SHADY TRANSACTIONS:
THREE ESSAYS ON THE UNDERGROUND ECONOMY

BY

LINDSAY M. TEDDS,
B.A. (HON.), B.A., M.A.

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AUTHOR: Lindsay M. Tedds, Hons. B.A. (Carleton University)
B.A. (University of Victoria)
M.A. (University of Victoria)

SUPERVISORY COMMITTEE: Professors Thomas F. Crossley (Supervisor)
David E.A. Giles
Michael R. Veall

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ABSTRACT

The term "underground economy" refers to output that is produced, and income that is generated, by agents who hide this fact from authorities. There has been a recent resurgence in interest in the underground economy and this interest has predominantly been stimulated by the perception that the underground economy is sizeable and growing. This dissertation is comprised of three essays, the goals of which are to provide empirical measures of underground activity.

The first paper in this dissertation applies a modeling technique that treats the underground economy as an unobservable or latent variable and incorporates multiple indicator and multiple causal (MIMIC) variables to estimate a time-path of the size of the broadly defined underground economy. Using macroeconomic Canadian data, the results indicate that the underground economy grew steadily over the sample period: from 7.5% of Gross Domestic Product (GDP) in 1976 to about 15.3% in 2001.

The second paper uses microeconomic data and proposes a nonparametric expenditure-based approach to obtain estimates of income under-reporting by self-employed households. The approach is illustrated by estimating the effect of the Canadian Goods and Services Tax (GST) on income under-reporting. It is found that the difference between true and reported self-employment income is larger for households at the lower end of the self-employment income distribution and that there was no statistically significant change in under-reporting behaviour following the implementation of the GST.

The third paper investigates the characteristics of businesses that engage in tax non-compliance using a survey of firms from around the world. Overall, small firms tend to be less compliant than larger firms. In addition, foreign owned firms, exporters, and firms that have audited financial statements are found to be more compliant but quite surprisingly, government ownership does not result in increased tax compliance. Finally, the existence of organized crime, high taxes, and government corruption all result in lower compliance.

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CHAPTER 1

INTRODUCTION

This dissertation examines a very active but somewhat neglected component of the economy, namely the underground economy. In this sector, output is generated and income is produced that is not reported to the authorities, usually for the express purpose of avoiding the tax liabilities associated with them. The study of the underground economy raises several interesting questions. Who participates in and what activities constitute the underground economy? How large is the underground economy and how might one go about measuring it? What factors cause agents to participate in this sector? How do changes in other economic variables and in economic policy affect this participation? As shall be seen, there are no simple or unique answers to these questions.

Research in the underground economy has grown substantially in the last twenty years, but there continues to be little consensus in the literature. Not only has the appropriate methodology used to estimate underground activity been a concern, but also the estimates themselves, as the various empirical studies have produced widely different estimates of underground activity. The problem is two-fold. First, by definition, the underground economy is unobservable. Consequently, the task of measuring – or, more correctly, estimating – underground activity is a challenging one. Second, there is in fact, no general consensus in the existing literature concerning

the type of activities one might expect to find taking place in the underground economy. "Consequently academic's interpretation of what activities ought to be included has produced various estimates for any one particular country." (Schneider and Bajada 2003, 3)

Despite the problems associated with estimating underground activity, understanding the size and structure of the underground economy is important because of the implications for both applied research and public policy. With respect to the former, as increasingly greater emphasis is placed on quantitative approaches to estimation and forecasting, the quality of the data used in the estimation process rises in importance. With respect to the latter, the underground economy is currently not taken into account in the information used in making policy choices, which may give rise to inefficient policy. The underground economy also effectively redistributes both income and wealth in ways that are not necessarily consistent with the redistribution intentions of the tax system. Further, the shortfall in reported income that is associated with the underground economy erodes the tax base and tax revenue and thus has consequences for public expenditures and tax policy alike.

Given the importance of understanding the underground economy and the perception that the underground economy is sizeable and growing, it is imperative that our knowledge and understanding of this section of the economy continues to grow. This dissertation contributes to the literature on the underground economy through three essays, the goals of which are to provide empirical measures of underground activity.

There is considerable agreement internationally about the factors that determine the relative size of the underground economy (e.g. tax burden, regulation, enforcement, confidence in government, labour force characteristics, and morality) and that evidence of underground activity will be captured in several economic indicators (e.g. Gross Domestic Product (GDP), currency in circulation, and consumption rates). Until recently, the methods employed to measure the underground economy focused on merely a few causal factors, one indicator, and only produced an estimate for one particular point in time. There does exist a modeling technique that allows the underground economy to be treated as an unobservable or latent variable and incorporates multiple indicator and multiple causal (MIMIC) variables. This latent variable/MIMIC model uses information contained within relevant indicator and causal variables to estimate a time-path of the size of the underground economy. The first paper attempts to measure the underground economy in Canada using the MIMIC model.

Two studies by the current author (Tedds 1998, and Giles and Tedds 2002) were the first, and are to date the only, attempts at applying the MIMIC model to estimating the underground economy in Canada. The first paper in this dissertation builds on these two studies as follows. First, it extends the time period being examined to 2001; the latest date for which most of the data used in the estimation process was available. This allows for a better examination of the effects of initiatives such as the Goods and Services Tax (GST), the Government of Canada's Underground Economy Initiative (UEI), and the recent tax reforms on the size and growth of the

underground economy. Second, it includes a number of new variables that the theoretical literature purports to have a sizeable impact on the underground economy. These new variables include measures of the regulatory burden, enforcement, and marginal tax rates. However, these new and seemingly important additions to the model are made difficult because there are few empirical studies which consider their inclusion in the MIMIC model to guide in the definition, calculation, and effect of these variables. Third, this paper addresses several of the criticisms raised by Smith (2002) and Hill (2002) in their review of Giles and Tedds (2002). Finally, important modifications are made to the empirical techniques.

In applying this estimation technique to Canadian data, the results indicate that the underground economy grew steadily relative to measured GDP over the period 1976 to 2001. The value of the broadly defined underground economy grew from about 7.5% of GDP in 1976 to about 15.3% in 2001. In real (1997) dollar terms, it increased from about $38 billion to $159 billion per annum.

The MIMIC model that is applied in the first paper, however, is not without shortcomings. For example, it has been criticized for being inconsistent with modern economic models of consumer behaviour, employing flawed econometric techniques, producing unreliable estimates, and providing limited guidance to policy makers. (Thomas 1999 and Breusch 2005a, 2005b) Further, as the approach used in the first paper employs aggregate data, it does not provide any information regarding the characteristics of those participating in the underground economy. In order to address many of these concerns, a method that utilizes microeconomic data is required. The

second paper in this dissertation does that by using household level data and asking a very specific question concerning underground activity. Specifically, it asks "by how much do the self-employed under-report their income?"

The question posed in the paper is premised on the fact that, due to a lack of third-party reporting the self-employed have the opportunity to under-report their income. If this additional income is used, at least in part, to increase the household's expenditures it may be possible to estimate income under-reporting by using household income and expenditure data. Based on a particular set of assumptions, it is possible to impute actual, or true self-employment income by comparing the expenditure levels of households with positive self-employment income to the expenditure-income bundles of households with similar characteristics that are assumed to have no ability to under-report their income.

Previous studies have implemented this method using highly parametric restrictions that imply households under-report their income by a constant fraction, independent of income. There is no empirical evidence that supports this restriction and little, if anything, is actually known about the functional form of the reporting function. The second paper proposes a nonparametric approach which minimizes the number of assumptions required for estimation, avoids parametric restrictions, and enables the reporting function to vary across income levels and household characteristics.

This nonparametric approach is illustrated by estimating the effect of the Canadian Goods and Services Tax (GST) on income under-reporting by married

households with self-employment income and has produced three key findings. First, income under-reporting does in fact, vary across household income levels. Second, the gap between true and reported self-employment income is larger for households at the lower end of the self-employment income distribution. Third, income under-reporting by households with self-employment income neither increased nor decreased following the implementation of the GST.

The self-employed represent just one type of business entity with the ability to under-report income. Research regarding tax evasion by other types of businesses is, however, surprisingly modest. One of the main constraints to being able to investigate business tax compliance is the lack of data. Possibly the only data sources available to date were from tax audits, but these sources were only available for a very small number of select countries, the data were costly to collect, and access to the data was limited. The World Business Environment Survey (WBES) recently became available and provides an opportunity to investigate the extent and intensity to which firms around the world are hiding income from the tax authority.

The third paper in this dissertation uses the WBES to investigate the factors that affect business tax compliance. To the author's knowledge, this is only the second study to examine firm tax compliance using worldwide data. The majority of previous empirical studies were confined to examining firms within a particular country, using tax audit data. The results indicated that firms in all regions around the world engage in tax non-compliance but that there is substantial variation within regions. In addition, large firms, firms in the service sector, and firms that are foreign owned, are

exporters, and/or have their financial statements audited are more compliant. On the other hand, small firms and firms who report that organized crime, high taxes, and government corruption are obstacles for doing business are less compliant.

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CHAPTER 2

THE UNDERGROUND ECONOMY IN CANADA

Introduction

The Bougons are a French-Canadian family who has recently achieved notoriety, not only in their home province of Quebec but also across Canada. The father, Paul Bougon, bribed a Canada Post letter carrier to deliver fraudulent welfare cheques to the Bougon house. His wife, Rita, is a self-employed phone sex operator. Their eldest son, Paul Jr., engages in car theft, among other illegal activities, and their daughter, Dolorès, is an exotic dancer/prostitute. The family also adopted a Chinese child, Mao, to help the family with computer scams. Not a penny of the income earned through any of these activities is reported to the appropriate tax collecting agency.

The family, however, has not attained their infamy as a result of a tax audit. Rather, the Bougon are a fictional family that is the subject of a sitcom (*Les Bougons*) that airs weekly on Radio-Canada, the French-language service of the Canadian Broadcasting Corporation (CBC), a public broadcaster. In an article entitled "Boozing scam artists steal hearts of viewers," published in the *Globe and Mail*, 16 February 2004, Ingrid Peritz reported that the show has quickly become popular, 34% of the French-speaking population in Canada tune in, and viewers seem to admire the enterprising Bougon family, describing them as contemporary Robin Hoods.

The Bougon family is participating in what is commonly called the underground economy. With the apparent wide-scale acceptance of the lifestyle of the Bougon family, it appears timely to reexamine the phenomenon of the underground economy in Canada and provide an update to the empirical evaluation conducted by Giles and Tedds (2002). In particular, this study extends Giles and Tedds' study by: lengthening the period under examination to 2001, including a number of new variables that the theoretical literature purport to have a sizeable impact on the underground economy, and making important modifications to the empirical techniques. The results reported in this paper are more robust than those reported in Giles and Tedds (2002) and responds to many of the criticisms contained in Hill (2002) and Smith (2002).

Overall, the results indicate that in general, the underground economy in Canada grew steadily, relative to measured Gross Domestic Product (GDP), over the period 1976 to 2001. The value of the broadly defined underground economy grew from about 7.5% of GDP in 1976 to about 15.3% in 2001. In real (1997) dollar terms, it increased from about $38 billion to $159 billion per annum. This paper begins with a discussion of the definition of the underground economy, followed by a description of the six key methodologies that have been used to obtain estimates of the underground economy. Next, a discussion of the causes and previous estimates of the Canadian underground economy is provided, along with a brief description of the modeling methodology employed in this study and a discussion of the results. The paper ends with some concluding remarks.

Defining the Underground Economy

Which activities are included in the definition of the underground economy affects the interpretation of any estimate of the extent of this phenomenon. For example, a very narrow definition would consider only legal market transactions that are omitted from measured GDP. A somewhat broader definition would incorporate both legal and illegal market transactions that are not included in measured GDP. One can also approach the above definitions by considering activity that is not detected by the tax authorities, rather than that omitted from GDP. Finally, a very broad definition of the underground economy would be one that included all transactions: legal and illegal, market and non-market transactions that are either intentionally excluded from GDP and/or omitted from the tax base. These definitions are summarized in Table 1. The one employed in this study is the fourth.

Whichever definition is used, it has become common practice to report the size of the underground economy as a percentage of GDP. This practice is simply a way of facilitating international and intertemporal comparisons by avoiding units of currency. The authors of these studies are not suggesting that reported GDP is mismeasured by this percentage amount. This is largely for two reasons: GDP is a value-added measure rather than a measure of total economic activity, whereas many measures of the hidden economy report total hidden activity; and, depending on the definition employed, the measure of the underground economy usually includes both legal and illegal activities, the latter of which are often excluded in the definition of GDP.

Measuring the Underground Economy

There are essentially six key methodologies that have been used to obtain estimates of the underground economy and they will be summarized briefly here. A more detailed account can be found in Giles and Tedds (2002).

The first three approaches base their measure on the amount of currency in circulation in the economy. Gutmann's (1977) Method or the *Currency Ratio Method* dates back to Cagan (1958) and studies the ratio of currency to demand deposits. It postulates that increases in the ratio over some base year are the result of the need to hold cash for underground transactions. *Tanzi's (1980) Method* relaxes the assumption of a constant ratio of cash to the money supply by making this ratio a function of the rate of interest, per capita income, various tax variables, and the share of wages in national income. Feige's (1979) *Transaction Method* examines the relationship between the total value of transactions (measured by adding currency transactions to cheque-based transactions, excluding purely financial ones) and measured GDP.

The fourth approach is the *National Accounts/Judgmental Method.* It involves no formal "modeling" of the underground economy. Instead, it rests on a detailed breakdown of either the expenditure or income side of the national accounts into its component parts, and the application of subjective judgments as to the maximum likely levels of unrecorded incomes or expenditures.

Fifth, is the *Latent Variable/MIMIC Model*, which involves the use of a structural econometric model. This application treats the size of the underground economy as an unobservable "latent" variable that is linked, on the one hand, to a

collection of (observable) indicators that "reflect" changes in the size of the underground economy and, on the other hand, to a set of (observed) causal variables that are believed to be important driving forces behind underground economic activity. It is this method of estimating the size of the underground economy that is employed in this paper.

The aforementioned macroeconomic measures, however, have been criticized for not being based on consumer theory and for employing flawed econometric techniques (Thomas 1999). One technique that responds to these criticisms, called the *Expenditure-Based Method,* uses estimates of the relationship between food consumption and income (i.e., an Engel curve) to measure the size of the underground economy.[1]

The Canadian Underground Economy: Determinants and Previous Estimates

There is considerable agreement internationally, on both theoretical and empirical grounds, about the factors that determine the relative size of the underground economy. These factors include the tax burden, regulation, enforcement, labour force characteristics, confidence in government, and morality. The relationship of these factors to the Canadian underground economy will be briefly discussed here.

[1] To do so, it is assumed that wage and salary earners always accurately report their income and this group is used as a baseline measure which is compared to the self-employed, who have greater opportunities to hide income from tax authorities. If the self-employed are concealing income, then it is expected that their household food consumption to be high relative to wage/salary earners households with similar reported incomes and characteristics. This method is discussed in more detail in Chapter 3.

