

Estimating the Underground Economy: A Critical Evaluation of the Monetary Approach

—Peter S. Spiro*

PRÉCIS

La fiabilité de l'approche monétaire pour évaluer l'ampleur de l'économie souterraine est examinée dans cet article. D'après les résultats de cet examen, le modèle Tanzi, selon lequel le taux d'imposition est utilisé pour prédire la croissance de la demande pour la monnaie, est valable pour les données canadiennes. Le taux d'imposition a un effet déterminant important sur la demande pour la monnaie; la demande pour la monnaie est donc un indicateur utile de la croissance de l'économie souterraine. Cependant, les résultats d'études antérieures dans lesquelles la monnaie était utilisée comme ratio des dépôts bancaires peuvent présenter des estimations peu fiables, et il est préférable de rattacher la demande pour la monnaie aux dépenses à la consommation. Selon les résultats, l'économie souterraine représenterait de 8 à 11 pour cent du produit intérieur brut (PIB) en 1993.

Selon l'opinion générale, l'économie souterraine a progressé considérablement au cours des dernières années. D'après cet article, cette augmentation pourrait atteindre 14 G\$ (presque 2 pour cent du PIB) depuis le début de 1991. Rien ne prouve que les récessions contribuent à la croissance de l'économie souterraine. Par conséquent, la récente progression découle vraisemblablement des modifications fiscales, la taxe sur les produits et services constituant le plus important facteur.

ABSTRACT

This article examines the reliability of the monetary approach in estimating the size of the underground economy. It finds that the Tanzi model, which uses the tax rate to predict growth in the demand for currency, holds up well for the Canadian data. There is a significant causal effect of the tax rate on the demand for currency, which implies that the demand for currency is a useful indicator of growth in the underground economy. However, previous studies that expressed currency as a ratio of bank deposits may have

* Of the Ontario Ministry of Finance. This article is based on a paper presented at the 28th annual meeting of the Canadian Economic Association, Calgary, June 1994. The opinions expressed in this article are those of the author, and do not necessarily reflect the policy of the Ontario Ministry of Finance. The author has benefited from the comments of numerous individuals, including David Longworth, Leo Van Hove, Kausar Thomas, Ed Feige, Michael Walker, Philip Smith, Gylliane Gervais, John Grant, David Laidler, Bill Robson, Don Drummond, and especially Rolf Mirus, who also provided data.

obtained unreliable estimates, and it is preferable to relate the demand for currency to consumer spending. The results indicate that the underground economy was probably in the range of 8 to 11 percent of Canadian gross domestic product (GDP) as of 1993.

There is widespread consensus that the underground economy has grown substantially in the past few years, and this article finds that it has grown by up to \$14 billion (almost 2 percent of GDP) since the beginning of 1991. No evidence was found that recessions contribute to the growth of the underground economy. Therefore, the recent growth is likely to be due mainly to tax changes, with the goods and services tax being the largest single factor.

INTRODUCTION

The measurement of the value of economic activity that evades taxes, the "underground economy," is vital for gauging the effectiveness of tax administration, but it is notoriously difficult to do. Recent estimates of the size of the underground economy in Canada run from roughly 3 percent to 22 percent of gross domestic product (GDP). As one author has noted, "[s]uch a huge discrepancy is hardly likely to instill confidence either in those who did the estimating or in the very concept itself."¹ This article explores the reasons why there is such a wide range of estimates, and attempts to determine whether the degree of uncertainty justifies a range this wide. It focuses on the monetary approach, and tries to improve the reliability of its estimates.

Estimates of the size of the underground economy based on monetary evidence are widely used. Accurate data on the amounts of currency in circulation are readily available from the central bank. Illicit economic activity generally relies on the use of cash transactions in order to avoid leaving an audit trail. Therefore, by measuring the discrepancy between the amount of cash actually in use and the amount that one would expect to be in use on the basis of income reported to tax authorities, one can make a forensic inference about the volume of hidden income.

Needless to say, a considerable amount of judgment needs to go into this estimation process. It is the contention of this article that a more critical scrutiny of the monetary techniques used in estimating the size of the underground economy can considerably refine the previous estimates and narrow the range of uncertainty. Such an approach yields the implication that the underground economy in Canada, although substantial, is considerably smaller than many of the previous monetary studies have suggested.

¹ Harry I. Greenfield, *Invisible, Outlawed, and Untaxed: America's Underground Economy* (Westport, Conn.: Praeger, 1993), 1, writing about a similar range of estimates for the United States.

PROBLEMS WITH PREVIOUS MONETARY STUDIES

A methodology developed by Vito Tanzi of the International Monetary Fund is widely acknowledged to be the most plausible of the monetary methodologies.² Over the years, it has been used by a number of researchers in estimating the size of Canada's underground economy.³

Tanzi's model includes some measure of tax rates as one of the variables explaining the demand for currency. The advantage of this specification is obvious. Assuming that it is possible to find an econometrically plausible formulation, it provides a direct measure of the effect of the tax system on cash in circulation. The only reason tax rates would affect the use of cash is that cash is used as a means of evading taxes in the underground economy.

The Problem of Choosing the Determinants of the Demand for Cash

Tanzi used the ratio of currency to M_2 as his monetary variable, and has been followed in this by most Canadian researchers. However, the use of M_2 as the denominator is problematic. Money supply M_2 includes chequing accounts on which interest is earned, and non-chequable savings accounts. Tanzi offered no particular rationale for his choice of M_2 as the denominator, apart from the fact that the cash-to- M_2 ratio was on a declining trend, whereas the cash-to-demand-deposit ratio was on a rising trend. He suggested that the latter might be due to "shifts by individuals from checking accounts into other financial assets (included in M_2) that paid interest rather than to sharp increases in currency holdings."⁴

Ingemar Hansson, however, made an even more persuasive argument that "changes in inflation, interest rates, and tax rates are likely to influence time deposits versus currency to an even greater extent than the influence between demand deposits and currency."⁵ After all, currency is used for transactions purposes, whereas M_2 contains substantial amounts that represent long-term wealth accumulation. Therefore, changes in the ratio of cash to M_2 are not particularly meaningful. The ratio could rise either because

² Vito Tanzi, "The Underground Economy in the United States: Annual Estimates, 1930-80" (June 1983), 30 *International Monetary Fund Staff Papers* 283-305.

³ See Mireille Éthier, "The Underground Economy: A Review of the Economic Literature and New Estimates for Canada," in François Vaillancourt, research coordinator, *Income Distribution and Economic Security in Canada*, Collected Research Studies of the Royal Commission on the Economic Union and Development Prospects for Canada, vol. 1 (Toronto: University of Toronto Press, 1985), 77-109; Rolf Mirus and Roger S. Smith, "Canada's Irregular Economy" (Summer 1981), 7 *Canadian Public Policy* 444-53; and Vladimir Karoleff, Rolf Mirus, and Roger S. Smith, "Canada's Underground Economy Revisited: Update and Critique," paper presented to the 49th Congress of the International Institute of Public Finance, Berlin (mimeograph, University of Alberta, 1993).

