Tax Evasion and Economic Growth," *Public Finance/Finances Publiques*, vol. 52 (3-4), pp. 318-40.

Cagan, P., (1958), "The Demand for Currency Relative to the Total Money Supply," *Journal of Political Economy*, vol. 66 (2), pp. 303-28.

Carson, C., (1984), "The Underground Economy: An Introduction," *Survey of Current Business*, vol. 64 (1), pp. 24-35.

Cebula, R J., (2001), "Impact of Income-Detection Technology and Other Factors on Aggregate Income Tax Evasion: The Case of the United States," *Banca Nazionale del Lavoro Quarterly Review*, vol. 54 (4), pp. 401-15.

Cebula, R.J., (2004), "Income Tax Evasion Revisited: The Impact of Interest Rate Yields on Tax-Free Municipal Bonds," *Southern Economic Journal*, vol. 71 (2), pp. 418-23.

Cebula, R.J., Coombs, C., Yang, B.Z (2009), "The Tax Reform Act of 1986: An Assessment in Terms of Tax Compliance Behavior in the U.S.," *International Economics*, vol. 51 (2), pp. 247-59.

Clotfelter, C.T., (1983), "Tax Evasion and Tax Rates: An Analysis of Individual Returns," *Review*

of Economics and Statistics, vol. 65 (2), pp. 363-73.
Council of Economic Advisors, (2010), *Economic Report of the President, 2010.* Washington, D.C.: U.S. Government Printing Office.
Cowell, F.A., (1990), *Cheating the government: The Economics of Evasion*. Cambridge, MA: M.I.T. Press.
Das-Gupta, A., (1994), "A Theory of Hard-to-Get Groups," *Public Finance/Finances Publiques*, vol. 49 (Supplement), pp. 28-39.
De Juan, A., (1989), *Fiscal Attitudes and Behavior: A Study of 16-35 Year Old Swedish Citizens.* Stockholm, Sweden: Stockholm School of Economics.
Erard, B., Feinstein, J.S., (1994), "The Role of Moral Sentiments and Audit Perceptions in Tax Compliance," *Public Finance/Finances Publiques,* vol. 49 (Supplement), pp. 70-89.
Falkinger, J., (1988), "Tax Evasion and Equity: A Theoretical Analysis," *Public Finance/Finances Publiques*, vol. 43 (3), pp. 388-95.
Feldman, N. E., Slemrod J., (2007) "Estimating tax noncompliance with evidence from unaudited tax returns." *Economic Journal*, 117(51): 327-352.
Feige, E.L., (1979), "How Big is the Irregular Economy?" *Challenge*, November-December.
Feige, E.L., (1986) "A Re-examination of the "Underground Economy" in the United States: A Comment on Tanzi," *Staff Papers, International Monetary Fund* 33(4) pp. 768-81.
Feige, E. L., (1989), T*he Underground Economies: Tax Evasion and Information Distortion.* Cambridge: Cambridge University Press.
Feige, E. L., (1990) " Defining and estimating underground and informal economies: The new institutional economics approach." World Development, Elsevier, vol. 18(7), pages 989-1002, July.
Feige, E.L., (1994), "The Underground Economy and the Currency Enigma," *Public Finance/Finances Publiques, v*ol. 49 (Supplement), pp. 119-36.
Feige, E.L., (1996), "Overseas Holdings of U.S. Currency and the Underground Economy," in Pozo, S. (ed), *Exploring the Underground Economy.* Kalamazoo, MI: W.E. Upjohn Institute for Employment Research, pp. 215-35.
Feige, E.L.,(1997), "Revised Estimates of the Size of the U.S. Underground Economy: Implications of U.S. Currency Held Abroad," in Lippert, O. and Walker, M., (eds.), *The Underground Economy: Global Evidence of Its Size and Impact.* Vancouver, Canada: Fraser Institute, pp. 146-65.
Feige, E.L., Urban, I, (2008) "Measuring underground (unobserved, non-observed, unrecorded) economies in transition countries: Can we trust GDP," *Journal of Comparative Economics*, Elsevier, vol. 36(2), pages 287-306.
Feige, E.L., (2012), "New Estimates of U.S. Currency Abroad, the Domestic Money Supply and the Unreported Economy," *Crime, Law and Social Change*. April, 2012
Friedland, N., (1982), "A Note on Tax Evasion as a Function of the Quality of Information about The Credibility of Threatened Fines: Some Preliminary Research," *Journal of Applied Psychology*, vol. 12 (1), pp. 54-59.
Garcia, G. (1978), "The Currency Ratio and the Subterranean Economy," *Financial Analysts Journal*, vol. 69 (1) pp.64-66.
Government Accounting Office, (1996). "Individual Audit Rates." Available at: http://www.gao.gov/archive/1996/gg96091.pdf