Tax Burden

Perhaps the single most commonly cited "driving force" of the underground economy is the tax burden. Since the 1970's, Canada has been subject to: a rise in personal income taxes net of transfers; a rise in these taxes as a share of personal income; an increase in total tax revenue as a share of GDP; and the replacement of the narrowly-based federal manufacturing sales tax in 1991 with the more broadly-based Goods and Services Tax (GST). This trend has only recently been halted with reductions in the federal marginal personal income tax rate and decreased tax rates in many of the provinces. The majority of these tax changes took place in the 2000 and 2001 tax year.

The implementation of the GST in 1991 has probably received the most "credit" for increasing the size and growth of the Canadian underground economy in recent times. It is often argued that the switch from the more narrowly based federal manufacturers' sales tax to this broadly based consumption tax may have increased the incentives and opportunities for tax evasion (Spiro 1993, Hill and Kabir 1996, and Giles and Tedds 2002). This is interesting because, when the GST was first proposed (and throughout its implementation), the federal government argued that the GST would reduce the scope for tax evasion. This was based, in part, on evidence at that time from New Zealand.

The "stacking" of taxes in Canada, is also a likely motivator for underground activity. In Canada, both the federal and the provincial governments have the ability to utilize methods of direct and indirect taxation to raise revenue. As a rule, Canadians

are taxed on the same base – whether it is income or consumption of goods and services – by both levels of government. Provincial personal taxes, for the most part, are based on a set percentage of federal personal tax collected.[2] In 1998, the maximum values for these ranged from a low of 42.75% in Ontario to a high of almost 70% in Newfoundland. As a result, any increase in the federal marginal tax rate automatically increased the amount of provincial tax paid, even if the provincial tax rate remained unchanged. The provinces, with the sole exception of Alberta, also charge provincial sales taxes (PST).[3] The PST's are applied primarily on retail goods, are paid solely by the consumer and, now in conjunction with the GST, are paid in addition to the GST. While the PST rates vary from province to province, the average sales tax rate paid (including GST and PST) by consumers is 15%.

Excise taxes are also a popular revenue generating tax for both levels of government. Goods that are susceptible to high levels of excise taxation at the federal and/or provincial level (other than those mentioned above) are alcohol, tobacco, and gasoline. For example, the Federal Excise Tax on gasoline adds 15 cents to the price of a litre of gasoline and the average provincial tax is 14.9 cents per litre. The GST is also collected, adding approximately another 3-4 cents per litre (depending upon the

[2] The provinces, however, have recently moved towards a tax-on-income system. Under this system, provincial income tax is now calculated on taxable income and not on basic federal tax. Ontario moved to this system starting with the 2000 tax year and all other provinces (excluding Quebec) and the three territories, implemented this system for the 2001 tax year. The province of Quebec has had an independent tax system since the change over from the 1917 Income War Tax Act.

[3] In 1997, the provinces of New Brunswick, Nova Scotia, and Newfoundland signed comprehensive integrated tax co-ordination agreements (CITCAs) with the federal government to harmonize their provincial sales taxes with the goods and services tax (GST), creating the harmonized sales tax (HST). Additionally, Quebec introduced a modified form of VAT which it collected itself, along with the GST.

actual pump price), and some provinces also collect municipal gas surtaxes. Combined, these taxes amount to about half of what Canadians pay for a litre of regular gas. While these taxes have received little attention in the past, in the face of rising gas prices and government surpluses, Canadians are now questioning its existence.

It is sometimes argued that, due to this stacking effect, Canadians may suffer from "tax fatigue". That is, it is the accumulation of different taxes that Canadians pay which drives them into the underground economy and not necessarily a particular tax. According to this argument, simply lowering one tax, such as the federal marginal tax rates, would likely do little to curb underground activity, whereas eliminating a tax, such as the GST or PST, would likely have a substantial impact.

Canadians are, for the most part, extremely proud of their social safety net, but it too provides incentive to hide income and to work "off the books". Small businesses in Canada often find it difficult to pay their portion of payroll taxes, notably workers' compensation, employment insurance, and pension premiums in the Canadian context. Employees can also find these so-called payroll taxes a burden. In addition, people receiving welfare or disability payments find that their payments are reduced if they earn any other income and an additional tax is imposed on those receiving Employment Insurance benefits if their total annual income exceeds about $35,000. Put these together and you have a segment of employers and employees who prefer to hire and work off the books to avoid these costs. In fact, Lemieux *et al.* (1994) present

evidence that taxes and social welfare payments do in fact distort labour-market activities away from the regular sector and into the underground sector.

Regulation

The degree of regulation is often cited as a factor that influences people to engage in underground activity as regulations pose limitations on an individual's freedom of choice. Canada underwent significant deregulation with the implementation of the Regulatory Reform Strategy in 1986, one of the first comprehensive regulatory policies developed in the OECD (OECD 2002). Since 1986, Canada has shown a declining trend in the growth rate of new legislation and regulation.

Enforcement

Greater effort put into the repression of crime and tax evasion by governments results in a greater probability of offenders being caught, thus lowering the rewards of participating in underground activity. The first important enforcement action taken by the Government of Canada was the implementation of the "Underground Economy Initiative" (UEI) by the Canada Revenue Agency (CRA) in November 1993.[4] The UEI was introduced in response to a widespread perception that the underground economy in Canada was growing rapidly. This initiative, which was directed at a

[4] An additional enforcement program is the "Anti-Smuggling Initiative" (ASI) which is a joint Canada Customs and Revenue Agency/RCMP program introduced in 1994 to crack-down on tobacco smuggling.

narrowly-defined underground economy, brought significant additional resources to the CRA's enforcement and collection programs. It also prompted a redirection of the CRA's field-audit resources into specific areas in which the probability of underground activity is high and led the CRA to work more closely with tax accountants and with community and industry groups. Until the advent of the UEI, the Canadian government dismissed the notion that the underground economy was of any significance in stark contrast with the position of the Internal Revenue Service (IRS) in the United States.

A key enforcement program under the UEI is the Voluntary Disclosure Program (VDP). This permits people to come forward and correct inaccurate or incomplete information, or to disclose material they did not report during previous dealings with the CRA, without penalty or prosecution. The program appears to be popular, with over 2,000 individuals using the VDP in 2000, up from 557 in 1993-1994 (CRA 2000).

The UEI, however, may not be as successful in reducing underground activity as first thought. The initiative was scrutinized by the Auditor General of Canada (Canada, 1999) in 1999. The Auditor General found that the reported gains in compliance were by no means all attributable to the UEI. According to the CRA, its activities to combat the underground economy had resulted in collecting $2.5 billion in additional tax revenue over a five-year period. However, according to the Auditor General, this amount included the results of regular ongoing enforcement programs.

The actual amount of additional tax revenue that could be attributed solely to the UEI's audit activities was actually less than $500 million.

Labour Force Characteristics

Many studies have found that the average worker in the underground economy also holds a regular job in the official economy (Dallago 1990 and Mogensen 1995). On the other hand, Lemieux *et al.* (1994), using micro data from a survey conducted in Quebec City, found that the substitution between labour market activities in the observed and underground sector was considerable and that there was high mobility between the sectors. These two factors result in an ambiguous causal relationship between labour force participation rates and the underground economy.

The self-employed generally have greater opportunity to evade taxes than do regular employees, if they so choose. In Canada, the self-employment rate has increased dramatically over the last 25 years: from about 12% in 1976 to almost 18% in 1998, although it has decreased in recent years to just over 15% in 2001. As such, this feature of the Canadian workforce raises some interesting questions about tax evasion in this country in recent years. For example, Pissarides and Weber (1989), Apel (1994), and Mirus and Smith (1997) note that in the U.S., the U.K., Sweden, and Canada respectively, only 60% to 80% of income in the self-employment sector is actually reported to the tax authorities.[5]

[5] Schuetze (2000) in a comprehensive study on self-employment in Canada found that increases in average income tax rates have a large and positive effect on the self-employment rate, which he

Confidence and Morality

Lack of confidence in the performance of government may also be a factor in the decision to participate in the underground economy. Some taxpayers may have concerns about the way in which tax dollars are being spent or are perceived as being spent. Closely related to this issue is morality. Individuals may choose their level of compliance with laws and regulations to match their perception of the extent to which others comply. Recent survey evidence shows that "some 86% of Canadians believe that governments squander a lot of the money they collect in taxes. Less than one quarter of Canadians could be categorized as 'model citizens'. Half of our respondents were categorized as 'upset and envious' or 'tax anarchists'." (Flexman 1997, 72)

Table 3 summarizes the estimates for the Canadian underground economy obtained by various researchers using one of the six methods described in the previous section. The estimates are reported in terms of a percentage of nominal Canadian GDP, unless otherwise noted. The studies which used the same definition of the underground economy that this study employs are noted in bold type. They estimate the value of the underground economy to be approximately 11% of GDP in 1993 and about 15% of GDP in 1995.[6]

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indicates suggests that under-reporting of self-employment income may be a key motivating factor for becoming self employed. This evidence allows some researchers to conclude that self-employment income should be considered as an indicator variable. There are many other factors, however, that have contributed to the increase in self-employment and self-employment income in Canada. For example, Canada has many special programs in place to assist self-employment and small businesses, financial institutions have created numerous financing options to support self-employment and small businesses, and the increasing use of contracting-out by governments and business. This leads the author to conclude that self-employment is a causal variable of the underground economy.

[6] The exception is the estimate obtained by both Gervais (1994) and Smith (1997) of 5.2% of GDP for 1992. There are three key reasons for the difference: first, they measure the underground economy from

MIMIC Model Approach

The MIMIC model is a structural econometric model that treats the size of the underground economy as an unobservable "latent" variable.[7] The MIMIC model was first applied to the problem of measuring the underground economy by Frey and Weck-Hannemann (1984). This application treats the size of the underground economy as an unobservable "latent" variable which is linked, on the one hand, to a collection of (observable) indicators that "reflect" changes in the size of the underground economy and, on the other hand, to a set of (observed) causal variables which are believed to be important driving forces behind underground economic activity. Given data for the causes and the indicators, one estimates the model by applying fairly standard econometric procedures. The MIMIC model methodology has become generally accepted as the most comprehensive approach to measuring the underground economy, with a small but growing number of applications. In fact, it has been described as a "meaningful and intellectually fascinating" approach (Helberger and Knepel 1988). (Details of the MIMIC model estimation framework are provided in Appendix C.)

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a value-added perspective; second, they exclude such items as capital gains and inheritances from underground economy; and third, they assumed illegal activity amounted to no more than 1% of measured GDP. With respect to this latter point, Giles and Tedds (2002, 89-92) conduct some "back of the envelope" calculations of the size of illegal activity in Canada and obtain a minimum estimate of 5% of GDP for the same year.

[7] The technique of modeling with an observable variable is not confined to the study of the underground economy or to economics itself. The archetypal example of an unobservable variable is intelligence. The estimation of supply and demand equations and the well known permanent-income hypothesis are probably two of the earliest examples in the field of economics of models based on unobservable variables.

One of the benefits of working with the MIMIC model is that it produces a time-series of the underground economy. Unfortunately, it can only generate an index for a time-series: it can tell us about changes in the ratio from year to year, but not about the actual values of the ratio in individual years. To convert the index series into a time series of values, a reliable estimate of the underground economy ratio for the sample period under consideration is required. Giles and Tedds (2002) formulated a non-linear currency demand model for Canada, based on that which was adopted by Giles (1999) for New Zealand and by Bhattacharyya (1990) for the U.K., developed in the context of trying to measure the size of the underground economy for the noted countries. Essentially, the method utilizes a conventional demand for cash model that is extended to allow for two sectors – one measured and one underground. This model, however, has subsequently been found to be extremely unstable.[8]

An alternative way to incorporate the underground economy into a demand for money equation is to treat underground output as an unobserved component and then estimate the resulting state space model by Maximum Likelihood using the Kalman (1960) filter. This approach was implemented in this paper (details of the demand for money estimation framework are provided in Appendix D) which produced some rather robust results.[9] The index series is then calibrated using the mean value of the underground economy obtained using the Kalman filter. The calibration process

[8] In particular, the highly nonlinear model that was used in the previous work proved to be sensitive to small data changes.

[9] Notably, the estimates were insensitive to small changes to the sample of data.

followed, preserves the proportional relationships found in the original index series. (Details of the calibration process are provided at the end of Appendix D)

In order to ensure that the various time-series are stationary and to avoid the consequences of estimating spurious regressions, the data are tested for unit roots. The variables in the demand for money equation were found to be a mixture of I(1) and I(2) series. (Appendix B provides a brief description of the unit roots tests employed and summarizes the test results). The series were then tested for cointegration using Haldrup's (1994) procedure and the results suggest that there is cointegration between the series. As a result, the demand for money equation is estimated using the levels of series. The variables for the MIMIC model were found to be a mixture of I(0), I(1) and I(2) variables. Unfortunately, there is no established literature to act as a guide for testing for cointegration in the context of the MIMIC model. Instead, the MIMIC model is estimated using the differenced data.

Results

The Canadian underground economy is estimated for the sample period 1976-2001. A number of different models, based on different combinations of causal and indicator variables, were estimated and it was found that the model was robust to alternative specifications and normalizing choices.[10] The models were also subjected to various econometric tests to determine the statistical "quality" of the estimates and

[10] As with all structural models, normalization must be imposed in order for it to be estimated. The choice among the endogenous variables is arbitrary as the normalization does not identify the dependent variable in any formal or causal sense.

to assist in the choice of a final "preferred" model. (See Appendix C for a detailed discussion.)

The preferred model incorporates three indicator variables and eleven key causal variables. (A summary of the data and data sources is provided in Appendix A.) The indicator variables are:

- Growth rate of gross domestic product (GDP);
- Real currency per capita (RCURR); and
- Ratio of expenditures on goods and services to disposable income (CONSUMP).

It is argued that a change in the size of the underground economy may be mirrored in the growth rate of measured real GDP, although the directional impact that this variable has on the underground economy is debatable and may vary from country to country. Those that find a positive relationship between GDP and the underground economy using the MIMIC method include: Tedds (1998), Giles (1999), Giles and Tedds (2002), and Schneider and Bajada (2003). Other authors argue that "an increase in the underground economy means that inputs move out of the official economy..." (Frey and Weck-Hannemann 1984, 38) This would, therefore, have a depressing effect on the officially measured growth rate of the economy. Frey and Weck-Hannemann (1984), Helberger and Knepel (1988), Loyaza (1996), Kaufmann and Kaliberda (1996), Schneider and Enste (2000), and Dell'Anno (2003) all find a negative relationship between GDP and the underground economy using the MIMIC

model; though these studies primarily focus on developing/transition economies (with the exception of Frey and Weck-Hannemann (1984) and Helberger and Knepel (1988) who examine 17 OECD countries).

Another key indicator is some type of monetary aggregate, as suggested by the monetary approaches to measuring the underground economy briefly discussed above. Most of the monetary methods advocate a ratio approach to examining this issue, which would measure changes in currency relative to a broader monetary aggregate such as M1 or M3. In Canada, however, these monetary aggregates have been distorted seriously over the sample period due to interest rate effects and banking innovations, making the inclusion of a ratio of currency to a broader monetary aggregate undesirable in the model. Instead, real currency per capita is used as an indicator variable.