⁴ *Supra* footnote 2, at 288.

⁵ Ingemar Hansson, "The Underground Economy in Sweden," in Edgar L. Feige, ed., *The Underground Economies: Tax Evasion and Information Distortion* (New York: Cambridge University Press, 1989), 219-36, at 227.

there is increased use of cash in the underground economy (the numerator goes up), or because other savings instruments become more attractive relative to bank savings deposits (the denominator goes down). M_2 is a particularly inappropriate indicator for Canada, because there have been large movements between M_2 savings deposits and Canada savings bonds in the last few years.

The ratio of currency to demand deposits, used in some previous Canadian studies, is a somewhat more appealing candidate, since both of these are primarily devoted to transactions purposes. The problem with using this ratio is that changes in financial technology can have different effects on the demand for cash versus chequing deposits. There have been substantial changes in payment systems, such as electronic transfers, which affect the use of demand deposits; credit cards and ATMs, which affect the use of currency; and interest-bearing chequing accounts (which are not classified as demand deposits), which affect both of these.

The currency-to-demand-deposit ratio rose steadily through the 1980s (which also happened to be a decade of rising tax rates), but it would be misleading to infer that all of this increase was due to growth in the underground economy.⁶ In fact, there is a purely financial explanation of this rising ratio that has nothing to do with the underground economy. The currency-to-demand-deposit ratio in this period rose not because currency was strong, but because demand deposits, which represent the denominator, were weak (see figure 1). The 1980s saw the widespread adoption of daily interest chequing accounts, which many consumers turned to as a joint savings and transactions vehicle. As a result, chequing accounts, which are in M_1 , are only a small fraction of the actual transactions balances that people have available to them. At the same time, the broader definition of money supply, which includes chequable savings accounts (M_1B), cannot be used as the denominator, because these same accounts pay a high interest rate on large balances, and a substantial part of this represents a store of wealth rather than a medium of exchange for transactions purposes.

The best alternative appears to be not to relate the demand for cash to any other monetary measure, but instead to explain it by changes in expenditure in the economy. The object of the exercise, after all, is to look for discrepancies between cash in circulation and measured expenditure. There is certainly not a fixed ratio between the two, because the advances in financial technology mentioned above have reduced people's reliance on currency. It is unlikely, however, that these advances can be correlated with changes in consumer spending, which implies that a relationship that focuses on the relative period-to-period changes in currency and consumer

⁶The coefficients on the tax variable in the 1993 Karoleff et al. study, *supra* footnote 3, may be overestimated because of a correlation between the tax rate and the currency-to-demand-deposit ratio. Note the large increase in the elasticity of currency demand to the tax rate compared with the results in Mirus and Smith's 1981 article, *supra* footnote 3. An increase in tax rates might be expected to increase the absolute amount of tax evasion, but not the elasticity of tax evasion with respect to the tax rate.

Figure 1 Interest-Bearing Chequing Balances Share of Total Personal Chequing Accounts, 1978-1993



Source: Statistics Canada, CANSIM series B486 and B2023.

expenditure would have an unbiased coefficient. The close relationship in the rate of change of these two variables may be seen in figure 2.

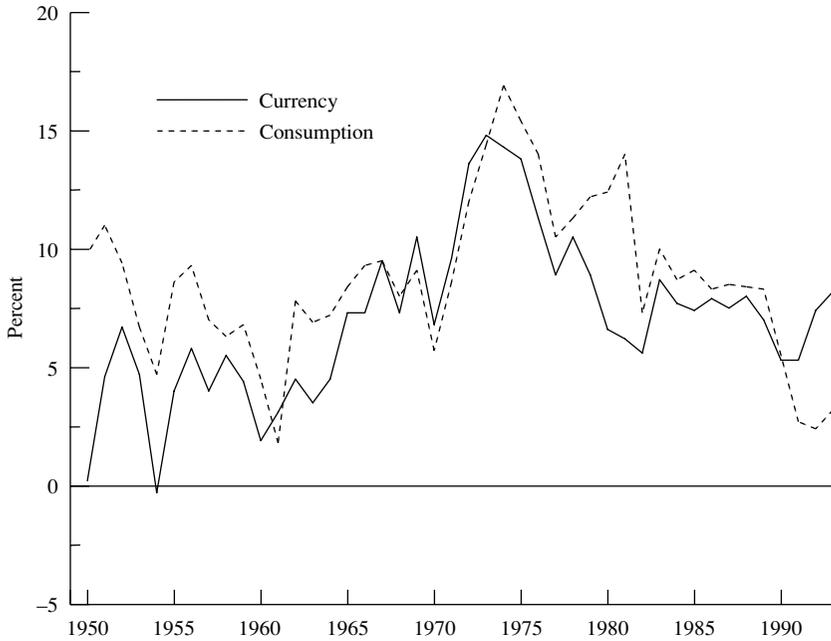
As a measure of expenditure, a broad variable such as GDP or total personal income, or a narrower one such as consumer expenditure, could be used. In fact, many transactions that form part of GDP, such as government spending and corporate investment, do not use cash. Cash as a medium of exchange is concentrated in the area of personal consumption expenditure. Two recent US studies of the demand for cash have found that either consumer expenditure or retail sales is the best variable for explaining the use of cash.⁷

The Velocity of Circulation of Money in the Underground Economy

As appealing as the Tanzi methodology is in principle, it presents a great many econometric pitfalls. The most serious of these is the possibility of

⁷ Michael Dotsey, "The Demand for Currency in the United States" (February 1988), 20 *Journal of Money, Credit, and Banking* 23-39; and Mark Ladenson and Gail Makinen, "The Currency Ratios 1920-1980: A Re-Examination" (1992), vol. 20, no. 4 *Atlantic Economic Journal* 1-9.

**Figure 2 Currency and Consumption Expenditure,
Annual Growth Rates, 1950-1993**

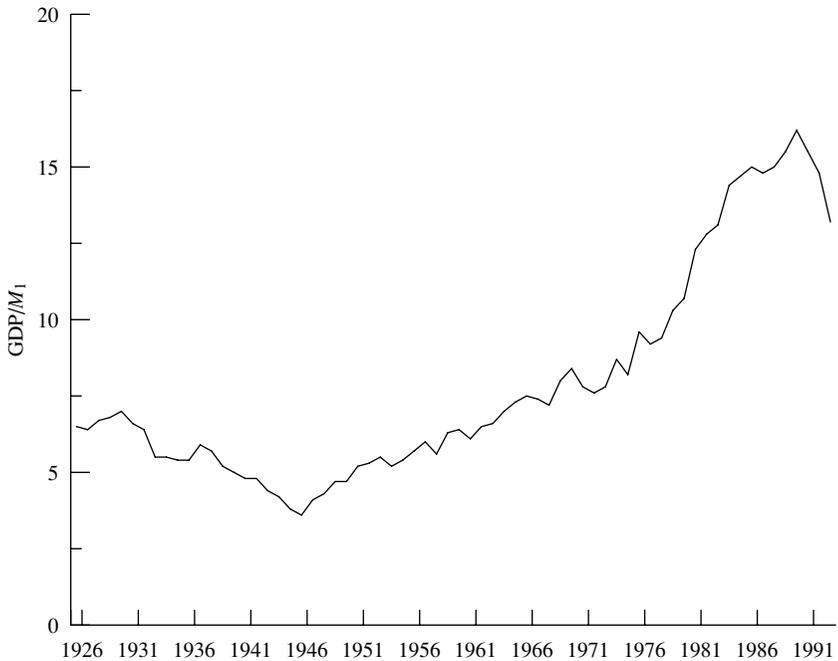


Source: Statistics Canada, CANSIM series B2001 and D43372.

spurious correlations, which will be investigated below for the Canadian data.⁸ Even if we can convince ourselves that the tax rate has a significant, causal impact on cash in circulation, there remains the problem of estimating the ratio of economic activity to cash in the underground economy, which is referred to as the “velocity of circulation.”