Gutmann, P.M., (1977), "The Subterranean Economy," *Financial Analysts Journal*, vol. 34 (1), pp. 26-7.
Internal Revenue Service (1979) "Estimates of Income Unreported on Individual Tax Returns" Department of the Treasury, Publication 1104 (9-79)
Internal Revenue Service (1983) Income Tax Compliance Research, "Estimates for 1973-1981," Research Division, July, 1983.
Internal Revenue Service (1988) Income Tax Compliance Research, "Supporting Appendices to Publication 7285," Publication 1415.
Klepper, S. Nagin, D., Spurr, S., (1991), "Tax Rates, Tax Compliance, and the Reporting of Long Term Capital Gains," *Public Finance/Finances Publiques*, vol. 46 (2), pp. 236-51.
Musgrave, R.A., (1987), "Short of Euphoria," *Journal of Economic Perspectives*, vol. 1 (1), 59-71.
Ott, A.F., Vegari, S.B., (2003), "Tax Reform: Chasing the Elusive Dream," *Atlantic Economic Journal,* vol. 31 (3), pp. 266-82.
Pestieau, P., Possen, U., Slutsky, S., (1994), "Optimal Differential Taxes and Penalties," *Public Finance/Finances Publiques,* vol. 49 (Supplement), pp. 15-27.
Sandmo, A., (2005), "A Theory of Tax Evasion: A Retrospective View," *National Tax Journal*, Vol. 63 (4), pp. 643-63.
Sanger, G.C., Sirmans, C.F., Turnbull, G.K., (1990), "The Effects of Tax Reform on Real Estate: Some Empirical Results," *Land Economics*, vol. 66 (4), pp. 409-24.
Slemrod, J., (1985), "An Empirical Test for Tax Evasion," *Review of Economics and Statistics*, vol. 67 (2), pp. 232-67.
Slemrod, J., (1992), "Did the Tax Reform Act of 1986 Simplify Tax Matters"? *Journal of Economic Perspectives*, vol. 6 (1), pp. 45-57.
Slemrod, J., (2007), "Cheating Ourselves: The Economics of Tax Evasion," *Journal of Economic Perspectives*, vol. 21 (1), pp. 25-48.
Slemrod, J., Weber, C., (2011), "Evidence of the invisible: toward a credibility revolution in the empirical analysis of tax evasion" *International Tax and Public Finance*, Springer.
Spicer, M.W., Lundsted, S.B., (1976), "Understanding Tax Evasion," *Public Finance/Finances Publiques*, vol. 31 (2), pp. 295-305.
Spicer, M.W., Thomas, J.E., (1982), "Audit Probabilities and the Tax-Evasion Decision: An Experimental Approach," *Journal of Economic Psychology*, vol. 2 (2), pp. 241-45.
Tanzi, V., (1982), *The Underground Economy in the United States and Abroad.* Lexington, MA: Lexington Books.
Tanzi, V., (1983), "The Underground Economy in the United States: Annual Estimates, 1930-1980," *IMF Staff Papers*, vol. 30 (2), pp. 283-305.
Thurman, Q. C., (1991), "Taxpayer Noncompliance and General Prevention: An Expansion of the Deterrence Model," *Public Finance/Finances Publiques*, vol. 46 (2), pp. 289-98.
University of Michigan Institute for Social Research, (2009), Public Dissatisfaction with Government. Available at http://www.isr@umich.edu
U.S. Census Bureau, (1994), *Statistical Abstract of the United States, 1994.* Washington, D.C., U.S Government Printing Office.