The third indicator variable is the ratio of personal expenditures on goods and services to personal measured disposable income. It is designed to measure changes in spending behaviour, based on the assumption that income earned through underground activities will be used to bolster consumption patterns rather than being used for savings (which leaves a paper trail for the authorities).

The causal variables, the relationship to the underground economy were discussed above, are:

- Labour force participation rate (LFPR);
- Real self-employment income (SEINC);

- Average direct tax rate (ADTR);
- Average indirect tax rate (AITR);
- Average marginal tax rate (AMTR);
- Average payroll tax rate (APTR);
- Dummy variable for the Voluntary Disclosure program (VDP) that equals the marginal tax rate (AMTR) for 1994 and onwards;
- Crime rate (CRIME);
- Dummy variable for the implementation of the GST (GST) that equals 1 in 1991 and onwards;
- Flow of federal regulatory transactions by the Governor in Council and individual Ministers (REGS); and
- Dummy variable for the implementation of the Underground Economy Initiative (UEI) that equals 1 in 1994 and onwards.

Figure 1 displays the results of the estimation of the MIMIC model. The indicator variables enter positively and significantly, implying that the Canadian underground economy has a positive relationship with currency holdings, personal consumption, and the growth rate of GDP.

Most of the causal variables are statistically significant and of the appropriate sign. Marginal tax rates are an important contributor to the underground economy, whereas the average direct and average payroll tax rates, while positive, are not statistically significant. Indirect tax rates have a negative relationship with the underground economy; however, the implementation of the GST caused a slight

increase in the Canadian underground economy. Generally, the Underground Economy Initiative (UEI) did not help combat underground activity; however, the specific initiative, the Voluntary Disclosure program, has had the anticipated negative effect. The fact that the MIMIC model produces an estimate that indicates that the UEI had a positive and significant impact on the underground economy in Canada is, on the surface, counter-intuitive. While enforcement was increased, many of the policies enacted under the UEI, however, increased the regulatory burden on businesses and individuals. This additional burden increased, rather than decreased, the incentive to participate in the underground economy. Finally, as anticipated, regulations, the crime rate (acting as a proxy for morality), the amount of self-employment income earned, and labour force participation are all positive and significant. This is one of the most richly specified models of the underground economy using the MIMIC model.

The index series is converted into a time-series of values using the results from the demand for money equation. A long-run value of the Canadian underground economy of 11.35% was obtained, with an associated 95% confidence interval of [9.98%, 12.76%]. Figure 2 presents the resulting time-series values for the size of the Canadian underground economy (expressed as a percentage of GDP), given the preferred specification of the model shown in Figure 1. The results indicate that, in general, the underground economy in Canada grew steadily, relative to measured GDP over the period 1976 to 2001. The value of the broadly defined underground economy grew from about 7.5% of GDP in 1976 to about 15.3% in 2001. In real (1997) dollar

terms, it increased from about $38 billion to $159 billion. Figure 2 also shows the uncertainty that these results are subject to, via a 95% confidence interval.[11]

The time-series depicted in Figure 2 shows that the growth of the Canadian underground economy contracted between 1976-1977, 1990-1991, and 1994-1995; and experienced no change in 1982, all periods of slow or negative GDP growth. The Canadian underground economy also contracted in 1987, possibly a temporary reaction to regulatory reform. Figure 2 also shows that the underground economy experienced a very high growth rate during the mid- to late-1980's, despite the fact that there were a number of tax reforms during the 1970's and 1980's. To address issues of fairness, complexity and distortions, these reforms included base broadening and lower rates.[12] A complex and inequitable tax system, however, allows for more legal tax avoidance by providing various tax exemptions and reductions (Schneider and Neck 1993).

Conclusion

According to the estimates of this study, the underground economy in Canada is sizable and continues to grow, despite the increased enforcement efforts of CRA. The results show that, not surprisingly, the underground economy responds positively

[11] The reported confidence interval only accounts for the randomness associated with the "benchmark" estimate of 11.35%. There is, however, also the randomness associated with estimated coefficients of the "causal" variables in the MIMIC model, and these in turn translate into randomness for the year-by-year predictions of the underground economy ratio, conditional on the average benchmark figure. It is, however, unclear as to how to combine these two sources of randomness, and hence only the randomness associated with the benchmark value is reported.

[12] The tax reforms also had the effect of raising the effective marginal rate for average income workers and the top rate came down for high income earners, in part to compensate them for lost deductions.

to marginal tax rates, the GST, the amount of self-employment income, labour force participation, the overall crime rate, and regulatory reform. Additionally, while CRA's enforcement activities under the UEI may have been unsuccessful, the Voluntary Disclosure program appears to play an important role in encouraging less underground activity.

The findings indicate that the underground economy in Canada grew from about 7.5% of GDP in 1976 to about 15.3% in 2001. These figures are consistent with previous studies employing the same definition as this study. The results are different from those reported by Giles and Tedds (2002), who found that the underground economy grew from about 3.5% of GDP in 1976 to about 15.7% of GDP in 1995. There are three main reasons why the results differ. First, the MIMIC model presented here is more richly specified than that of Giles and Tedds (2002) and includes more of the variables that the theoretical literature purports to cause the underground economy. Second, the calibration process followed in this study preserves the proportional relationships found in the original index series. Third, this study estimated a demand for money equation using the Kalman filter, which resulted in a larger long-run value of the Canadian underground economy (11.35% compared to the 9.46% obtained by Giles and Tedds (2002)).

TABLES

Table 1: Definitions of the Underground Economy[1]

1. Legal market based transactions missing from measured GDP.
2. Legal market based transactions not reported to the revenue-gathering agency.
3. Legal and illegal market based transactions missing from measured GDP.
4. **Legal and illegal market based transactions not reported to the revenue-gathering agency.**[2]
5. Legal and illegal market and non-market based transactions that escape detection or are intentionally excluded from measured GDP.

Source: Taken from Giles and Tedds (2002, 89).
Notes: [1]The relationship between the resulting estimates from these definitions can be portrayed as follows: $1 < 2 < 3 < 4 < 5$.
[2]Definition employed in this study.

Table 2: Empirical Measures of the Canadian Underground Economy

Study	Definition (see Table 1)	Year	UE (% of GDP)* *Unless otherwise noted
		GUTMANN	
Mirus and Smith (1981)	3	1976	15.7%
Haas (1978)	3	1977	11.1% of GNP
Barthelemy (1988)	3	1978	13%
Mirus (1984)	3	1980	11%
Mirus et al (1994)	3	1980	13.5%
Mirus et al (1994)	3	1985	25.9%
Karoleff et al (1993)	3	1990	21.6%
Mirus et al (1994)	3	1990	27.6%
Schnieder and Enste (2000)	3	1996, 1997	14.9%
Schnieder (2000)	3	1997, 1998	15%-16.2%
		TANZI	
Barthelemy (1988)	3	1976	1976
Mirus and Smith (1981)	3	1976	4.9%-7.5%
Éthier (1982)	**4**	**1980**	**1980**
Ethier (1985)	3	1981	5.7% (of GNP)
Ng and Karolyi (1984)	3	1982	1982
Mirus et al (1994)	3	1990	5.1%
Pouftis (1993)	3	1990	7.4%-13%
Hill and Kabir (2000)	**4**	**Increase attributable to GST**	**0.02-0.3%**
Spiro (1993)	**4**	**1992**	**0.8% growth**
Spiro (1994)	**4**	**1993**	**8%-11%**
Hill and Kabir (1996)	3	Growth from 1964-1995	3%-11%
		TRANSACTIONS METHOD	
Mirus and Smith (1981)	3	1976	27.5%
Mirus (1984)	3	1976	10%
Barthelemy (1988)	3	1979	22%
Mirus (1984)	3	1980	13.5%
Mirus and Smith (1989)	3	1982	10.96%-12.36%
Karoleff et al (1993)	3	1984	19.3%
Mirus et al (1994)	3	1984	23.9%

(The table is continued on the next page)

Table 2 Continued

Study	Definition (see Table 1)	Year	UE (% of GDP)* *Unless otherwise noted
NATIONAL ACCOUNTS/JUDGEMENT/SURVEY			
Berger (1986)	1	1981	2.8%-3.3%
Gervais (1994) &	1	1992	2.7%
Philip Smith (1997)	3	1992	3.7%
	4	**1992**	**5.2%**
	5	1992	47.1%
Paquet (1989)	5	1989	33%-100%
Drummond et al (1993)	3	1993	4.5%
Lemieux, Fortin and Frechette (1994)	**4**	**1986**	**1.4% (Quebec)**
LATENT VARIABLE			
Frey and Weck Hannemann (1984)	**4**	**1978**	**8.7%**
Schneider (1997)	**4**	**1994**	**15%**
Tedds (1998)	**4**	**1976-1995**	**4.2%-14.7%**
Giles and Tedds (2002)	**4**	**1976-19995**	**3.5%-15/7%**
EXPENDITURE-BASED			
Mirus and Smith (1997)	2	1990	1% (Self-Employed)
Schuetze (2002)	2	1969	20%†
		1974	12%†
		1984	15%†
		1986	17%†
		1990	18%†
		1992	21.5%†

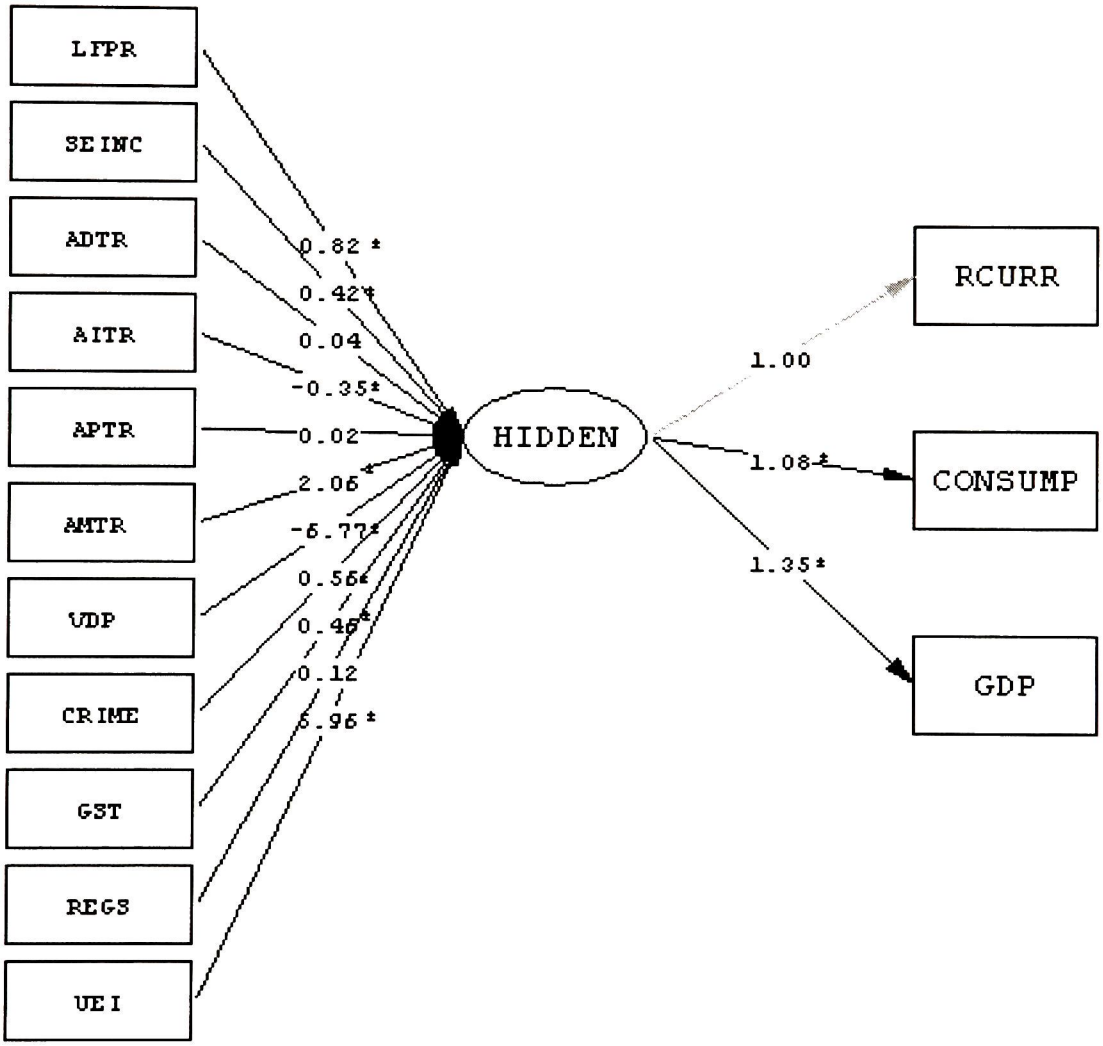
Source: Table is modified from Giles and Tedds (2002, 90-91).

Notes: § Bold type indicates studies that used the definition of the underground economy that is employed in this study.

† Percentage by which self-employment income is under-reported.

FIGURES

Figure 1: MIMIC Model of the Canadian Underground Economy



Notes: * indicates coefficient is statistically significant at the 5% significance level.