In 1993, Canadian GDP was estimated to be about \$712 billion, while the cash in the hands of the public totaled \$23 billion. Therefore, as a first order of approximation, one could say that every dollar of cash supported \$31 dollars of economic activity. It would be very unrealistic to suppose, however, that the ratio is this high in the underground economy. In the legal economy, a large proportion of transactions take place through means of payment other than cash: cheques, credit cards, and electronic transfers. The underground economy probably relies almost entirely on cash for its transactions, and therefore its ratio of activity to cash would be lower.

⁸ This has been a serious problem with Tanzi’s original US studies. It was found that when a different sample period was chosen, the tax variable in Tanzi’s equation had an incorrect sign. See Richard D. Porter and Amanda S. Bayer, “Monetary Perspective on Underground Economic Activity in the United States,” in *The Underground Economies*, supra footnote 5, 129-57. As suggested above, this may have occurred because Tanzi used an inappropriate monetary variable as the denominator in his dependent variable.

Figure 3 Velocity of M_1 , 1926-1993

Source: Statistics Canada, historical series J3, J187, and J188.

Many researchers have assumed that the velocity of cash in the underground economy is the same as for M_1 in the regular economy. M_1 consists of the total of cash plus chequable demand deposits, and the ratio of GDP to M_1 has been as high as 16 in recent years. As noted above, however, legal transactions are not limited to cash and cheques. Moreover, chequing accounts that earn interest are included in M_2 rather than M_1 , and these chequing accounts also support transactions. Therefore, the velocity of M_1 is likely to overestimate seriously the velocity of cash in the underground economy.

The history of the velocity of circulation of M_1 , shown in figure 3, provides some insight into this tendency. It can be seen that, until the 1960s, the ratio of GDP to M_1 fluctuated in a fairly narrow band. The average velocity from 1926 to 1959 was 5.4. Subsequently, the velocity began to increase rapidly, peaking at 16 in 1990. The reasons for the growth of M_1 's velocity are several, and reasonably well understood: higher nominal interest rates, more flexible banking arrangements that permit small depositors to easily use interest-bearing chequing accounts (which are not included in M_1), and credit cards accounting for a large proportion of consumer transactions. As a result of better banking services, many transactions that used to be in the form of cash are now made by cheque. Many industrial

workers used to be paid in cash, which provided the basis for that great staple of black-and-white crime thrillers, the payroll robbery. At that time, it could not be taken for granted that an ordinary labourer would have a bank account into which he could deposit a paycheque.

All of these institutional changes have allowed consumers to economize on their inventories of the type of money that pays no interest. These means of economizing on the use of cash, however, are not available to the underground economy. Its participants know they must use cash in order to avoid leaving an audit trail. It may be true that, in a few instances, an underground supplier will accept a "bearer" cheque from a customer, but the supplier will immediately convert the cheque into cash at his own bank without depositing it. This type of deal does not greatly increase the transactions-to-cash ratio. It is unlikely, therefore, that the underground economy has benefited from as large an increase in the velocity of circulation as seen in figure 3.

In the 1920s, the velocity of M_1 was close to 7. It dipped toward 5 in the 1930s, no doubt due to fears that banks were unreliable.⁹ Although bank failures were not a problem in Canada, Canadians were no doubt impressed by the experience of their American neighbours. The use of cash as a store of wealth, and not just a medium of exchange, is also inevitably a characteristic of individuals who derive a large proportion of their income from the underground economy, and do well enough to have substantial savings. Therefore, this period probably comes as close as any historical period to representing the velocity of circulation in the underground economy. A velocity of 5 appears to be the most plausible factor for estimating the size of the underground economy.¹⁰

Although the use of cash as a means of saving does contribute to a lower velocity of circulation in the underground economy, its significance should not be exaggerated. Cash hoarding is probably most prevalent in a few specialized sectors such as illegal drug markets, where all transactions are cash-based. In the case of very large hoards, the owners will contrive to "launder" the money. The largest part of what is loosely referred to as the underground economy probably consists of underreporting of sales by otherwise legitimate businesses, and this does not necessarily entail any cash hoarding at all. For example, a retailer might underreport his annual sales by 10 percent, making his net income appear substantially smaller

⁹ During World War II, the velocity of M_1 dipped even further, getting down to 3.8 by 1945. The same sort of bulge in the use of cash was observed in the United States. It is likely that this reflects a burgeoning underground economy, in response to price controls, rationing and higher tax rates. See Phillip Cagan, "The Demand for Currency Relative to the Total Money Supply" (August 1958), 66 *The Journal of Political Economy* 303-28; and Richard H. Timberlake, *Monetary Policy in the United States: An Intellectual and Institutional History* (Chicago: University of Chicago Press, 1993), 308.

¹⁰ A recent Belgian study of the underground economy takes a similar approach to estimating the velocity of circulation. See L. Van Hove and J. Vuchelen, "The Demand for Currency and the Underground Economy: Two Amendments on the Tanzi Method," CFEC paper no. 93-09 (Free University of Brussels, 1993).

than it really is. All he needs to do is ensure that 10 percent of his sales is in the form of cash. The rest can be made in the form of cheques or credit cards, whose receipts he duly deposits in his bank account. This unscrupulous retailer would use the cash for part of his own personal spending. Whatever part of his income he wishes to save can come out of his legally declared income.

EMPIRICAL ESTIMATES OF THE EFFECT OF TAX RATES ON EVASION

Including the tax rate as a variable explaining the demand for currency was a profound insight by Tanzi. The finding that it has a significant causal effect is an important piece of evidence for tax policy decision making. It is widely felt that higher tax rates lead to increased evasion. This layman's consensus, however, should not be confused with hard economic evidence. Economic theory itself is ambiguous about the effects of tax rates on evasion, because there are both substitution and income effects, which work in opposite directions.