Yaniv, G., (1994), "Tax Evasion and the Income Tax Rate: A Theoretical Examination," *Public Finance/Finances Publiques*, vol. 49 (1), pp. 107-12.

Yitzhaki,S. (1974) "A Note on Income Tax Evasion: A Theoretical Analysis" *Journal of Public Economics*, 3 (2) pp. 201-202.

Appendix A: The General Currency Ratio (GCR) Model

The General Currency Ratio (GCR) model as described in Feige (1986; 1989) is a heuristic framework capable of representing a variety of common monetary approaches for obtaining time series estimates of the "unobserved" sector of the economy.

Let:

o = subscript to denote the observed sector

u = subscript to denote the unobserved sector

C= actual currency stock

D= actual stock of checkable deposits

Y_o= observed income

k_o = ratio of domestic currency to checkable deposits in the observed sector

k_u = ratio of domestic currency to checkable deposits in the unobserved sector

V_o= observed sector income velocity

V_u = unobserved sector income velocity

When the object of analysis is to estimate unreported income on federal income tax returns, the empirical counterpart to observed income is the IRS measure of adjusted gross income (AGI). The unobserved sector now is measured by Y_u, namely unreported adjusted gross income.[29]The GCR model specifies the following:

(A:1) $C = C_o + C_u$

(A:2) $D = D_o + D_u$

(A:3) $k_o = C_o / D_o$

(A:4) $k_u = C_u / D_u$

(A:5) $V_o = Y_o / C_o + D_o$

(A:6) $V_u = Y_u / C_u + D_u$

(A:7) $\beta = V_o / V_u$

[29] When the object of the analysis is to estimate" unrecorded" income, defined by Feige (1990) as "the amount of income that should (under existing rules and conventions) be recorded in national income accounting systems but is not recorded," the analysis should be based on a National Income and Product account (NIPA) aggregate that is properly adjusted for non-monetary imputations and for imputations already included in the recorded aggregate which accounts for omissions due to underreporting on tax source data. See Feige (1989) and Feige and Urban (2008).

Equations (A: 1) and (A: 2) decompose the actual stocks of currency and checkable deposits into their reported and unreported components. Equations (A: 3) and (A: 4) are definitions of the terms k_o and k_u which can be specified either as constants or functions. Similarly, (A: 5) and (A: 6) define income velocity in the two sectors. To solve the model for unreported income (Y_u), we must evaluate (A: 6) in terms of the models observable variables namely, C, D and Y_o. Repeated substitution and rearrangement of terms yields the general solution:

(A: 8) $Y_{ut} = \frac{1}{\beta} Y_{ot} \frac{(ku+1)(C_t - ko\, D_t)}{(ko+1)(ku\, D_t - C_t)}$

The most restrictive variants of the GCR model impose the following assumptions: [30]

a) The entire stock of currency is held domestically.

b) Currency is the exclusive medium of exchange for unreported transactions.

($D_u \rightarrow 0$; $k_u \rightarrow \infty$)

c) The income velocities in the reported and unreported sectors are identical. ($\beta = 1$)

d) The ratio of currency to checkable deposits in the observed sector is constant over time.

(k_{ot} = constant for all t)

Imposing these assumptions on equation (8) yields the restrictive form of the GCR model,

(A: 9) $Y_{ut} = Y_{ot} \left\{ \frac{C_t - k_o D_t}{(k_o + 1) D_t} \right\}$

Empirical estimates of unreported income (Y_{ut}) require an estimate of the parameter k_o which Cagan (1958) and Gutmann (1977) assumed could be approximated as follows:

e) $k_o = (\frac{C_o}{D_o})_{1940} = (\frac{C}{D})_{1940}$

The 1940 benchmark assumption implied that prior to World War II, income tax evasion was zero.[31] The restrictive assumptions represented by (a….e) give rise to what is commonly known as the "simple currency ratio" model. Given a value of k_o, obtained via assumption (e), Equation (A: 9) expresses the unknown unreported income as a simple function of observed variables.