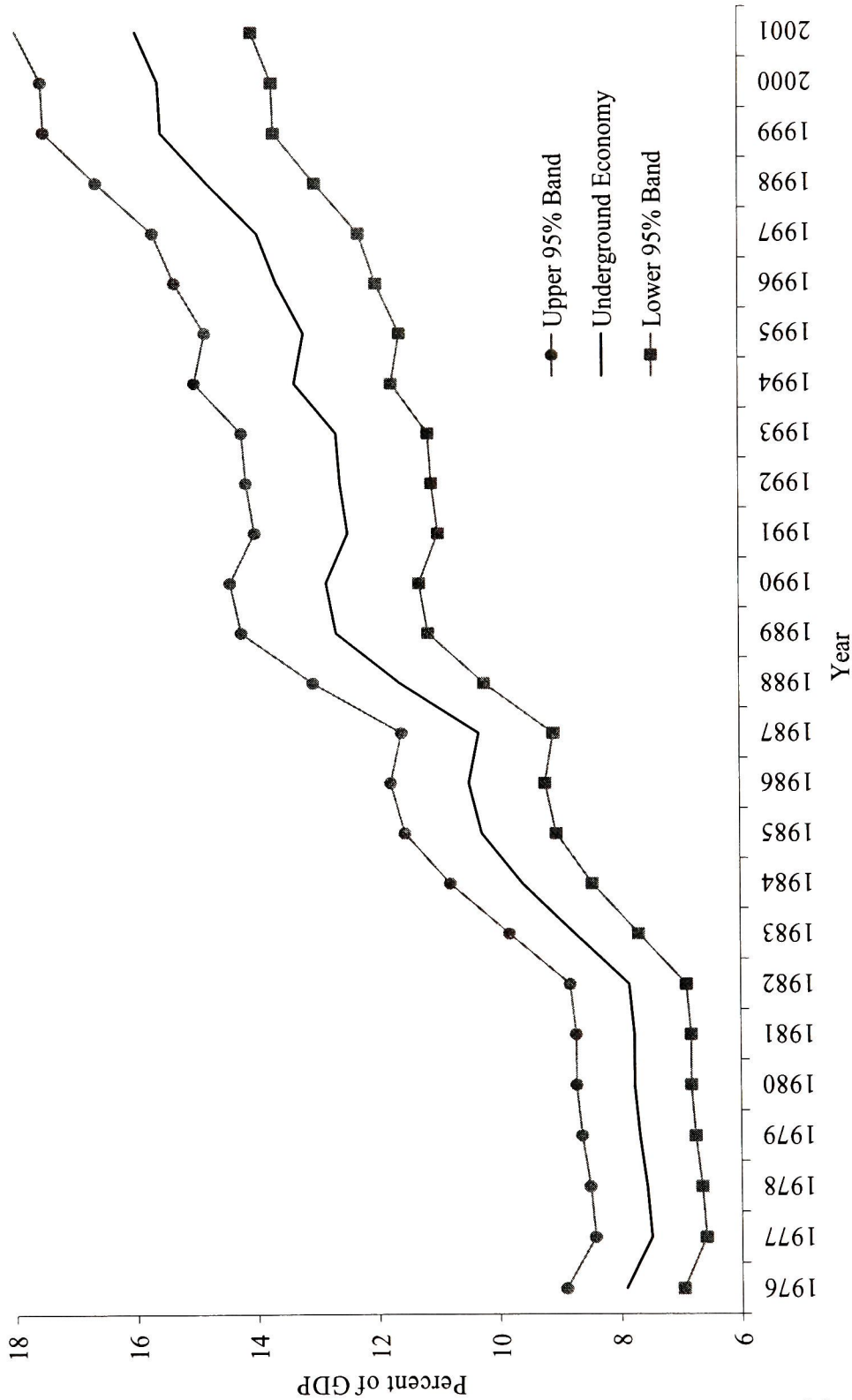


Figure 2: The Canadian Underground Economy and Approximate 95% Confidence Interval

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APPENDICES

A. DATA SOURCES AND DESCRIPTIONS

Table A1: MIMIC Model

VARIABLE	ACRONYM	DESCRIPTION	SOURCE	SAMPLE AVAILABLE
		INDICATORS		
Real Currency Per Capita	RCURR	Average real currency held per person calculated as: currency in circulation outside banks and chartered banks deposits divided by CPI, divided by the total population.	CANSIM series V37173, V735319, and V1	1946-2002
Consumption Rate	CONSUMP	Log of personal expenditures on goods and services expressed as a percentage of personal disposable income.	CANSIM series V498919 and Statistics Canada, National Economic and Financial Accounts, 13-001.	1961-2002
Growth Rate of Real GDP	GDP	Year over year change of expenditure-based GDP at market prices, expressed as a percentage and measured in 1997 constant prices.	CANSIM series V1992292	1961-2002
		CAUSES		
Average Direct Tax Rates	ADTR	ADTR was found by dividing personal direct tax revenue (both federal and provincial governments) by personal income.	Statistics Canada, National Economic and Financial Accounts, 13-001	1961-2001[§]

(This table is continued on the next page)

Table A1 Continued

VARIABLE	ACRONYM	DESCRIPTION	SOURCE	SAMPLE AVAILABLE
		CAUSES CONTINUED		
Average Indirect Tax Rate	AITR	An average indirect tax rate was calculated using data on total indirect tax revenue (both federal and provincial governments) and dividing it by personal income.	Statistics Canada, National Economic and Financial Accounts, 13-001	1961-2001[§]
Average Payroll Tax	APTR	Contributions to social insurance plans (both federal and provincial governments) divided by the total payroll tax base.	Statistics Canada, National Economic and Financial Accounts, 13-001. CANSIM series V123645, D17025 and V1996534.	1961-2001[§]
Average Marginal Tax Rate	AMTR	Calculated as the combined federal and provincial rates applicable to a single taxpayer with the level of average assessed income where the Ontario provincial tax rate was used as a proxy for average provincial tax rates. AMTR is calculated using all returns.	*Taxation Statistics*, *Tax Statistics on Individuals*, *Finances of the Nation*, and *The National Finances*.	1947-2001[§]
Crime Rate	CRIME	Number of crimes for all offenses expressed as a percentage of the total population.	CANSIM series V1 and V101681.	1962-2002
Goods and Services Tax	GST	Dummy variable that takes the value of 1 for the years the GST is in effect (1991 onwards) and zero otherwise.	N/A	Full sample

(This table is continued on the next page)

Table A1 Continued

VARIABLE	ACRONYM	DESCRIPTION	SOURCE	SAMPLE AVAILABLE
		CAUSES CONTINUED		
Labour Force Participation Rate	LFPR	The total number of people employed or seeking employment in a country or region as a percentage of the total population. Average worker in the underground economy holds a regular job in the official economy. Also, the more people participating means increased competition for employment which may drive people underground.	CANSIM series V2091198	1976-2002
Government Regulations	REGS	Measures the flow of regulatory transactions by the Governor in Council and individual Ministers. It includes new regs. and items that amend, repeal or revise an existing regulation.	Canada Gazette, Part II	1975-2001
Self-employment Income	SEINC	Real self-employment income.	Statistics Canada	1976-2001
Significant Tax Changes	TAXCNG	Measures the impact of the tax changes that began in 1998. It is a dummy variable that takes a value of AMTR for the year of a significant tax change and zero otherwise.	N/A	Full sample
Underground Economy Initiative	UEI	Dummy variable that takes the value of 1 for the years CRA's UEI and ASI is in effect (1993 onwards) and zero otherwise.	N/A	Full sample
Voluntary Disclosure Program	VDP	Measures the impact of Revenue Canada's VDP program which was part of the UEI. Takes the value of the AMTR variable for the years starting in 1994	N/A	Full Sample

Notes: § At the time that this study was done, only interim tax data, as opposed to final tax data, for the 2002 tax year were available. As a result, the sample period under examination was 1976-2001.

Table A2: Demand For Money Equation

VARIABLE	ACRONYM	DESCRIPTION	SOURCE	SAMPLE AVAILABLE
Money	m_t	The logarithm of currency Outside Banks' and Chartered Banks' Deposits, $Millions, end of Year.	CANSIM series V37173	1946-2002
Output	y_t	The logarithm of real GDP, Expenditure Based, 1997 Prices, $ Millions/1000.	Cansim II Series V1992292	1961-2002
Prices	p_t	The logarithm of the implicit GDP Deflator, Base =1 in 1997	CANSIM II Series V498906 and V1992292.	1961-2002
Interest Rate	r_t	The logarithm of Bank of Canada Bank Rate, % p.a., end of Year.	Cansim II Series V122530.	1935-2003

B. SUMMARY OF UNIT ROOT TESTS

In order to ensure that the various time-series are stationary and to avoid the consequences of estimating spurious regressions, the data is tested for unit roots. This is a commonly ignored step in the study of the underground economy, including in the MIMIC model. To be conservative, both the Augmented Dickey Fuller (Said and Dickey 1984) and the KPSS tests (Kwiatkowski, Phillips, Schmidt, and Shin 1992) for stationarity are used. The results of these tests are shown in Tables B1 through to B4 and summarized in Tables B5 and B6.

Several of the series used in the MIMIC model appear to exhibit structural breaks. As the ADF and KPSS tests, as well as tests for cointegration, are adversely sensitive to the presence of breaks in the data, special attention was paid to this issue. Perron's (1989) modified ADF test and well as Kurozumi's (2002) modified KPSS test were applied to allow for exogenous structural breaks. These results are shown in Table B7 and a revised summary of the test results to this point are summarized in Table B8. The consumption series, however, could be treated as having outliers rather than a structural break (Ryan and Giles 1998). That is, the observations for the years 1982 and 1983 could be viewed simply as oddities. Following Ryan and Giles (1998), the values for these two years were removed and replaced with the value for 1981. An ADF test was then conducted on the new series. The results are shown in Table B9. There is, however, no work that indicates that this is appropriate for the KPSS test.

All of these tests were employed so that they test downwards (Dickey and Pantula 1987). In other words, the highest possible order of integration is tested first.

Given that economic time series are, for the most part, I(2) or less, it ws assumed that the highest possible order of integration is I(3). Mackinnon's (1991) critical values are used in the ADF tests; Perron's (1989) crucial values were used in the modified ADF test; Kwiatkowski, Phillips, Schmidt, and Shinn's (1992) asymptotic critical values are employed when testing a null of stationarity in the KPSS tests; and Kurozumi's (2002) critical values were followed in the modified KPSS test. As no variables were found to be integrated of order higher than two, the results of testing I(3) against I(2) are omitted from the Tables below. In case of conflicting conclusions, the results of the KPSS test were chosen over the results of the ADF test because of the test's standard set-up of the null hypothesis.

TABLES

Table B1: ADF Tests for Unit Roots (Annual Data – 1974-2001[§]): MIMIC Model

Variable	Trend P[1]	Trend t_{dt}[2]	Trend Decision	Level P[1]	Level t_{dt}[2]	Level Decision
H(0): I(2) vs. H(A): I(1)						
		Indicators			**Indicators**	
RCURR	5	-5.206**	Reject I(2)	0	-2.234	I(2)
CONSUMP[3]	0	-4.178**	Reject I(2)	0	-3.962***	Reject I(2)
GDP[3]	0	-3.540*	Reject I(2)	1	-3.284**	Reject I(2)
		Causes			**Causes**	
ADTR	0	-4.048**	Reject I(2)	0	-4.241***	Reject I(2)
AITR	7	0.017	I(2)	0	-0.388	I(2)
APTR	0	-4.615***	Reject I(2)	0	-4.699***	Reject I(2)
AMTR	8	-4.399**	Reject I(2)	8	-5.511***	Reject I(2)
CRIME	7	-3.998**	Reject I(2)	0	-3.708**	Reject I(2)
LFPR	1	-1.986	I(2)	1	-2.072	I(2)
REGS	0	-5.379***	Reject I(2)	0	-5.335***	Reject I(2)
SEINC[3]	0	-3.575*	Reject I(2)	0	-3.683**	Reject I(2)
H(0): I(1) vs. H(A): I(0)						
		Indicators			**Indicators**	
RCURR	7	-2.196	I(1)	-	-	-
CONSUMP[3]	0	-1.865	I(1)	0	-0.3940	I(1)
GDP[3]	1	-3.216	I(1)	1	-0.4289	I(1)
		Causes			**Causes**	
ADTR	0	-2.711	I(1)	0	-0.5113	I(1)
AITR	-	-	-	-	-	-
APTR	2	-3.608**	I(0)	0	-0.8048	I(1)
AMTR1	8	-10.965**	I(0)	8	-7.097	I(0)
CRIME	1	-2.841	I(1)	0	-1.434	I(1)
LFPR	-	-	-	-	-	-
REGS	0	-5.379***	I(0)	0	-5.335***	I(0)
SEINC[3]	1	-2.707	I(1)	0	0.819	I(1)

Notes: § Except REGS which is tests over the 1975-2001 sample period and LFPR, RSEINC and UNEMP which is tested over the 1976-2001 sample period.

[1]Indicates the number of lagged terms included in the ADF regression equation, selected by EVIEWS using Schwartz Criteria.

[2]* Indicates significant at a 10% level, ** Indicates significant at a 5% level, *** Indicates significant at a 1% level, using MacKinnon's (1991) critical values.

[3]Indicates variables tested in their logarithm form.

Table B2: ADF Tests for Unit Roots (Annual Data – 1974-2001[§]): Demand for Money Model

Variable	Trend P[1]	Trend t_{dt}^2	Trend Decision	Level P[1]	Level t_{dt}^2	Level Decision
		H(0): I(2) vs. H(A): I(1)				
m_t^3	3	-2.749	I(2)	0	-4.443	Reject I(2)
y_t^3	0	-3.540*	Reject I(2)	1	-3.284**	Reject I(2)
r_t^3	0	-6.645***	Reject I(2)	0	-6.396***	Reject I(2)
p_t^3	1	-3.985**	Reject I(2)	1	-1.810	I(2)
		H(0): I(1) vs. H(A): I(0)				
m_t^3	-	-	-	0	-3.589	I(1)
y_t^3	1	-3.216	I(1)	1	-0.4289	I(1)
r_t^3	0	-2.915	I(1)	0	-1.268	I(1)
p_t^3	3	-1.855	I(1)	-	-	-

Notes: § Except REGS, tested over the 1975-2001 period, and LFPR, SELF and UNEMP, tested over the 1976-2001 period.

[1]Indicates the number of lagged terms included in the ADF regression equation, selected by EVIEWS using Schwartz Criteria.

[2]* Indicates significant at a 10% level, ** Indicates significant at a 5% level, *** Indicates significant at a 1% level using MacKinnon's (1991) critical values.

[3]Indicates variables tested in their logarithm form.

Table B3: KPSS Tests for Unit Roots (Annual Data – 1974-2001[§]): MIMIC Model

Variable	Trend ℓ	Trend η	Trend Decision	Level ℓ	Level η	Level Decision
H(0): I(1) vs. H(A): I(2)						
		Indicators			**Indicators**	
RCURR	2	0.0589	At most I(2)	3	0.3934*	I(2)
CONSUMP[3]	10	0.2532***	I(2)	3	0.3290	At most I(1)
GDP[3]	2	0.0697	At most I(1)	2	0.0703	At most I(1)
		Causes			**Causes**	
ADTR	1	0.1094	At most I(1)	2	0.1389	At most I(1)
AITR	4	0.1732**	I(2)	4	0.2781	At most I(1)
APTR	5	0.0998	At most I(1)	5	0.1144	At most I(1)
AMTR	27	0.5185***	I(2)	27	0.5185**	I(2)
CRIME	2	0.0502	At most I(1)	1	0.1503	At most I(1)
LFPR	4	0.1047	At most I(1)	4	0.2750	At most I(1)
REGS	4	0.1419*	I(2)	4	0.3270	At most I(1)
SEINC[3]	0	0.078	At most I(1)	1	0.201	At most I(1)
H(0): I(0) vs. H(A): I(1)						
		Indicators			**Indicators**	
RCURR	4	0.1723**	I(1)	-	-	-
CONSUMP[3]	-	-	-	4	0.3656*	I(1)
GDP[3]	4	0.0691	I(0)	4	0.681**	I(1)
		Causes			**Causes**	
ADTR	4	0.0972	I(0)	4	0.5861**	I(1)
AITR	-	-	-	4	0.3193	I(0)
APTR	4	0.0906	I(0)	4	0.637**	I(1)
AMTR	-	-	-	-	-	-
CRIME	4	0.0928	I(0)	4	0.2442	I(0)
LFPR	4	0.1511**	I(1)	4	0.3429	I(0)
REGS	-	-	-	4	0.5213**	I(1)
SEINC[3]	2	0.112	I(0)	3	0.72***	I(1)

Notes: §Except REGS, tested over the 1975-2001 period, and LFPR, SELF and UNEMP, tested over the 1976-2001 period.

[1]The maximum lag order (bandwidth) was using the Newey-West (1994) data-based automatic bandwidth parameter method.