Empirical evidence on the relationship between tax rates and evasion is necessarily sparse, because accurate data on the amount of tax evasion are hard to come by. The study cited most frequently in support of a positive association between tax rates and evasion is by Charles Clotfelter, which used US Internal Revenue Service (IRS) data from tax-compliance audits.¹¹ Clotfelter did indeed find that higher marginal tax rates were associated with a higher percentage of income evaded. However, his study was a cross-section across income levels, and in fact his results show only that higher-income people (those with higher marginal tax rates) are more prone to evade taxes than lower-income people. Clotfelter's findings cannot tell us what the effect would be of raising overall tax rates from year to year. Dennis Cox of the IRS used the same data base as Clotfelter, but analyzed it in a different way.¹² He divided up the tax returns according to the state of residence, since different US states have quite different rates of income tax. Looking at the problem this way, Cox found *no* evidence that higher income tax rates increase the rate of tax evasion.

As already noted, the Tanzi variant of the monetary approach uses the tax rate as a means of predicting the demand for cash, and thus serves as an indirect means of estimating the effect of the tax rate on evasion. The type of tax rate to use as an explanatory variable is an important empirical issue. Tanzi chose the average income tax rate, while Karoleff, Mirus, and Smith tried both that and total taxes as a percentage of GDP.

One thing that is clear from previous studies is that the top marginal income tax rate is not relevant for growth in the underground economy. This conclusion was borne out in a recent survey study conducted in

¹¹ Charles T. Clotfelter, "Tax Evasion and Tax Rates: An Analysis of Individual Returns" (August 1983), 65 *The Review of Economics and Statistics* 363-73.

¹² Dennis Cox, "Raising Revenue in the Underground Economy" (September 1984), 37 *National Tax Journal* 283-88.

Quebec, which found that “underground goods and services are produced by workers with low (regular) incomes.”¹³ The people who are subject to top marginal tax rates are mainly high-income professionals and executives, who tend to use legal tax-avoidance schemes rather than tax evasion to minimize their taxes.

The tax variable chosen in this article is a compromise between the two alternatives used by Karoleff et al.: it is the first difference of total personal taxes as a percentage of personal income. The history of this tax rate is depicted in figure 4. This is the most intuitively appealing tax variable, because it comes the closest to fully representing the taxes that people evade when they enter the underground economy. It includes personal income taxes, provincial sales taxes, and the goods and services tax (GST), and employer and employee contributions to social insurance and government pensions. It excludes corporate taxes and the old manufacturers’ sales tax (MST).

The “direct” nature of the GST as opposed to the “hidden” nature of the MST is important in two respects. First, value-added taxes generally have a reputation of not being more prone to evasion than income taxes, for example, and some analysts suggest that they may offset evasion of income tax.¹⁴ The MST, however, was much less prone to evasion than most other taxes, since the bulk of it was collected through several thousand large corporations. In contrast, the GST was supposed to collect the same revenue from over 1.5 million businesses, many of them providing services to final consumers for whom an input tax credit was irrelevant. Second, the GST is highly visible, generating much public hostility, compared with the MST, of whose existence many people were simply unaware.¹⁵

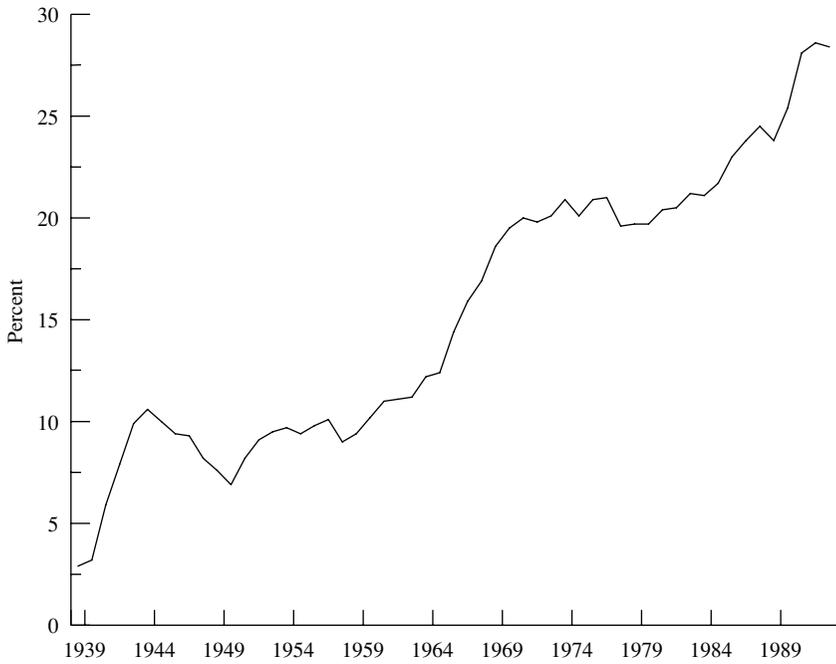
The introduction of the GST has not been the only tax change since 1991. There have also been tobacco tax increases and income tax increases. However, an evaluation of the timing and magnitude of the various tax changes suggests that the introduction of the GST was probably the largest single factor leading to an increase in tax evasion.¹⁶

¹³ Thomas Lemieux, Bernard Fortin, and Pierre Fréchette, “The Effect of Taxes on Labor Supply in the Underground Economy” (March 1994), 84 *The American Economic Review* 231-54, at 236. However, this study has to be regarded with considerable caution, because it was carried out through direct interviews rather than anonymous questionnaires.

¹⁴ For example, there are some individuals who work entirely in the underground economy and escape all income taxes. It has been argued that the presence of consumption taxes means that they do not avoid taxation entirely. For an enlightening discussion of these and related issues, see Jonathan R. Kesselman, “Evasion Effects of Changing the Tax Mix” (June 1993), 69 *The Economic Record* 131-48.

¹⁵ A public attitude survey in early 1994 found that 49 percent of the public admitted that they would use cash to evade the GST, while only 19 percent said they would cheat on their personal income tax returns. See Sal Badali, “Survey of Canadian Attitudes Towards Taxation” (KPMG Peat Marwick Thorne, March 1994).

¹⁶ See Peter S. Spiro, “Taxes, Deficits, and the Underground Economy,” in Michael Walker and Edgar Feige, eds., *The Underground Economy: A Global Perspective* (Vancouver: Fraser Institute, forthcoming).

Figure 4 Direct Taxes as a Share of Personal Income, 1939-1993

The results produced by the *Tanzi* model, showing a significant effect of tax rates on tax evasion, are the closest thing to hard evidence that economists have on this subject. They allow us to make an informed statement that higher tax rates do significantly increase the rate of tax evasion. Moreover, this methodology allows us to make a rough estimate of the extent of the increase in evasion for a given rate of tax increase.

One can use the equations described in the appendix to simulate the effect of an increase in the tax rate variable. Calculating the outcome of an increase in the tax rate, the model (using the coefficients of equation 2) implies that tax increases in Canada produce revenue of roughly 84 cents on the dollar after increased evasion is taken into account.¹⁷ That is to say, when tax rates are increased with the intention of raising \$1 billion of revenue, the actual increase is on the order of \$840 million. This is a behavioural relationship, and there is no guarantee that it will hold for future tax increases. Nevertheless, the coefficient on the tax variable appears to be quite stable when the econometric equation is estimated over different time periods, suggesting a fairly steady rate of response.