In principle, any year t for which we have an independent estimate of both reported and unreported income can serve as "benchmark" year for estimating the GCR model. Given

[30] These assumptions were employed by Cagan (1958) and Gutmann (1977). Tanzi's (1980) imposes the first three restrictive assumptions, but treats a variant of ko (C/M2) as a function rather than a constant .

[31] In 1940, individual income taxes amounted to 14 percent of total government receipts.

$\alpha_t = \frac{Y_{ut}}{Y_{ot}}$, we can solve equation (9) for k_{ot}:

(A: 10) $$k_{ot} = \frac{C_t - \alpha_t D_t}{\alpha_t D_t + D_t} = \frac{(1-\eta_t)C_t}{D_t} - \eta_t$$

where η_t is the noncompliance rate. If $k_{ot} = k_o$ for all t, it is possible to generate a temporal path of the noncompliance rate from equation (A: 9).

If we have independent knowledge concerning the values of the parameters, β and k_u, assumptions (b) and (c) can be discarded and equation (A: 8) can be employed to directly solve for Y_{ut}.

Appendix B: Empirical results

Table B:1. Descriptive Statistics

Variable	Mean	Standard Deviation
Period: 1960-2008:		
(U_{AGI}/R_{AGI})	19.17	2.93
AET	13.83	1.086
TRA	0.0408	0.19999
UN	5.856	1.401
INC	25437	7326
DIS	0.0361	0.969
AUDIT	2.0529	1.458
i	6.415%	2.72%
Period: 1970-2008:		
(U_{AGI}/R_{AGI})	20.159	2.423
AET	13.989	1.087
TRA	0.0513	0.2235
UN	6.132	1.35
INC	27833	6180
DIS	0.43	0.63
AUDIT	1.362	0.54
i	6.873%	2.854%
Period: 1980-2008:		
(U_{AGI}/R_{AGI})	20.86	2.1414
AET	13.934	1.21
TRA	0.07	0.258
UN	6.103	1.42
INC	30353	5046
DIS	0.387	0.651
AUDIT	1.12	0.374
i	6.76%	3.2%

Table B:2. Data for Dependent Variable, U_{AGI}/R_{AGI}, by Year, 1960-2008

Year	U_{AGI}/R_{AGI}	**Year**	U_{AGI}/R_{AGI}
1960	16.10	1985	21.11
1961	15.47	1986	18.89
1962	15.86	1987	17.42
1963	16.44	1988	18.74
1964	15.88	1989	21.06
1965	14.62	1990	21.06
1966	14.86	1991	21.39
1967	15.36	1992	19.04
1968	15.21	1993	17.70
1969	15.32	1994	17.98
1970	16.30	1995	20.01
1971	16.04	1996	18.64
1972	16.16	1997	18.66
1973	16.27	1998	18.30
1974	17.47	1999	20.55
1975	18.81	2000	22.29
1976	20.17	2001	22.73
1977	20.37	2002	23.94
1978	20.63	2003	23.17
1979	21.14	2004	21.57
1980	22.84	2005	21.98
1981	22.25	2006	23.85
1982	22.93	2007	24.90
1983	21.46	2008	23.94
1984	21.86		

U_{AGI}/R_{AGI} is expressed as a percentage.

Table B:3 Correlation Matrix for Explanatory Variables, 1970-2008

	AET	*UN*	*INC*	*AUDIT*	*DIS*	*i*	*TRA*
AET	1.00						
UN	0.325	1.00					
INC	-0.265	-0.561	1.00				
AUDIT	0.393	0.441	0.325	1.00			
DIS	0.267	0.252	-0.291	0.475	1.00		
i	0.481	0.412	-0.571	0.403	0.147	1.00	
TRA	0.178	0.075	-0.068	-0.109	-0.111	0.121	1.00