[2]* Indicates significant at a 10% level, ** Indicates significant at a 5% level, *** Indicates significant at a 1% level using approximate critical values for the KPSS test are taken from Kwiatkowski, Phillips, Schmidt, and Shin (1992).

[3]Indicates variables tested in their logarithm form.

Table B4: KPSS Tests for Unit Roots (Annual Data – 1974-2001): Demand for Money Model

Variable	Trend ℓ	Trend η	Trend Decision	Level ℓ^1	Level η	Level Decision[1]
			H(0): I(1) vs. H(A): I(2)			
m_t^3	4	0.133*	I(2)	2	0.6316**	I(2)
y_t^3	2	0.0697	At most I(1)	2	0.0703	At most I(1)
r_t^3	23	0.429***	I(2)	9	0.4022*	I(2)
p_t^3	1	0.143*	I(2)	4	0.637**	I(2)
			H(0): I(0) vs. H(A): I(1)			
m_t^3	-	-	-	-	-	-
y_t^3	4	0.0691	I(0)	4	0.6807**	I(1)
r_t^3	-	-	-	-	-	-
p_t^3	-	-	-	-	-	-

Notes: [1]The maximum lag order (bandwidth) was using the Newey-West (1994) data-based automatic bandwidth parameter method.
[2]* Indicates significant at a 10% level, ** Indicates significant at a 5% level, *** Indicates significant at a 1% level, using approximate critical values for the KPSS test are taken from Kwiatkowski, Phillips, Schmidt, and Shin (1992).
[3]Indicates variables tested in their logarithm form.

Table B5: Initial Summary of Unit Root Tests: MIMIC Model

	ADF		KPSS		
Variables	**Trend**	**Level**	**Trend**	**Level**	**Decision**
	Indicators		**Indicators**		**Indicators**
RCURR	I(1)	I(2)	I(1)	I(2)	?
CONSUMP	I(1)	I(1)	I(2)	I(1)	?
GDP	I(1)	I(1)	I(0)	I(1)	I(1)
	Causes		**Causes**		**Causes**
ADTR	I(1)	I(1)	I(0)	I(1)	I(1)
AITR	I(2)	I(2)	I(2)	I(0)	I(2)
APTR	I(0)	I(1)	I(0)	I(1)	I(1)
AMTR	I(0)	I(0)	I(2)	I(2)	?
CRIME	I(1)	I(1)	I(0)	I(0)	?
LFPR	I(2)	I(2)	I(1)	I(0)	?
REGS	I(0)	I(0)	I(2)	I(1)	?
SEINC	I(1)	I(1)	I(0)	I(1)	I(1)

Table B6: Final Summary of Unit Root Tests: Demand for Money Model

	ADF		KPSS		
Variables	**Trend**	**Level**	**Trend**	**Level**	**Decision**
m_t	I(2)	I(1)	I(2)	I(2)	I(2)
y_t	I(1)	I(1)	I(0)	I(1)	I(1)
r_t	I(1)	I(1)	I(2)	I(2)	I(1)
p_t	I(1)	I(2)	I(2)	I(2)	I(2)

Table B7: Perron's Modified ADF Test & Karzumi's Modified KPSS Test: MIMIC Model

		ADF H(0): I(2) vs. H(A): I(1)			KPSS H(0): I(1) vs. H(A): I(2)		
Variable	**Type**	**P[1]**	**t_{dt}[2]**	**Decision**	**P[1]**	**t_{dt}[2]**	**Decision**
		Indicators			**Indicators**		
RCURR	Level - 1982	0	-4.75***	Reject I(2)	3	0.056	At most I(1)
CONSUMP[3]	Trend - 1983	0	-4.99***	Reject I(2)	4	0.060	At most I(1)
GDP[3]	-	-	-	-	-	-	-
		Causes			**Causes**		
ADTR	-	-	-	-	-	-	-
AITR	Trend – 1985	0	-0.868	I(2)	4	0.17***	I(2)
APTR	-	-	-	-	-	-	-
AMTR	Level & Trend – 1997	8	-4.52***	Reject I(2)	2	0.056	At most I(1)
CRIME	Trend – 1991	8	-5.49***	Reject I(2)	0	0.067	At most I(1)
LFPR	Level & Trend – 1989	0	-6.90***	Reject I(2)	10	0.25***	I(2)
REGS	Level & Trend – 1986	0	-6.56***	Reject I(2)	12	0.26***	I(2)
SEINC[3]	-	-	-	-	-	-	-
		ADF H(0): I(1) vs. H(A): I(0)			KPSS H(0): I(0) vs. H(A): I(1)		
Variable	**Type**	**P[2]**	**t_{dt}**	**Decision**	**P[2]**	**t_{dt}**	**Decision**
		Indicators			**Indicators**		
RCURR	Level - 1982	0	-2.24	I(1)	3	0.139**	I(1)
CONSUMP[3]	Trend - 1983	0	-2.65	I(1)	2	0.061	I(0)
GDP[3]	-	-	-	-	-	-	-
LFPR	Level & Trend – 1989	0	-3.54	I(1)	-	-	-
SELF	Trend - 1989	0	-2.44	I(1)	3	0.105*	I(1)
		Causes			**Causes**		
ADTR	-	-	-	-	-	-	-
AITR	-	-	-	-	-	-	-
APTR	-	-	-	-	-	-	-
AMTR	Level & Trend – 1997	8	-5.36***	I(0)	2	0.065	I(0)
CRIME	Trend – 1991	7	-3.44	I(1)	0	0.073*	I(1)
LFPR	Level & Trend – 1989	0	-3.54	I(1)	-	-	-
REGS	Level & Trend – 1986	0	-5.11***	I(0)	-	-	-
SEINC[3]	-	-	-	-	-	-	-

Notes: [1]The maximum lag order (bandwidth) was using the Newey-West (1994) data-based automatic bandwidth parameter method.
[2]* Indicates significant at a 10% level, ** Indicates significant at a 5% level, *** Indicates significant at a 1% level using approximate critical values for the KPSS test are taken from Kwiatkowski, Phillips, Schmidt, and Shin (1992).
[3]Indicates variables tested in their logarithm form.

Table B8: Revised Summary of Unit Root Tests: MIMIC Model

	NO STRUCTURAL BREAKS				STRUCTURAL BREAKS		
	ADF		KPSS		ADF	KPSS	Decision
Variables	Trend	Level	Trend	Level			
	Indicators				Indicators		
RCURR	I(1)	I(2)	I(1)	I(2)	I(1)	I(1)	I(1)
CONSUMP[6]	I(1)	I(1)	I(2)	I(1)	I(1)	I(0)	?
GDP[6]	I(1)	I(1)	I(0)	I(1)	-	-	I(1)
	Causes				Causes		
ADTR	I(1)	I(1)	I(0)	I(1)	-	-	I(1)
AITR	I(2)	I(2)	I(2)	I(0)	I(2)	I(2)	I(2)
APTR	I(0)	I(1)	I(0)	I(1)	-	-	I(1)
AMTR	I(0)	I(0)	I(2)	I(2)	I(0)	I(0)	I(0)
CRIME	I(1)	I(1)	I(0)	I(0)	I(1)	I(1)	I(1)
LFPR	I(2)	I(2)	I(1)	I(0)	I(1)	I(2)	I(2)
REGS	I(0)	I(0)	I(2)	I(1)	I(0)	I(2)	I(2)
SEINC	I(1)	I(1)	I(0)	I(1)			I(1)

Table B9: Testing for Unit Roots with Outliers: MIMIC Model

	Trend			Level		
Variable	P[1]	t_{dt}[2]	Decision	P[1]	t_{dt}[2]	Decision
	H(0): I(2) vs. H(A): I(1)					
CONSUMP[1]	6	-3.722**	Reject I(2)	0	-2.995**	Reject I(2)
	H(0): I(1) vs. H(A): I(0)					
CONSUMP[1]	1	-1.879	I(1)	1	-1.089	I(1)

Notes: § Combined with the evidence of all the other tests, the author concluded that CONSUMP is I(1).
[1]The maximum lag order (bandwidth) was using the Newey-West (1994) data-based automatic bandwidth parameter method.
[2]* Indicates significant at a 10% level, ** Indicates significant at a 5% level, *** Indicates significant at a 1% level using approximate critical values for the KPSS test are taken from Kwiatkowski, Phillips, Schmidt, and Shin (1992).

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C. MIMIC MODEL FRAMEWORK

The MIMC type of structural-equation model was introduced by Zellner (1970) and subsequently developed by Goldberger (1972) and by Jöreskog and Goldberger (1975). In basic terms, a MIMIC model incorporates several observable indicator variables that reflect the size and the form of an unobservable or latent variable and several observable causal variables that are believed to be determinants of the size and the form of the latent variable. The model is formulated to link the causes and the latent variable and to link the latent variable to the indicators. Given data for the causes and the indicators, one estimates the model by applying fairly standard econometric procedures.

Essentially, the MIMIC model is specified as follows. First, the scalar latent variable (in this case, the size of the underground economy), denoted as η, is linearly determined by a set of observable causes $x' = (x_1, x_2, \ldots, x_q)$, subject to a scalar random error term, ζ, which is a (px1) vector,

$$\eta = \gamma' x + \zeta \tag{1}$$

where Υ is a (qx1) vector of parameters. The latent variable, in turn, linearly determines a set of observable endogenous indicators $y' = (y_1, y_2, \ldots, y_q)$, also subject to a scalar random error term, ε, which is a (px1) vector,

$$y = \lambda \eta + \varepsilon \tag{2}$$

where λ is a (px1) vector of parameters. It is assumed that ζ and ε are Normal and mutually uncorrelated so that Var. $(\zeta) = \Psi$ and Cov. $(\varepsilon) = \Theta_\varepsilon$.

Substituting (1) into (2), the reduced form relation connecting the observable variables is obtained that expresses them in a p-equation multivariate regression model,

$$y = \Pi x + z \tag{3}$$

where the reduced form coefficient matrix is $\Pi = \lambda\Upsilon'$, the reduced form disturbance vector is $z = \lambda\zeta + \varepsilon$, and the covariance matrix is Cov. $(z) = \lambda\lambda'\Psi + \Theta_\varepsilon$.

The p-equation model in (3) is restricted so that the regressor coefficient matrix (Π) has a rank of one and the error covariance matrix is similarly constrained. The first restriction is common in econometrics and typically arises in simultaneous equation models (SEMS) where the exclusion of certain exogenous variables from a structural equation implies that a certain portion of the reduced form coefficient matrix is short ranked. The second restriction, that the disturbance covariance matrix is singular, often arises in systems of factor demands and factor cost shares from production where one common factor is assumed. Consequently, only the relative magnitudes of the parameters can be estimated. Estimation, therefore, is achieved by pre-assigning a value of one to an element of λ. The choice among the endogenous variables is arbitrary as the normalization does not identify the dependent variable in any formal or causal sense.

Since both y and x are observable data vectors, the equation in (3) can be estimated using conventional (restricted) Maximum Likelihood estimation. This yields consistent and asymptotically efficient estimates of the elements of Π, and hence λ and Υ. Given an estimate of the γ vector and given that the error term ζ has been set to its mean value of zero, equation 1 can be used to "predict" a value for η, the latent variable at any

point in the sample period. This value is taken to be an index of the relative size of the hidden economy at that point. Once again, the resulting series will simply be an index series, with no cardinal interpretation, unless additional information is used. If a value of the latent variable η is known for some point in the sample, then the index series could easily be converted into a cardinal time-path.

Several different model specifications were considered, based on various combinations of the indicator and causal variables, as well as normalization choices. The estimation results and associated time paths of the underground economy, however, were quite insensitive to the model specification. Table C1 reports the estimation specifications of six different models. These models were estimated by Maximum Likelihood, using the LISREL computer package. Model 1 and 2 are identical models, except for the choice of the normalizing variable. These particular results are presented to show that the choice of normalizing variable did not dramatically affect the results.

The results in C1 show a positive relationship between the size of the underground economy and all three indicator variables. Additionally, in all models, the relationships are statistically significant. The dummy variable for the tax changes that started in 1998 has a positive coefficient but is not statistically significant. The outcome is likely the result of the fact that the number of observations for this series is small. Of prime importance is that the results in all models for the causal variables all have the anticipated sign and most of them are statistically significant. This is in stark contrast to all of the previous studies, which have applied the MIMIC method to the underground economy, where most of the causal variables in the models are not statistically

significant. Additionally, the t-values reported in Table C1 have asymptotic validity. That is, they are asymptotically standard Normal. The sample under examination, however, has only twenty-four observations. Accordingly, the statistical significant of the variables is likely understated.

Rather than focus just on statistical significance, attention has also been paid to various goodness-of-fit measures as a means of judging the models presented here. This is standard practice in the context of MIMIC model estimation. It should be noted that in LISREL terminology, a "residual" is the difference between an observed and fitted covariance, so that "there is one residual for each pair of observed variables in the model, and "standardized" residuals are ones that have been scaled by the estimated standard error to render them unitless..." (Giles 1999, 38) (and hence comparable across models).

The goodness-of-fit results for each of our models are presented in Table C2. The non-central Chi-Square statistics relate to the test of the MIMIC models against the alternative that the covariance matrix of the observed variables is unconstrained. In this case, a large p-value, and therefore an acceptance of the null reflects a good "fit" of the structural model, so the models perform well under this test. The other summary statistics that are reported relate to various criteria that may be used to evaluate the overall performance of a MIMIC model. As these measures are quite well known they will not be discussed in great detail here, except to point out that *small* values of Akaike's (Akaike 1974) information Criterion (AIC), Bozdogan's CAIC measure (Bozdogan 1987), the single-sample Cross-Validation Index (ECVI), and the Root Mean Square Residual (RMR) measure each favour the model being tested. On the other hand, *large*

values of the Adjusted Goodness of Fit Index (AGFI) and the Parsimony Goodness of Fit Index (PFGI), each reflect a good fit (Jöreskog and Sörbom 1993). The measures presented in Table C2 can be compared across models with similar sets of indicator variables.

The last step in the diagnostic testing is the analysis of the *conventional* residuals from the models for normality and serial correlation. Using the coefficients in Table C1 together with the data, the difference between the fitted and actual values is obtained for each of the indicator (dependent) variables in each model over the full sample period. These are "conventional residual" series, which are typically constructed in econometric regression modeling. Each residual series is then scaled to have a zero mean because this is not ensured by the estimation procedure that has been used and can then be analyzed for normality and autocorrelation. This is achieved by regressing the residual series against a constant and then using the results from the DIAGNOS command in the SHAZAM computer package.[13]

The test for normality of the residuals that was used is the Jarque-Bera (JB) test, which is distributed as $\chi^2(2)$ under the null (Jarque and Bera 1980). The Lagrange multiplier tests (LM1 through LM4) were employed for testing for serial independence against simple autoregressive or moving average processes of order 1 through 4. These tests however, have only asymptotic justification and so they are only approximate here.

[13] These tests have to be computed separately because the LISREL package, used to estimate the MIMIC models, provides no standard diagnostics of this type.

The various test results support normality and independence of the residuals at at least a 10% significance level.