¹⁷The actual net tax revenue increase might be even smaller than this if, as many authors have argued, increased tax rates also reduce the amount of work effort in the economy.

THE SIZE OF THE UNDERGROUND ECONOMY

The currency-demand equations can be used to simulate what the demand for currency would have been if there had been no tax increases in the past. The difference between the actual currency in circulation and the simulated value can be considered “excess currency,” indicating the size of the underground economy.

The estimates of excess currency based on equations 1, 2, and 3 from the appendix are shown in table 1. They are all quite similar,¹⁸ and they suggest that in 1993 almost half of the cash in circulation in Canada served to meet the demands of the underground economy. The legal economy is already well on its way to becoming a “cashless society.” It is the illegal economy that has continued to keep paper money popular.

The figures on excess currency from table 1 can be multiplied by an assumed velocity of circulation of 5 to estimate the trend of the underground economy as a percentage of Canadian GDP, which is shown in table 2. Technically, these figures are based on zero tax increases since 1950, and hence represent the increase in the underground economy since 1950 rather than its total size. The size of the underground economy in 1950 needs to be added to the numbers in table 2 to obtain the total size of the underground economy.

Tax rates before 1950 were quite low, which may imply an underground economy in the neighbourhood of 2 percent of GDP as of 1950. It could also be argued, however, that in the total absence of retail sales taxes and with income tax still enjoying the aura of being “temporary,” the underground economy might have been even smaller than this. If a range from 0 to 3 percent is posited for the 1950 base value, these equations imply an estimate of the underground economy in the range of 8 to 11 percent for 1993, which is quite similar to the estimates for the United States based on IRS audits.

The figures in table 2 show a dip in the underground economy’s share in the early 1980s. This is not because of a decline in its absolute size. Tax rates stabilized in that period, and therefore the equation implies that the underground economy grew more slowly than total GDP. All three equations indicate a substantial increase in the years after 1990. Over this three-year span, the underground economy is estimated to have increased in total by 1.6 to 1.9 percent of GDP. This estimate is based purely on the econometric impact of increases in the tax rate. Using a quite different approach, a recent Statistics Canada study has also found several items of evidence indicating a growing underground economy, noting that “[w]hat is probably most significant is that all signs point consistently in the

¹⁸ This is in marked contrast to the findings in Peter S. Spiro, “Evidence of a Post-GST Increase in the Underground Economy” (1993), vol. 41, no. 2 *Canadian Tax Journal* 247-58. The equations used there were identical to the ones in the present study except that they did not include the tax rate as an explanatory variable, and they led to four widely different estimates of the amount of excess currency (at 257). Including the tax rate has helped considerably in narrowing the range of uncertainty.

Table 1 Total Currency and Excess Amount Induced by Tax Changes

Year	Actual total	Excess		
		Equation 1	Equation 2	Equation 3
<i>millions of dollars</i>				
1970	3,271	808	816	856
1971	3,587	972	992	1,003
1972	4,074	1,234	1,264	1,240
1973	4,675	1,556	1,614	1,526
1974	5,341	1,894	1,981	1,811
1975	6,080	2,278	2,370	2,151
1976	6,766	2,580	2,702	2,463
1977	7,365	2,825	2,968	2,719
1978	8,141	3,230	3,400	3,057
1979	8,863	3,567	3,785	3,335
1980	9,448	3,765	4,005	3,487
1981	10,032	3,921	4,188	3,575
1982	10,592	4,165	4,373	3,811
1983	11,515	4,537	4,704	4,086
1984	12,405	4,828	5,011	4,361
1985	13,322	5,176	5,389	4,690
1986	14,369	5,679	5,875	5,247
1987	15,451	6,149	6,341	5,687
1988	16,681	6,791	6,984	6,355
1989	17,851	7,468	7,649	7,062
1990	18,793	8,116	8,228	7,819
1991	19,799	8,880	8,814	8,593
1992	21,256	9,982	9,756	9,702
1993	23,001	11,285	10,943	10,987

expected direction.”¹⁹ These numbers suggest that, notwithstanding some understatement in the post-1991 official GDP data due to growth in the underground economy, Canada suffered a very deep recession.

Is the Underground Economy Cyclical?

The change in the unemployment rate is included as an explanatory variable in all the equations, but it is insignificant in all of them.²⁰ This is not due to the presence of the change in the interest rate and consumption as alternative cyclical indicators. The unemployment rate remains insignificant even when these other variables are omitted. Real GDP growth and a distributed lag on the change in the unemployment rate were also tried, and proved to be similarly insignificant. The level of the unemployment

¹⁹ Statistics Canada, *The Size of the Underground Economy in Canada*, catalogue no. 13-603E, no. 2, 46.

²⁰ The variable used here is the measured unemployment rate, rather than what is often considered the real unemployment rate (measured minus the “natural rate”). For this purpose, however, it is the measured rate that matters, since many people who are priced out of the regulated legal economy could still be competitive in the underground economy. In any event, it is the first difference of the unemployment rate that is used here, and so an upward trend in the natural rate would affect only the constant term of the regression.

**Table 2 Estimated Increase in the Underground Economy
Over the 1950 Base as a Percentage of GDP**

Year	Equation 1	Equation 2	Equation 3
1970	4.5	4.6	4.8
1971	5.0	5.1	5.2
1972	5.7	5.8	5.7
1973	6.1	6.3	6.0
1974	6.2	6.5	6.0
1975	6.6	6.9	6.3
1976	6.5	6.8	6.2
1977	6.5	6.8	6.2
1978	6.7	7.0	6.3
1979	6.5	6.9	6.0
1980	6.1	6.5	5.6
1981	5.5	5.9	5.0
1982	5.6	5.8	5.1
1983	5.6	5.8	5.0
1984	5.4	5.6	4.9
1985	5.4	5.6	4.9
1986	5.6	5.8	5.2
1987	5.6	5.7	5.2
1988	5.6	5.8	5.2
1989	5.7	5.9	5.4
1990	6.0	6.1	5.8
1991	6.6	6.5	6.4
1992	7.2	7.1	7.0
1993	7.9	7.7	7.7

rate was also tried in the Karoleff-Mirus-Smith equations, and there too it was completely insignificant. These results cast doubt on the optimistic view that recent growth in the underground economy is partly due to the recession, which implies that the underground economy will decline as unemployment declines.

It is tempting to suppose that unemployment contributes to greater underground activity, because there are more unemployed workers available and willing to work in it (to supplement their unemployment insurance or welfare benefits). However, this is only the supply side. Many of the services that take place underground represent discretionary expenditure by consumers, and that means the demand for these services falls in a recession. The regression results here suggest that falling demand offsets the rising willingness to supply, and recessions do not have any net effect on the underground sector's share of the total economy. These findings are consistent with international studies on the issue.²¹

Comparison with Statistics Canada's Studies

Two recently published studies by Statistics Canada have argued that the underground economy in Canada is no larger than 5.2 percent of GDP, and

²¹ "Most studies suggest that recessions tend to squeeze the black economy as much as the formal one." See "The Black Economy: Ghostbusters," *The Economist*, August 14, 1993, 55.

describe this as an “upper-limit” estimate.²² Given the margin of uncertainty inherent in this subject, one would not want to insist that there is a significant difference between estimates of 5 percent and 8 percent. However, the Statistics Canada approach has its own difficulties. It uses a detailed sector-by-sector adding up of the estimated size of the underground economy in every field of economic activity. This approach may appear rigorous, but the final estimate is no better than the data that went into the adding up. Unfortunately, in many instances the Statistics Canada studies were forced to rely on assumptions where actual data were unavailable.

It should be noted that the Statistics Canada studies make a distinction between the total amount of economic activity missing from official GDP due to the underground economy and the total amount of income unreported to tax authorities. They estimate the former to be no more than 2.7 percent of GDP, while the latter could be as much as 5.2 percent. The distinction is a valid one, and the monetary methodology should be viewed as giving an estimate of the total of unreported activity.

At first blush, it may seem that this is not the case. A component of GDP is included as an explanatory variable. It might be supposed that since the increase in cash is not explained by measured GDP, all this underground economic activity must be missing from the official GDP data. However, the velocity of circulation of cash in the underground economy is considerably lower than that in the regular economy. Therefore, an increase of a dollar in underground activity will give rise to a greater demand for cash than an increase of a dollar in ordinary GDP. Hence, a substantial part of the growth in the demand for cash would not be explained by the growth in GDP even if GDP actually included all the underground activity.

One of the problems for the Statistics Canada methodology of adding up the underground economy is the lack of systematic Canadian data on taxpayer non-compliance. In the United States, in contrast, the IRS conducts tax-compliance audits on a scientific random-sampling basis. These audits lead to an estimate that in 1992 unreported income amounted to \$539 billion, or about 9 percent of GDP.²³ Some of the income unreported to tax authorities in the United States consists of items such as interest and dividends that are also reported by the paying institutions, or is otherwise picked up elsewhere in the national accounts. One US researcher deducted items of this kind from the IRS estimates, and concluded that official US gross national product figures for 1990 were understated by 6.2 percent as a result of the underground economy.²⁴

In the absence of data from systematic audits, Statistics Canada was forced to make an assumption about the extent to which small owner-

²² Philip Smith, “Assessing the Size of the Underground Economy: The Statistics Canada Perspective,” in (May 1994), *Canadian Economic Observer*, Statistics Canada catalogue no. 11-010, 3.16-33, at 3.29; and supra footnote 19.

²³ United States, Department of Labor, *The Underground Economy in the United States*, Occasional Paper no. 2 (Washington, DC: the department, 1992), table 7.

²⁴ Greenfield, supra footnote 1, at 65.

operated businesses underreport their sales. Statistics Canada suggests that its estimates of underreporting are “on the high side since they imply that businesses may be hiding well over 50% of their net income.”²⁵ In fact, the calculation of the percentage by which businesses understate their net income is predicated on the assumption that the total number of businesses and their total costs are known. There are probably some small businesses that are not measured at all, and some others that understate their costs as well as their sales (by employing illegal immigrants whose income cannot be declared). Therefore, to arrive at an estimate of the underground economy as high as 5 percent of GDP, it is not necessary to assume that individual businesses that file tax returns understate their net income by anything close to 50 percent.

There have recently been indications that Canada’s population was previously underestimated. A new methodology to correct for census undercoverage implies that the 1991 census count of total Canadian population needs to be increased by almost 3 percent. Moreover, the undercoverage is concentrated among people of working age, with those aged 20 to 34 underestimated by about 6 percent.²⁶ The true number of people could be even higher. The new methodology focuses on people who were inadvertently missed by the latest census but were included in the previous one. It cannot count illegal immigrants or others who have never reported themselves to a census (because, coming from countries with non-democratic governments, they have learned to distrust government).

It is possible that quite a number of small businesses and self-employed people are entirely missing from official data. It is even harder to count the number of small businesses than it is to count the number of people in Canada. This type of measurement error is inevitably biased rather than random. There is a clear motive for hiding taxable economic activity, leading to the presumption that a substantial number of small entrepreneurs, especially in the service areas, are missing from official counts of the number of businesses.

One of the presumptions underlying the Statistics Canada methodology is that it has better information on spending than it has on income. For example, it acknowledges that there are underground home renovation contractors who underreport their income to government agencies.

²⁵ Smith, *supra* footnote 22, at 3.23. In fact, IRS audits in the United States found that net income was underreported by 60 percent for sole proprietorships (see US Department of Labor, *supra* footnote 23, table 7). Statistics Canada data indicate that in 1990 unincorporated self-employed individuals represented 9.2 percent of total employment in Canada, while their net income (excluding rent) represented only 3.4 percent of GDP (see (Winter 1991), *Perspectives on Labour and Income*, Statistics Canada catalogue no. 75-001E, 46). This is a surprisingly low income share for this group, given that it includes some very high income earners such as physicians and lawyers.

²⁶ Statistics Canada, *Annual Demographic Statistics, 1993*, catalogue no. 91-213, table III. The methodology is discussed by Manon Declos, “Revised Postcensal and Intercensal Estimates for Canada, Provinces and Territories, 1971-1993” (mimeograph, Statistics Canada, Demography Division, 1993).

Statistics Canada points out, however, that this income is not necessarily missing from GDP data, because most of it is divulged by consumers when Statistics Canada surveys them regarding their expenditure patterns.

Statistics Canada has to depend on an optimistic view that people who answer surveys will be honest, and the average error unbiased. The oft-cited low margin of error on large surveys refers only to random-sampling error, and is irrelevant when the respondents have something to hide. Statistics Canada's surveys of such things as homeowner spending on repairs and renovation are not anonymous. They are based on interviews carried out over the telephone or in person as part of the Labour Force Survey interview.²⁷ The interviewer always knows the name of the interviewee, and under those circumstances many people would be shy about admitting to an illegal activity, even if they are not personally liable for the evaded taxes. Statistics Canada is, of course, legally prohibited from passing its information on to Revenue Canada. However, a suspicious person who had hired an underground contractor to finish his basement without a building permit would be reluctant to divulge this information to any official from any branch of government. A Norwegian study found that almost twice as many people admitted to underground activity when they responded to an anonymous mail-in survey as when they participated in a direct interview.²⁸

The staff of Statistics Canada's census division are quite forthcoming about the problem of increasing public suspicion of government agencies. In their advance planning for the 1996 census, they point out that "[o]ne of the most pervasive social changes which has occurred over the past decade is the growth in public apathy—bordering on hostility—to either demands for personal information or co-operation with government."²⁹

The margin of error around the estimation of the underground economy is necessarily quite large, and there is a risk of seriously understating the problem of tax evasion if Statistics Canada's studies are accepted at face value. Words such as "could not possibly" and "upper limit," which appear in the Statistics Canada studies, are too strong to be used when describing hidden economic activity. Fortunately, we do not live in a country such as the one depicted in George Orwell's *1984*. We live in a decentralized economy with little direct government monitoring. Government agencies are dependent on information voluntarily supplied by the public, and in some instances this information will not be truthful. Given the inherent limitations of government data gathering, it is not obvious that the Statistics Canada approach can produce a more reliable estimate of the underground economy than the monetary approach. The Statistics Canada approach does offer insights into the potential sectoral composition of the underground

²⁷ The process is described in the methodology section of Statistics Canada, *Homeowner Repair and Renovation Expenditure in Canada, 1992*, catalogue no. 62-201.