There are now several of pieces of information available to assist in the selection of one or more model specifications noted in Table C1 for further analysis. One way to summarize the above results would be to say that if a fairly parsimonious specification that performs well is desired, then Model 3 might be a good choice. On the other hand, a more "complete" model specification is preferred, Models 1, 2, 4 or 6 may be good choices. A more fully specified model is also appealing on statistical grounds, as the adverse implications (such as bias) of "under-specifying" a model are much more severe than those of "over-specifying" a model. The results from Model 2 where selected and reported in the body of the paper; however, the resulting time-path from all of these models were similar.

TABLES

Table C1: MIMIC Model Results: Parameter Estimates

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
GDP	1.00	1.78	1.31	1.35	1.000	0.83
(+)	(n.a.)	(3.02)	(3.85)*	(3.79)*	(n.a.)	(4.09)*
CONSUMP	0.70	1.25	1.06	1.08	0.95	0.78
(+)	(4.20)*	(2.55)	(3.20)*	(3.14)*	(3.36)*	(3.81)*
RCURR	0.56	1.00	1.00	1.00	1.17	1.00
(+)	(3.02)*	(n.a.)	(n.a.)	(n.a)	(4.13)*	(n.a.)
LFPR	1.15	0.65	0.75	0.82	0.82	0.96
(+)	(7.15)*	(2.83)*	(3.80)*	(3.73)*	(4.42)*	(6.09)*
RSEINC	0.41	0.23	0.50	0.42	0.62	0.72
(+)	(2.65)*	(2.01)*	(3.28)*	(2.84)*	(4.08)*	(5.15)*
ADTR	0.01	0.00		0.04	0.14	0.19
(+)	(0.08)	(0.08)		(0.49)	(1.57)	(1.79)
AITR	-0.40	-0.23	-0.34	-0.35	-0.48	-0.57
(-)	(-3.16)*	(-2.21)*	(-2.74)*	(-2.84)*	(-3.64)*	(-4.50)*
APTR				0.02	0.05	0.05
(+)				(0.02)	(0.52)	(0.45)
AMTR	2.42	1.36	2.03	2.06	2.38	2.75
(+)	(3.37)*	(2.27)*	(2.83)*	(2.88)*	(3.39)*	(3.95)*
VDP	-8.02	-4.51	-6.65	-6.77	-7.86	-9.14
(-)	(-3.41)*	(-2.29)*	(-2.82)*	(-2.87)*	(-3.39)*	(-3.97)*
CRIME	0.67	0.38	0.58	0.56	0.62	0.70
(+)	(4.44)*	(2.53)*	(3.37)*	(3.23)*	(3.37)*	(4.46)*
GST	0.26	0.15	0.47	0.46	0.98	1.20
(+)	(1.13)	(1.05)	(2.35)*	(2.23)*	(3.82)*	(4.93)*
REGS	0.25	0.14		0.12		
(+)	(2.06)*	(1.71)		(1.21)		
TAXCNG	0.14	0.08				0.07
(+)	(1.18)	(1.10)				(0.63)
UEI	7.15	4.02	5.88	5.96	6.66	7.66
(-)	(3.57)*	(2.33)*	(2.90)*	(2.95)*	(3.40)*	(3.94)*

Notes: § Anticipated signs appear in brackets.
† Asymptotic "t-values" appear in parentheses below the estimated coefficients
± * denotes a significant t-statistic at 10%

Table C2: MIMIC Model Results: Goodness of Fit

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Chi-Square (n.c.p.; d.o.f)	32.74 (10.74;22)	32.74 (10.74;22)	26.82 (10.82;16)	30.22 (8.22;22)	29.24 (9.24;20)	31.24 (9.24;22)
AIC	237.76	237.76	126.82	196.29	171.24	197.24
CAIC	268.23	268.23	235.73	248.79	325.88	378.01
ECVI	8.64	8.64	5.51	8.53	7.45	8.57
AGFI	0.193	0.193	0.278	0.246	0.26	0.22
PGFI	0.174	0.174	0.200	0.176	0.18	0.17
RMR	0.091	0.091	0.09	0.07	0.07	0.07

Notes: § n.c.p. denotes non-centrality parameter
† d.o.f. denotes degrees of freedom

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D. DEMAND FOR MONEY EQUATION FRAMEWORK: AN 'UNOBSERVED COMPONENTS' APPROACH

An alternative way to incorporate the 'underground economy' into a demand for money equation to that outlined by Giles and Tedds (2002), is to treat (the logarithm of) underground output as an 'unobserved component', and then estimate the resulting 'state space' model by Maximum Likelihood using the Kalman (1960) filter.

There are two equations in a state space model (see Harvey 1989, Chapter 3 for a more detailed discussion). The first equation is called the 'measurement equation' or 'signal equation', and it describes the stochastic relationship between the dependent variable, y_t, and a vector of 'state variables', α_t,

$$y_t = d_t + z_t'\alpha_t + \varepsilon_t \tag{1}$$

where

$$E(\varepsilon_t) = 0, Var(\varepsilon_t) = h_t. \tag{2}$$

The second equation is called the 'state equation' or 'transition equation',

$$\alpha_t = c_t + T_t\alpha_{t-1} + R_t\phi_t \tag{3}$$

where

$$E(\phi_t) = 0, Cov(\phi_t) = Q_t. \tag{4}$$

Equation (1) describes the stochastic relationship between the dependent variable and an (mx1) vector of 'state variables'. The latter are 'unobservable components' of the equation and they are described in terms of a first-order Markhov process in equation (3). Higher-order processes are readily modeled by making the state variable(s) dependent

upon first-order lagged values of other state variable(s) in equation (3) and adding additional state equations.

Notice that the scalar parameters d_t and c_t, the parameter vector z_t, and the parameter matrices, T_t and R_t, may be time-dependent. This type of model framework allows for the possibility of 'random coefficient' and 'recursive coefficient' models as special cases. Both stationary and non-stationary processes can be considered. Moreover, equations (1) and (3) can also include traditional regressors as explanatory variables, an option that was pursued.

In the demand for money equation, the logarithm of the money stock (m_t) is the dependent variable in the measurement equation, which, in the preferred version[14] of the model, has been modeled as a function of last period's values[15] of the logarithms of output (y_t), interest rate (r_{t-1}), money (m_{t-1}), prices (p_{t-1}), and the current period's unobserved value of the logarithm of underground output (u_t), which is also the state variable,

$$m_t = \alpha_{1t} y_t + \alpha_{2t} r_{t-1} + \alpha_{3t} p_{t-1} + \alpha_{4t} m_{t-1} + u_t. \qquad (5)$$

The single state variable, the logarithm of underground output (u_t), is then modeled as a function of last period's value of the logarithm of underground output (u_{t-1}), the logarithm

[14] Different versions of the measurement and state equations were experimented with. A 'General-to Specific' modeling strategy was adopted, with account being taken of the signs and significance of the estimated coefficients, as well as the values of the Akaike and Schwartz information criteria.

[15] That is, the measurement equation is recursive. This is consistent with the past literature on the well-known instability of demand-for-money equations. In that literature, some authors have used recursive least squares estimation and time-varying coefficient models to capture instabilities in the coefficients over time (*e.g.*, Burns 1975 and Cogley 1993).

of output from two previous periods ago (y_{t-2}), the compounding annual rate of inflation, lagged one period ($p_{t-1} - p_{t-2}$), and a random shock (ϕ_t),

$$u_t = c_1 u_{t-1} + c_2 y_{t-2} + c_3 (p_{t-1} - p_{t-1}) + \phi_t. \tag{6}$$

The ratio of underground output to measured real output can then be obtained in percentage terms as:

$$Ratio_t = \exp(\hat{u}_t - y_t) * 100 \tag{7}$$

where $\hat{u}_t$ is the predicted value of the logarithm of underground output obtained by estimating equations (5) and (6).[16] An average value for the underground economy that can be used to calibrate the index series obtained from the MIMIC model is obtained by finding the mean of the $Ratio_t$ series. The model produces an arithmetic mean for the ratio of underground output to measured real output of 11.35%, with an associated 95% confidence interval of [9.98%, 12.76%].

The mean value of $Ratio^*$ = 11.35% can be used to convert the time-series index for the underground economy ratio, generated by the preferred MIMIC model, into a time-series of values in the following way. Suppose that I_t denotes the index for the ratio of the underground economy to the measured economy in period t, where

$$I_t = a_t I_1, \ t = 2,3,....,T. \tag{8}$$

To preserve the content of the index time-series of the underground economy ratios, then the values must retain the same proportional relationship as do the index values. That is, it is necessary that

[16] The model was formulated and estimated using the EViews package.

$$Ratio_t = a_t Ratio_1, \quad t = 2,3,....,T. \tag{9}$$

Making use of the estimated average ratio from the money demand equation, the additional relationship

$$Ratio^* = \frac{1}{T}\sum_{t=1}^{T} Ratio_t = \frac{1}{T}(Ratio_1 + \sum_{t=2}^{T} a_t Ratio_1) = \frac{Ratio_1}{T}(1 + \sum_{t=2}^{T} a_t) \tag{10}$$

is obtained. These relationships yield T equations to be solved for the T unknown ratio values.

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CHAPTER 3

NONPARAMETRIC EXPENDITURE-BASED ESTIMATION OF INCOME UNDER-REPORTING AND THE UNDERGROUND ECONOMY

Introduction

There has been a recent resurgence in interest in measuring the underground economy and this interest has been stimulated predominantly by the perception that the underground economy is sizeable and growing. In broad terms, the phrase "underground economy" refers to output that is produced and income that is generated by agents who hide this fact from authorities. Knowledge of the size and structure of the underground economy is important for a number of reasons. First, because underground activities are unmeasured, they are not taken into account in the information-set that is used to assist economic policy-makers. Second, the underground economy effectively re-distributes both income and wealth in ways that are not necessarily consistent with the re-distributional goals of the taxation system. Third, the shortfall in income-reporting that is associated with underground activities leads to an erosion in the tax base and tax revenue with subsequent implications for both public expenditure and taxation policies. Finally, enforcement activities are unlikely to be successful (and may have counter productive consequences) without detailed knowledge of the characteristics and types of activities of underground economy participants.

To date, research that seeks to measure the underground economy has predominately employed macro-methods.[1] These macroeconomic measures, however, have been criticized for not being consistent with modern economic models of consumer behaviour, employing flawed econometric techniques, producing unreliable estimates, and providing limited guidance to policy makers (Thomas 1999). In particular, the macro-methods developed to date do not provide any information regarding the characteristics of those participating in the underground economy. In order to obtain this type of information, a method that utilizes microeconomic data is required.

One such approach, popularized by Pissarides and Weber (1989) and modified by Lyssiotou *et al.* (2004), utilizes household income and expenditure data to estimate the degree of income under-reporting (i.e. the amount by which household income should be scaled upwards to obtain true, or actual, income as opposed to reported income). The basic principle of this *Expenditure-Based Method* is that true household income can be imputed from reported household expenditures. The method is premised on variations of several key assumptions, namely: the reporting of expenditures on some items by all households is accurate; those who report zero self-employment income report income accurately while those who report non-zero self-employment income may under-report; and the marginal propensity to consume out of unreported income is equal to the marginal propensity to consume out of reported income. Actual, or true, self-employment income is then imputed by comparing the expenditure levels of households

[1] Such methods include: the *Currency-Ratio Approach* (Gutmann 1977); the *Monetary-Transactions Method* (Feige 1979); *Tanzi's Approach* (Tanzi 1980); *National Accounts/Judgmental Methods;* and the *Latent Variable/MIMIC model* (Frey and Weck-Hanneman 1984) that was discussed in Chapter 2.

with positive self-employment income to the expenditure-income bundles of households with zero self-employment income and similar characteristics. In practice, the method is implemented by estimating reliable expenditure functions (i.e. Engel curves) for wage earners that are then inverted to estimate true income for the self-employed.

Previous studies have implemented the *Expenditure-Based Method* using highly parametric restrictions on: (1) an Engel curve (Pissarides and Weber 1989) or a system of Engel curves (Lyssiotou *et al.* 2004); and (2) an income reporting function. These restrictions imply that households under-report their income by a constant fraction, independent of income. There is no empirical evidence that supports this restriction and little, if anything, is actually known about the functional form of the reporting function. This paper considers an alternative way of implementing the *Expenditure-Based Method.* In particular, the parametric restrictions are relaxed and a nonparametric approach to the measurement of income under-reporting is explored.

Specifically, a two-step approach to estimating a variable-with-income reporting function is proposed, within the framework of the *Expenditure-Based Method.* The approach is essentially as follows. First, a nonparametric inverse food Engel curve is estimated for the sample of households that report zero self-employment income, to obtain an estimate of true income given (accurately) reported expenditures for every household in the sample (including those with self-employment income). Second, the nonparametric reporting function for self-employment income for households that report positive self-employment income is estimated. This approach improves on the implementation of the *Expenditure-Based Method* by minimizing the number of

assumptions required for estimation. More particularly, the proposed framework avoids the usual functional form restrictions and enables the reporting parameter to vary across income levels and household characteristics.

The approach is illustrated by estimating the effect of the Canadian Goods and Services Tax (GST) on income under-reporting by married households with self-employment income. It is often argued that the implementation of this broadly based consumption tax increased the incentives and opportunities for tax evasion (e.g. Spiro 1993, and Hill and Kabir 1996) though the Government of Canada maintained that it would reduce the scope the tax evasion. The empirical analysis uses the Canadian Family Expenditure Survey (FAMEX), which contains household level information about income and expenditures.

Overall, this refinement to the *Expenditure-Based Method* produces results that demonstrate that income under-reporting does vary across household income levels. In particular, the gap between true and reported self-employment income is larger for households at the lower end of the self-employment income distribution. Possible explanations of this finding are that households with more self-employment income may be more likely to be audited by the authorities, face higher utility costs if they are caught, and/or disproportionately benefit from legal tax avoidance (e.g. by exploiting various tax credits or loopholes). It is also found that some self-employed households, notably those households at the upper end of the self-employment income distribution, over-report their income. The parametric restrictions imposed previously masked this possible behaviour. Overall, the aggregate results neither support the hypothesis that the GST increased tax

evasion nor the claim by the Canadian federal government that the GST would reduce tax evasion, at least for the self-employed.

The remainder of this paper is organized as follows. First, estimating income under-reporting from micro data is discussed, including a brief overview of the literature and details regarding the nonparametric approach proposed by this paper. The application of the approach is then described, including a description of the data, the results, and a discussion. The paper ends with some concluding comments.

Estimating Income Under-Reporting from Micro Data

Previous Approaches

In this section, attention is focused on two critical aspects of the empirical work in this paper with the view of placing the empirical strategy in context. These aspects concern: (1) functional form restrictions; and (2) the treatment of permanent income.