²⁸ Arne Jon Isachsen and Steiner Strom, "The Underground Economy in Norway with Special Emphasis on the Hidden Labor Market," in *The Underground Economies*, supra footnote 5, 251-65.

²⁹ Statistics Canada, "1996 Census Consultation Report," March 1994, 1.

economy, and is a useful complement to the monetary approach. It would be rash, however, to suggest that it can supplant monetary studies of the underground economy.

IMPLICATIONS FOR THE EVALUATION OF MONETARY POLICY

The brief exploration of non-standard monetary aggregates undertaken in this article suggests that this would be a fruitful area of research for monetarists seeking to use monetary aggregates to predict economic growth. The regressions in appendix table 1 point out the fact that the demand for currency is quite different from the demand for the rest of M_1 .

The difference between the coefficients on the increase in consumption in equation 2 and those in equation 5 (in the appendix) is quite interesting. It is highly significant in the former, and insignificant in the latter. (This holds even if GDP growth is substituted for consumption growth.) There is a transactions demand for currency that merely reacts to the volume of consumer expenditure, and it has a very low interest elasticity of demand. The demand for this currency does change, with financial technology and tax rates, but it has very little to do with monetary policy.

In contrast, there is not much relation between M_1 excluding currency and current consumption expenditure. The former has a higher interest elasticity, which implies that as monetary policy is tightened people substitute chequable savings deposits for demand deposits. Broadly speaking, currency growth is caused by expenditure growth, while changes in the growth of M_1 excluding currency are an indicator of significant interest rate changes, and tend to lead subsequent changes in expenditure growth.

A very substantial part of the demand for currency appears to be in the underground economy, where it has a much lower velocity. In view of this fact, it is not surprising that the growth of M_1 excluding currency explains nominal GDP growth much better than the ordinary measure of M_1 , which includes currency.³⁰ This is of considerable interest for the analysis of monetary policy in recent years. In the 1991-1993 period, total M_1 grew at an average rate of 9.2 percent, while M_1 excluding currency grew at a rate of only 6.5 percent. Calculations of the non-inflationary rate of money supply growth³¹ will need to take this factor into account.

CONCLUSIONS

The first and primary finding of this article is that the Tanzi model, which predicts currency demand based on tax rates, holds up very well for

³⁰ A regression was tried in which the growth of GDP in the 1970-1993 period was explained by a four-year distributed lag of the growth rate of the monetary aggregate. When total M_1 was used, the corrected R^2 was only 0.39. When M_1 excluding currency was used, the R^2 rose to 0.70.

³¹ See, for example, David E.W. Laidler and William B.P. Robson, "Re-Entry in Progress: Canada's Transition to Noninflationary Growth" (August 1993), no. 51 *Commentary* (C.D. Howe Institute).

Canadian data. There is a significant, causal effect of tax rates on the demand for currency in Canada. This can only be due to the use of cash in the underground economy, which grows in response to higher tax rates.

An examination of alternative monetary aggregates suggests that past studies, which used the ratio of cash to demand deposits or to M_2 , have produced less reliable estimates. There is no systematic relationship between cash and either of these other two monetary aggregates, and therefore no reason to try to explain their ratio using the Tanzi model. A currency-demand specification relating the growth of currency to growth in consumer expenditure produces more plausible estimates. Taking these factors into account, and using a cautious estimate of the velocity of circulation, implies that the Canadian underground economy was in the neighbourhood of 8 to 11 percent of GDP in 1993.

These figures for the underground economy based on monetary analysis represent income on which tax is evaded. It is possible that Statistics Canada can impute some of this income through other means. Therefore, the estimates in this article do not address the question how much the official GDP data may be understated due to the underground economy.

The results imply that roughly half of Canada's currency stock is in use in the underground economy. This represents a substantial proportion of total M_1 , and indicates that this monetary aggregate should be approached with caution in the analysis of monetary policy. It is likely that cash used in the underground economy circulates much more slowly than money in the legal economy. It is necessary to take this into account for a correct analysis of the effects of the growth of money supply on economic activity.

APPENDIX: ECONOMETRIC ESTIMATION OF THE DEMAND FOR CURRENCY

Previous studies, following Tanzi's example, have carried out regressions in a log-linear formulation of the levels of explanatory variables. Although the tax variable in these regressions appeared to be significant, the relationship was not always robust, as found in Porter and Bayer's study.³² When approaching this issue, it is legitimate to suspect that the apparent significance of the tax variable was a spurious correlation. To check this, Granger causality tests were tried, but in all cases the results strongly supported the hypothesis that tax rates did indeed have a causal effect on the demand for currency.³³ In order to avoid any risk of spurious correlation, all the variables in the regressions below are specified as period-to-period changes rather than as levels.

³² Supra footnote 8.

³³ Testing the tax rate used in the present study for the 1950-1993 period, a causality test produced $F = 34.3$. The probability of the tax rate not having a causal influence on currency demand with an F -statistic this high is 0.0000. It should be noted, however, that this is really a joint test on two different elements of causation. Changes in tax rates also affect economic growth, and hence affect the demand for currency through that channel. This is, of course, controlled for in the regressions below.

The first three equations in appendix table 1 are the ones used in tables 1 and 2 for gauging the size of the underground economy. Equations 1 and 2 employ the same specification over different time horizons. Equation 3 uses substantially different data formulations, expressing currency growth and consumption growth as real per capita values. The tax rate variable is highly significant, and remarkably similar in all three equations, which suggests that a reliable structural relationship has been identified. The R^2 in these equations is quite high in view of the fact that the dependent variable is a rate of change rather than a level. The equations appear to explain the demand for currency in Canada to a very satisfactory degree. The change in the interest rate is quite significant, but its coefficient suggests a low interest elasticity of demand for currency, of about -0.09 .

The sample periods for the equations shown in appendix table 1 include the three years since the GST has been in place. However, the tax variable's coefficient is hardly affected when this period is omitted from the sample. For example, if equation 1 is estimated for the period 1950 to 1990, the coefficient changes only very slightly, to 4.02 from 4.08.

The tax variable was entered with a long distributed lag. It was found to take about eight years for its impact on currency demand to work itself through fully.³⁴ This result is consistent with behavioural studies that suggest that there is a psychological inertia to engaging in illegal activity of this type. The log of time was included as an additional explanatory variable to help account for institutional and technological changes that affect the demand for currency with the passage of time.