Functional Form Restrictions

A critical aspect of the empirical work in this area is the specification of the expenditure and reporting functions. The pioneering work in the development of the *Expenditure-Based Method* was conducted by Smith *et al.* (1986) and Pissarides and Weber (1989).[2] First, they categorize households as either being self-employed or wage earning. Second, they specify a log-log (in expenditures and income) form for the

[2] The *Expenditure-Based Method* was developed following work conducted by Dilnot and Morris (1981) who calculated the difference between reported household income and expenditures and arbitrarily classify households as "black economy" households if expenditures exceeded income by at least 20 percent.

expenditure equation (i.e. the constant elasticity Engel curve) that is used to estimate the parameter θ in the linear reporting function for self-employed households, defined as

$$y_{SE}^{*} = \theta y_{SE} \tag{1}$$

where y_{SE}^{*} represents true self-employment income, y_{SE} denotes reported self-employment income, and θ is assumed to be greater than one. This method of estimating income under-reporting consists of two steps. First, an expenditure function is estimated for wage earners. Second, the expenditure function is inverted to calculate θ, the amount by which reported self-employment income must be scaled up by in order to obtain true self-employment income.

Figure 1 provides a graphical representation of the approach. Constant-elasticity Engel curves for wage (or employee) and self-employed households are shown. A self-employed household reports expenditures, E*, and income, Y, but the reported level of expenditures is actually consistent with true income, Y*. The amount by which reported income must be scaled up to obtain true income is calculated by taking the ratio of the distance 0Y*/0Y which is equivalent to the parameter θ in equation (1) above. As the Engel curve for the self-employed is assumed to be parallel to that of wage earners, the distance is the same for every household (i.e. the reporting parameter is constant).

Lyssiotou *et al.* (2004) propose a systems approach to the *Expenditure-Based Method*. They specify a system of Engel curves of quadratic-in-(log)income Working-Leser form. They assume that durable and nondurable goods are separable and base their demand system on nondurable goods only, namely: food, alcohol, fuel, clothing, personal

goods/services, and leisure goods/services. Lyssiotou *et al.* (2004) maintain the specification of the linear reporting function given in equation (1) above but avoid classifying households as either wage earners or self-employed.[3]

The functional form for the Engel curve that is specified by Lyssiotou *et al.* (2004) raises two concerns. First, there is an implicit assumption of the *Expenditure-Based Method* that the Engel curve(s) employed in the estimation must be monotonic in income. In reference to Figure 1, if this critical assumption is violated, then a unique value of true income associated with a particular level of expenditures may not exist. The quadratic-in-(log)income Working-Leser form of the Engel curve specified by Lyssiotou *et al.* (2004) is not necessarily consistent with the monotonicity assumption, with particular goods, notably alcohol and clothing, known to violate this assumption (Banks *et al.* 1997). Second, the quadratic-in-(log)income Working-Leser form of the Engel curve is not invertible over all values due to the presence of asymptotes. While the presence of asymptotes is not a concern under the structure imposed by Lyssiotou et al. (2004) - the system of Engel curves is not (implicitly) inverted over all data points - it underscores the likelihood that the estimates are influenced, in whole or in part, by the parametric restrictions.

[3] Lyssiotou *et al.* (2004) also allow for what they call "preference heterogeneity". They note that income from self-employment may not be spent in the same way as income from other sources. In particular, it could be that households spend wage income, which is predictable, on necessities and the self-employment income, which is subject to under-reporting and is unpredictable, on luxuries. Equally, the self-employed could just have different preferences. Pissarides and Weber (1989) assumed homogenous preferences among all households. Lyssiotou *et al.* (2004) allow for preference heterogeneity in their estimated system of budget shares through the inclusion of the self-employment proportion of reported income, which can enter the system nonlinearly. The preference heterogeneity term(s), however, are identified only by functional form and are not identified in the nonparametric framework proposed in this paper.

More generally, this approach still assumes a parametric Engel curve, albeit one that is more widely accepted than that implied by earlier constant-elasticity assumption. Perhaps more importantly, this approach continues to assume that households under-report their income by a constant fraction, independent of income. In fact, little is known about the form of the reporting function and it is plausible that under-reporting will differ with income and household characteristics. This paper proposes a nonparametric approach which avoids functional form restrictions. The proposed method also works directly with an inverse Engel curve, avoiding problems associated with inversion, and continues with the tradition of the single equation approach. The single equation approach also allows the analysis to be restricted to a good for which the Engel curve is widely acknowledged to be monotonic in income.

Permanent Versus Transitory Income

There is a general belief that households base expenditures on permanent rather than transitory income. This implies that households save when they have positive transitory income and dissave when they have negative transitory income. If the *Expenditure-Based Method* is implemented using transitory, or annual income, this may lead to biased estimates of income under-reporting. Pissarides and Weber (1989) acknowledge that permanent income is the measure of income that influences consumption decisions but stop short of requiring their expenditure function to conform exactly to the permanent income hypothesis, perhaps because the dataset used in their analysis (1982 British Family Expenditure Survey) did not contain information regarding

household savings behaviour. They indicate that "...for given permanent income, the measured income of the self-employed may be more variable than the measured income of employees in employment. If this is correct, our measure of income under-reporting by the self-employed will have to be adjusted accordingly." (Pissarides and Weber 1989, 20) Empirically, they implement this assumption by treating reported income as endogenous and then using instrumental estimation, which "...enables an independent estimate of the residual variance of reported income for each group which is exploited in the calculation of income under-reporting." (Pissarides and Weber 1989, 22)

Whether Pissarides and Weber's (1989) Two-Stage Least Square (2SLS) approach is preferred to Ordinary Least Squares (OLS) depends on the quality of the instruments. Datasets that contain information on household expenditures and income may not contain relevant instrumental variables required for this analysis. Further, the approach requires the researcher to make additional and somewhat arbitrary assumptions which restrict the analysis. As a result, an alternative approach which addresses the issue of permanent income is desirable. This paper explores such an alternative.

A Nonparametric Approach

As outlined above, to date, the *Expenditure-Based Method* has been implemented by estimating Engel curves which are implicitly or explicitly inverted to obtain an average estimate of income under-reporting. A more direct approach to estimating income under-reporting is to utilize an inverse Engel curve (i.e. with income taking on the role of the dependent variable) and nonparametric methods. Within the framework of

the *Expenditure-Based Method*, a two-step approach to estimating a variable-with-income reporting function is proposed that responds to the concerns raised in the previous section. The first step nonparametrically estimates an inverse Engel curve, which can be consistently estimated for households that report zero self-employment income, to obtain true income for all households. The second step nonparametrically estimates the reporting function for households with positive self-employment income.

The use of nonparametric methods[4] has three advantages. First, it enables the reporting function to vary across income levels and household characteristics. Second, it avoids functional form restrictions on the Engel curve. Third, within this framework it is also possible to test the null hypothesis that the reporting function is linear, as has been assumed in the previous literature.

To achieve estimation, some initial assumptions are required. The three fundamental assumptions of Pissarides and Weber (1989) are maintained and classifying households as either self-employed or not is avoided following Lyssiotou *et al.* (2004). First, food expenditures are used in the analysis and it is assumed that the reporting of food expenditures by all households is accurate.[5] Second, only self-employment income

[4] Semiparametric estimation was not pursued as Blundell *et al.* (1998) have found that "...the additive structure between demographic composition and income that underlies the partially linear semiparametric model implies strong and unreasonable restrictions on behaviour." (Blundell *et al.* 1998, 461). The nonparametric estimation strategy proposed here cannot be implemented if income and demographic terms enter non-additively. Instead, estimation is conducted separately on an identified homogenous sub-population (i.e. married couples without children).

[5] The arguments for using food as opposed to any other commodity or group of commodities are that: there is no social stigma associated with food consumption which could cause expenditures to be reported inaccurately (counter examples would include tobacco and alcohol); food expenditures are more likely to be reported accurately by households participating in the underground economy since individual expenditures on food are small and are unlikely to rouse suspicion; tastes for food are more likely to be uniform across employment groups and over time; it is very difficult for a household to postpone food

can be under-reported.[6] Third, the marginal propensity to consume out of unreported income is constrained to be equal to the marginal propensity to consume out of reported income.[7]

The approach in this paper also considers the issue of permanent versus transitory income. As indicated above, there is a general belief that households base expenditures on permanent rather than transitory income. This implies that households save (dissave) when transitory income is greater (less) than permanent income. If transitory, rather than permanent, income is used when estimating income under-reporting then it is likely that (dis)savings activity is being confused with misreporting. For example, a person with temporarily low income will dissave in order to maintain consumption but, if dissavings are ignored in the analysis, this behaviour will be indicative of income under-reporting. The result will be a biased estimate of income under-reporting. If, however, one can observe whether a household is saving or dissaving, then this information, along with reported income, can be used to approximate permanent income and used in the

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consumption; most food purchases cannot be included as a business expense; and, the food Engel curve is widely acknowledged to be monotonic.

[6] Taxes for most sources of income, particularly wage and salary income, and various "payroll" taxes are "pay as you earn". That is, income and payroll taxes are withheld at source from these payments to individuals. Self-employment income, on the other hand, is reported and taxed at year end (though many self-employed are required to make estimated tax payments during the year in order to ensure that they meet their tax obligation in a timely manner) by the individual who earned the income and there is no third party who also reports this income. That is, there is no check and balance within the system to ensure that the individual is accurately reporting their self-employment income. As a result, there is an opportunity for some self-employment income to be under-reported. That said, the assumption that only self-employment income is under-reported is likely not entirely accurate. For example, employers can pay their employees in whole or partially in cash as a way to evade income and payroll taxes. The extent that this assumption is not valid will lead to the resulting estimate of the degree of under-reporting to be biased toward zero.

[7] The reader should be made aware that this assumption may not be accurate. It may not be true that the marginal propensity to consume out of unreported income is equal to the marginal propensity to consume out of reported income. Households may use all unreported income to boost expenditures. Alternatively, households may use unreported income to boost savings, though the inclusion of the net change in assets and liabilities in the analysis will likely account for this behaviour.

estimation of income under-reporting, which obviates the need for the 2SLS approach followed by Pissarides and Weber (1989) described in the previous section.

The estimation strategy is as follows. The object of interest is true household self-employment income, $y^{*}_{SE,h}$, which is assumed to be a function of reported household self-employment income, $y_{SE,h}$, plus a white noise disturbance term:

$$E(y^{*}_{SE,h} \mid y_{SE,h}, d = 1] = f(y_{SE,h}) + \xi_h \tag{2}$$

where h denotes an individual household and d is a dummy variable that takes a value of one if the household reports any self-employment income.

The first stage of the procedure is to nonparametrically estimate an inverse Engel curve to obtain true (permanent) income given (accurately) reported expenditures. The inverse Engel curve expresses income, in this case permanent income, for reasons discussed above, as a function of expenditures. For this exercise, the nonparametric representative of the inverse Engel curve is given by:

$$y^{p}_{TOTAL,h} = h(x_h) + \nu_h \tag{3a}$$

where x_h represents household reported (and assumed to be true) food expenditures, ν_h is a white noise disturbance term, and $y^{p}_{TOTAL,h}$ represents true (reported plus unreported) total permanent household income, defined as

$$y^{p}_{TOTAL,h} \equiv y^{*}_{SE,h} + y_{OTH,h} - \Delta A_h. \tag{3b}$$

$y_{OTH,h}$ refers to household reported (and assumed to be accurately reported) other income and ΔA_h indicates household net change in financial assets and liabilities (a household that has positive (negative) transitory income will save (dissave) the additional money and $\Delta A_h > 0$ (<0)).

By assumption, x_h is accurately observed for all households but $y^p_{TOTAL,h}$ is only accurately observed for those households that have zero self-employment income ($y^*_{SE,h} = y_{SE,h} = 0$). This implies that $h(x_h)$ can be consistently estimated for households that report zero self-employment income. The fitted values from the first stage regression, $\hat{h}(x_h)$, for households that report zero self-employment income are used to obtain an accurate estimate of total permanent income for households with positive self-employment income based on food expenditures. As a result, consistent estimates of total permanent household income, $\hat{h}(x_h)$, are obtained for every household.

As indicated in equation (3b) above, total permanent household income is comprised of three elements, namely the household's: true self-employment income, ($y^*_{SE,h}$); reported other income, ($y_{OTH,h}$); and net change in financial assets and liabilities, (ΔA_h). If $y_{OTH,h}$ is subtracted from and ΔA_h is added to the estimate of total permanent household income obtained in the first step, $\hat{h}(x_h)$, one obtains an estimate of true self-employment income, $y^*_{SE,h}$, for those households that report positive self-employment income. That is, $y^*_{SE,h}$ can be calculated as follows:

$$y^{*}_{SE,h} = \hat{h}(x_h) - y_{OTH,h} + \Delta A_h. \tag{3c}$$

This relationship is exploited in the second step of this approach.

The second step estimates the nonparametric form of the reporting function, the parametric form of which is given by equation (1), for those households that report positive self-employment income ($y_{SE,h}>0$). The nonparametric form of the reporting function is given by:

$$y^{*}_{SE,h} = f(y_{SE,h}) + \zeta_h. \tag{4}$$

The amount of self-employment income that is unreported by each household is calculated as the predicted value of true self-employment income, $\hat{f}(y_{SE,h})$, minus reported self-employment income, $y_{SE,h}$. Total unreported income is found by summing over households with positive reported self-employment income.

Testing Linearity of the Reporting Function

As indicated above, previous studies assumed that the reporting function took the form denoted in equation (1), where θ is assumed to be greater than one. The nonparametric approach outlined above provides an opportunity to test the null hypothesis that the reporting function takes the linear form specified by equation (1) versus the alternative that the reporting function takes the nonparametric specification specified by equation (4).

To implement this test, a testing method described by Yatchew (1998, 2003) is utilized. The test statistic is given by

$$V = \frac{T^{1/2}(s_{res}^2 - s_{diff}^2)}{s_{diff}^2} \sim N(0,1) \tag{6}$$

where

$$s_{diff}^2 = \frac{1}{2T}\sum_{h=2}^{T}(y_{SE,h}^* - y_{SE,h-1}^*)^2 \tag{7}$$

$$s_{res}^2 = \frac{1}{T}\sum_{h=1}^{T}(y_{SE,h}^* - \hat{\theta} y_{SE,h})^2 \tag{8}$$

and T is the total number of households.

The testing procedure is as follows. First, the data is reordered such that $y_{SE,1} \leq \ldots \leq y_{SE,T}$. Second, s_{diff}^2 is calculated. Third, the restricted regression given by equation (1) is performed to obtain $y_{SE,h}^* - \hat{\theta} y_{SE,h}$. Fourth, s_{res}^2 is calculated. Finally, the test statistic, V, is calculated and a one-sided test is conducted, comparing the value of the test statistic to a critical value from a standard normal distribution.

Testing the Significance of the Change in Asset Term

It is also possible to test the significance of ΔA_h, the change in financial assets term, in equation (3) by employing the differencing method discussed in Yatchew (1998, 2003). To do so, note that equation (3) can be rewritten as

$$y_h^a = h(x_h) + \beta \Delta A_h + \nu_h \tag{9}$$

where y_h^a represents a household's annual income (where $y_h^a = y_{SE,h}^* + y_{OTH,h}$). Equation (9) is a partially linear model in ΔA_h. In equation (3) above, β was assumed to be equal to one.