Alternative Monetary Aggregates

Equation 4 examines the hypothesis that high-denomination currency (\$100 and \$1,000 bills) are important in the underground economy. It finds the opposite. Currency excluding high-denomination bills is actually more sensitive to the tax rate than total currency. This is not entirely surprising. The underground economy thrives on anonymity, and \$1,000 bills cannot be used anonymously. There is, however, a caveat to this equation. We do not actually have data on high-denomination bills in circulation among the public versus high-denomination bills used as vault reserves by banks. The dependent variable in this equation assumes that the ratio of high-denomination bills in circulation to total high-denomination bills is the same as that for all currency.³⁵ The finding that the significance of the tax

³⁴ This implies that there may be some further growth in the underground economy in the coming years in response to past tax increases. It will also depend, however, on how the promised replacement of the GST is carried out.

³⁵ There is a particular risk of bias here because bank reserve requirements have been falling over time. It is possible that, in the early part of the sample, high-denomination bills were held primarily by banks, while in the latter part they were used more by the underground economy. According to Mr. Gerrit Bilkes of the Bank of Canada, it is customary for processors in the resource industries to pay their suppliers in cash (for example, for a boat-load of fish), using \$1,000 bills.

Appendix Table 1 Regression Results^a

Eq. no.	Dependent variable	Sample period	Constant	Unemployment rate	Log of time	Interest rate	Consumption	Tax rate	D - W	R ²
1	Currency	1950-1993	-3.48 (-3.50)	-0.19 (-0.54)	0.69 (2.40)	-0.91 (-4.04)	0.83 (9.17)	4.08 (6.18)	1.93	0.86
2	Currency	1970-1993	-11.40 (-1.70)	0.11 (0.34)	3.08 (2.01)	-0.95 (-6.15)	0.80 (5.50)	3.48 (4.83)	1.92	0.93
3	Real currency per capita	1950-1993	-3.25 (-2.39)	0.10 (0.29)	0.39 (1.02)	-1.17 (-5.11)	0.70 (3.12)	3.56 (5.53)	1.96	0.80
4	Currency excluding high denominations ...	1970-1993	-8.21 (-0.92)	-0.05 (0.11)	0.93 (0.45)	-0.63 (-3.07)	1.01 (5.20)	4.51 (4.69)	2.23	0.92
5	M ₁ excluding currency	1970-1993	6.01 (0.15)	-2.00 (-0.99)	-0.82 (-0.09)	-2.43 (-2.62)	0.37 (0.43)	0.98 (0.23)	2.31	0.49
6	M ₂ excluding currency	1970-1993	27.30 (1.44)	-0.98 (-1.03)	-5.07 (-1.17)	1.84 (4.21)	0.21 (0.52)	0.04 (0.02)	2.75	0.81

^a T-statistics are in parentheses. Dependent variable and consumption are percentage changes. Unemployment rate, interest rate, and tax rate are first differences. Interest rate and consumption are distributed lags from t to t-2. The tax rate is a distributed lag from t to t-7. R² is corrected for degrees of freedom.

variable is not related especially to high-denomination bills is useful for reducing uncertainty about the velocity of circulation. An accumulation of high-denomination bills in the underground economy might imply hoarding and an even lower velocity than suggested above.³⁶

At the other end of the spectrum, one might wonder whether the introduction of a \$1 coin in 1989 affects this picture. Following the introduction of the loonie, the coins-to-currency ratio rose steadily until the beginning of 1991. The percentage of total cash in Canada accounted for by coins fell to 9.4 percent by December 1993, compared with 10.4 percent in December 1990.³⁷ The value of coins outstanding rose \$253 million over the same period, compared with a \$4.525 billion increase in bank notes. The loonie certainly did not play a role in the unusual growth of cash in this period. Indeed, the decline in the coins-to-currency ratio is suggestive of an increasing use of cash for large transactions.

Equations 5 and 6 have alternative monetary aggregates as their dependent variables: M_1 and M_2 redefined to exclude currency. The complete insignificance of the tax rate variable in these equations compared with equation 2 tends to show that cash and cheques are indeed very different in the eyes of the underground economy. This tends to suggest that M_1 or M_2 excluding currency will be a better predictor of future growth in measured GDP.

In the case of US currency, it is known that a substantial proportion of it is used as a medium of exchange in foreign countries. Even if there were a substantial amount of Canadian currency outside Canada, it would not affect the estimates for excess cash. The econometric equations use first differences of Canadian tax rates, and it is very unlikely that there is a correlation between this variable and any foreign demand for Canadian currency. In that case, the coefficient estimated for this variable would be unbiased, and give an accurate estimate of the excess currency in circulation within Canada.

Foreign circulation, however, is probably not a major source of demand for Canadian dollars. The Canadian dollar is not sufficiently well known to become a widely accepted medium of exchange abroad. Indeed, the proposition that Canadian dollars do not circulate abroad is one of the key assumptions used by the US Federal Reserve in estimating how many US dollars circulate internationally. Its study used an analysis of the differences

³⁶ This phenomenon is extensively discussed by Willem C. Boeschoten, *Currency Use and Payment Patterns* (Boston: Kluwer, 1992). Boeschoten had access to a special survey of currency holdings in the Netherlands, which included the dubious claim that it was able to estimate how many high-denomination bills were held by drug dealers. The increase in high-denomination bills in Canada in the last few years does not necessarily imply a rapidly increasing tendency to hoard currency. The issuance of high-denomination notes is at the discretion of the Bank of Canada rather than currency hoarders. As new high-denomination notes become available, hoarders may simply exchange them for the smaller denomination notes they previously held in their hoards.

³⁷ Statistics Canada, CANSIM series B2011 and B2012.

in the seasonality of the stocks of Canadian and US currency to impute the proportion of US dollars that is outside the United States.³⁸

Data Definitions

Monetary Aggregates

B2001 (cash outside banks); B2033 (M_1); B2031 (M_2). They were expressed as percentage changes.

Consumer Expenditure

D43372, total consumer expenditure on goods and services, expressed as a percentage change.

Interest Rate

B14007, three-month treasury bill rate, was used in first-difference form.

Tax Rate

Direct taxes are the sum of D43370 (deductions from personal income), D464273 (provincial sales tax), and GST revenue (from federal government budgets). The tax rate was expressed as a percentage of personal income (D43361), and the first difference of this percentage was used as an explanatory variable.

Currency Excluding High-Denomination Notes

Notes by denomination are found in table K1, in the Spring or February issue of the *Bank of Canada Review*. To estimate high-denomination notes outside banks, the total of \$100 and \$1,000 bills was multiplied by the ratio of currency outside banks to total notes. The result was subtracted from B2001.

Real Per Capita Values

Real per capita values were obtained by dividing the nominal values of currency and consumption by D14477, the implicit price index for consumption expenditure, and D31254, the civilian labour force. Labour force is preferred to population as a better indicator of the number of "spending units" who have substantial disposable income.

³⁸Richard D. Porter, "Estimates of Foreign Holdings of U.S. Currency—An Approach Based on Relative Cross-Country Seasonal Variations" (Federal Reserve Board working paper, 1993).