In order to test if β=0 or, alternatively, if β=1, the data must first be sorted such that $x_1 \leq \ldots \leq x_T$. The variables y_h^a and ΔA_h are then differenced (which, in heuristic terms, "removes" the direct effect, $h(x_h)$, of the nonparametric variables, x_h, that occurs through ΔA_h). The Ordinary Least Squares (OLS) estimator is then applied to the differenced data such that:

$$\hat{\beta}_{diff} = \frac{\sum_{h=2}^{T} (y_h^a - y_{h-1}^a)(\Delta A_h - \Delta A_{h-1})}{\sum_{h=2}^{T} (\Delta A_h - \Delta A_{h-1})^2}. \tag{11}$$

The process of differencing the data, however, creates autocorrelation in the error term. Yatchew (2003) notes that the correction is simple if homoskedasticity is assumed: the standard errors simply need to be multiplied by the square root of 1.5. Following this correction, standard inference techniques can be employed.

Application

The nonparametric application of the *Expenditure-Based Method* outlined above is illustrated here by estimating the effect of the Canadian Goods and Services Tax (GST) on income under-reporting. The implementation of the GST in 1991 represents an interesting opportunity to explore changes in income under-reporting by the self-

employed in Canada. The GST is a federal value-added tax that applies at a rate of 7% to the supply of most goods and services in Canada, including services offered by the self-employed[8], and replaced a less comprehensive manufacturers' sales tax (MST).

Prior to introducing the GST, the federal government argued that it would reduce the scope for tax evasion because it is applied successively at different stages of processing. That is, businesses, including the self-employed, are required to pay the GST on all its inputs but this is credited against the GST it collects from its own customers. In order to obtain the credit, however, the business is required to produce receipts showing that it paid the GST on its inputs. For this reason, the tax is said to apply only to the value added by a business. Another promoted virtue of the GST was that, as a consumption tax, it is a tax that even the hard-to-tax (e.g. those earning their full income in the underground economy) would have to pay since they must purchase at least some of their goods and services in the observed economy. On the other hand, it is often argued that the implementation of the GST increased the incentives and opportunities for tax evasion. First, the business can choose not to report some fraction of their sales, avoiding both their income and GST tax liability, while still claiming their whole input

[8] Most businesses, including the self-employed, are required to register for the GST (and collect and remit the GST or HST). However, "small suppliers" are not *required* to register for the GST. The Canada Revenue Agency defines a GST Small Supplier as a sole proprietor, partnership, or corporation whose total taxable revenues before expenses are $30,000 or less annually. However, the Small Supplier GST registration rule doesn't apply to all types of businesses; taxi and limousine operators, for instance, must always register for the GST. Additionally, even if a business does qualify as a GST Small Supplier, the business can still register for the GST. As a GST registrant, the business can reclaim the GST they have paid on business purchases, on everything from capital property through office supplies. The FAMEX data contains no information regarding the GST registrant status of the self-employed contained in the data sample.

tax credit. Second, the business and customer can collude and avoid collecting and paying the GST, respectively.

Data

The data used in this paper come from the public use Canadian Family Expenditure Surveys (FAMEX), which were conducted at irregular intervals between 1969 and 1996.[9] The FAMEX is a cross-sectional household recall survey that is intended to be representative of all persons living in private households in the ten Canadian provinces.[10] (Additional information on the collection of the FAMEX is provided in Appendix A.)

Two previous studies applied the Pissarides and Weber (1989) variant of the *Expenditure-Based Method* to FAMEX data. Mirus and Smith (1997) find that the self-employed in Canada under-report their income by 12.5% for the year 1990. Schuetze (2002) pools FAMEX data for the period 1969 to 1992 and finds that the self-employed under-reported their income by between 11-23% and that the self-employed in the construction and service occupations are more likely to be involved in tax non-compliance.

The sample for this analysis is limited to married couples (without children) and it is assumed that the household unit acts as a single decision maker regarding expenditure and income reporting. (A short discussion concerning the unit of analysis is provided in

[9] In 1997, the Survey of Household spending (SHS) replaced the FAMEX and has been conducted annually since. The SHS, however, does not provide detailed information regarding the sources of household income so this data cannot be used for this analysis.

[10] Households in the Territories are also surveyed but their data is not included in all the public use files.

Appendix B.) The sample is further restricted to households: where the head and spouse are of working age (25-64 years of age); which constitute one economic family; that have positive food expenditures; and for which the head's occupation is known and is not working in the primary occupation category. (This last restriction will exclude farm households, which are likely to have much different expenditure patterns on food than those in other occupations.) Households whose annual gross income was either in the top or bottom 1% of the income distribution were excluded from the analysis. In addition, households whose permanent gross income[11] was either in the top or bottom 1% of the income distribution were also excluded from the analysis. These last two exclusions are intended to avoid households with negative income and extreme positive income in both steps of the method described above. Finally, households with negative self-employment income were also excluded from the analysis.

To conduct the analysis, results from using FAMEX data for the years 1982 and 1986 will be compared to those obtained using data for the years 1992 and 1996. Pooling the data in this way attempts to ensure that there are sufficient observations included in each stage of the analysis. Each pooled sample contains one year during which the economy was sluggish (1982 and 1992) and one year in which the economy was in a growth period (1986 and 1996). The implicit restriction made by pooling the data in this way is that the marginal propensity to consume food is the same for each of the two years contained in each of the pooled samples. Two additional households in the pooled

[11] This is the dependent variable in the first stage regression and is defined as gross income less change in assets.

1982/1986 sample were excluded from the analysis as well as one additional household in the pooled 1992/1996 sample. These households had self-employment income that exceeded average self-employment income by a factor of almost six. As there were no other observations within their vicinity it was not possible to obtain nonparametric estimates at these points by using any reasonable bandwidth. Pooling, along with the restrictions noted here and above, left a total of 1,907 households in the 1982 and 1986 pooled sample, of which 303 are self-employed and a total of 1,840 households in the 1992 and 1996 pooled sample, of which 369 are self-employed. The increase in the ratio of self-employed households to nonself-employed households between the two samples is not unexpected, given that the Canadian self-employment rate rose from 13% in 1979 to 18% by 1997 (Picot *et al.* 1998).

Expenditures are converted to real 1996 dollars using the food price index developed by Browning and Thomas (1999). Food expenditures, which includes expenditure on food consumed at home and in restaurants, are used in estimating equation (3).[12] Income terms and the change in asset term are converted to real 1996 dollars using a general price index. All income terms are inclusive of income taxes because net income by source is not available in the FAMEX.[13]

Table 1 provides some summary statistics of the data. The top half of the table presents statistics for households with zero self-employment income, while the bottom half of the table presents statistics for households with positive self-employment income.

[12] Similar estimates to those reported above were obtained when food expenditures were restricted to include only expenditures on food consumed at home.
[13] Pissarides and Weber (1989) use net income in their analysis.

The left column shows statistics for the 1982/1986 pooled sample and the right column for 1992/1996. The two household groups report comparable average incomes, changes in assets, and expenditures on food in each of the two samples, but self-employed households have greater variability in their assets in the 1982/1986 sample.

Results

Nonparametric estimation of equations (3) and (4) is achieved by employing the locally-weighted least-squares procedure, using the Gaussian weighting function and adaptive bandwidth[14]. Equation (3), the inverse Engel curve, is estimated at every point in the data but assigns a weight of zero to households with positive self-employment income in the estimation process. The reporting function given by equation (4) is estimated only for those households which report positive self-employment income ($y_{SE,h}>0$).

As outlined above, it is possible to test the significance of the ΔA_h term in equation (3a). The results of this test are outlined in Table 2. As before, the results for 1982/1986 are in the column on the right and 1992/1996 are presented in the left-hand column. The parameter estimates for β_{diff}, noted in the first row, are very close to unity in value. In both cases, the null hypothesis that $\beta_{diff} = 0$ is rejected with p-values of essentially zero, as is noted in the second row of the table. The results for testing the null hypothesis that β_{diff} =1 are shown in the third row. For the 1982/1986 pooled dataset,

[14] The initializing bandwidth was selected by cross-validation (Härdle and Marron 1990).

the null hypothesis that $\beta_{diff} = 1$ is not rejected at the 1% or 5% significance levels but would be rejected at a 10% significant level. For the 1992/1996 pooled dataset, the null hypothesis that $\beta_{diff} = 1$ is not rejected at any conventional significance level. Given the test results and the fact that the estimates for β_{diff} are economically no different from unity, it is concluded that the ΔA_h term should be included in the analysis as outlined above and proceed accordingly.

Figure 2 presents graphs of the inverse food Engel curve, estimated from equation (3a). Recall from above that equation (3a) can be consistently estimated on the sample of households that report zero self-employment income and provides an estimate of true household income for all households. The graph on the left is for the 1982/1986 pooled sample while the graph on the right is for 1992/1996. Reported food expenditure is plotted on the horizontal axis and gross household income, less changes in assets, is plotted on the vertical axis. For both samples, the inverse food Engel curve appears linear over most food expenditures, but takes on some curvature at higher levels of food expenditures, notably where the data becomes sparse.[15]

Figure 3 presents graphs of the nonparametrically estimated reporting function that were obtained using equation (4). Again, the graph on the left is for the 1982/1986 pooled sample while the graph on the right is for 1992/1996. Estimated true self-

[15] The inverse Engel curves obtained from equation (3) but without the change in asset term (where gross income is the dependent variable), are similar in shape to those shown in Figure 2 but are shifted vertically. Ignoring the change in asset term, therefore, leads to inflated estimates of true gross income given reported food expenditures.

employment income is plotted on the vertical axis and reported self-employment income is plotted on the horizontal axis. Both axes use the log scale. Also shown are 90% bootstrapped confidence intervals obtained using the "wild" bootstrap procedure (Wu 1986) which allows for heteroskedastic errors. The forty-five degree line in the figures shows reported self-employment income. When the plot of estimated true self-employment income is above the forty-five degree line, a household is under-reporting their self-employment income. Each graph also presents three vertical lines, which represent the tenth, fiftieth, and ninetieth percentiles of the data. This information is presented to provide the reader with detail regarding the density of the data and its relation to the estimation of the reporting function.

The graphs in Figure 3 show that the reporting function appears to be nonlinear. For the 1982/1986 pooled sample, estimated true self-employment income is above reported self-employment income for households with less than almost $40,000 in reported self-employment income, but under-reporting decreases as reported self-employment income approaches approximately $40,000. For the 1992/1996 pooled sample, estimated true self-employment income is above reported self-employment income for households with less than just over $40,000 in reported self-employment income, but under-reporting decreases as reported self-employment income increases beyond approximately $40,000. Beyond the approximate $40,000 threshold amount in both samples, the results indicate that households over-report self-employment income. It should be noted that the estimated number of married households that over-report is small in percentage terms.

There are two possible explanations for the over-reporting finding. First, this particular result could be driven, at least in part, by data sparsity and a breakdown in the nonparametric procedures. In both pooled samples, the data are sparse beyond $40,000. In the 1982/1986 pooled sample, the ninetieth percentile occurs at approximately $46,800 ($55,000 in the 1992/1996 pooled sample). In both cases, the ninetieth percentile occurs in the vicinity of where estimated true self-employment income falls below reported self-employment income. Second, and much more plausible, some self-employed households may over-report their income due to a misinterpretation of tax laws, to avoid a tax audit, to secure financing, and/or to exploit various tax deductions, credits and loopholes in an effort to reduce their tax bill. This is an issue that has not received a lot of attention in the tax evasion literature to date and the parametric restriction imposed on the *Expenditure-Based Method* previously masked this possible behaviour. It should be noted that Rice (1992), using the U.S. Internal Revenue Service's (IRS) Tax Compliance Measurement Program (TCMP) data, found that about 6% of firms overstate their taxable income to some extent, providing some support for this hypothesis.

As mentioned above, it is possible to test whether or not the reporting function, equation (4), is linear, as assumed previously in the literature. Table 3 summarizes the results of the test of null hypothesis, that the reporting function takes the form of equation (1), against the alternative, that the reporting function takes the nonparametric specification of equation (4). The results for the 1982/1986 pooled dataset are noted in the first column. The value of the test statistic is noted in the first row and the associated p-value is reported in the second row. A value for the test statistic of 1.306 is obtained

with an associated p-value of 0.096; hence, the null hypothesis, $H_0: y^*_{SE,h} = \theta y_{SE,h}$, is rejected in favour of the alternative, $H_a: y^*_{SE,h} = f(y_{SE,h})$, at the 10% significance level. For the 1992/1996 pooled dataset, the results of which are reported in the column on the left of Table 3, a value for the test statistic of 2.863 is obtained, noted in the first row, with an associated p-value of essentially zero, shown in the second row. Therefore, the null hypothesis is rejected at all of the usual significance levels.

While not shown in this paper, the second stage results, that were obtained when the change in assets term is excluded from the analysis, differ from the results obtained when the change in asset term is included in the analysis. The appearance of the reporting function for households with self-employment income of less than $40,000 is similar in both cases, with those results obtained when the asset term was ignored, being only slightly higher than those shown in Figure 3. The dramatic difference occurs at self-employment incomes greater than $40,000. The reporting function that is obtained for these higher income levels, when the asset term is ignored, flattens out immediately while the reporting function that is obtained, when the asset term is included, continues its upward tend, as shown in Figure 3. These results imply that using annual income, as opposed to permanent income, in the analysis will result in an overstatement of income under-reporting for households with lower amounts of reported self-employment income and a sharp understatement of income under-reporting by households with higher amount of reported self-employment income.

Table 4 reports household population estimates of income under-reporting by the Canadian self-employed for 1982/1986, presented in the column on the left, and 1992/1996 in the column on the right. The total amount of income under-reporting is found by subtracting reported self-employment income from estimated household true self-employment income and summing up over households. The first row of table 4 shows the population estimates for total income under-reporting, obtained by using the FAMEX survey weights. Total income under-reporting almost doubled between the 1980's and the 1990's, amounting to just over $0.619 billion in the 1982/1986 pooled sample and increasing to approximately $1.198 billion in the 1992/1986 pooled sample. The associated 90% bootstrapped confidence intervals are noted in the parenthesis. There are two things to note with respect to the reported confidence intervals. First, for both samples, the confidence intervals indicate that total income under-reporting was statistically significantly greater than zero. Second, the overlapping of the confidence intervals suggests that total income under-reporting in 1992/1996 was not statistically significantly different from total income under-reporting in 1982/1986. Further statistical tests confirm that the difference is not statistically significant.

As the number of self-employed households increased between the two pooled samples, as shown in the second row of table 4, it could be that the increase in total income under-reporting was simply due to the increase in self-employed households over the sample period, rather than due to the implementation of the GST. In order to determine if there was a change in the amount of income under-reporting per household,

the average per household income under-reporting is calculated.[16] Despite the fact that the number of self-employed households increased between these two pooled samples, there was an increase in the average amount of self-employment income that went unreported. Income under-reporting per married household, presented in the third row, amounted to $2,462.70 in the 1982/1986 pooled sample and $3,015.71 in the 1992/1996 pooled sample. The 90% bootstrapped confidence intervals for these per household amounts are presented in the final row of the table. Again, for both samples, the confidence intervals indicate that average income under-reporting is statistically significant, but the results are not statistically different from each other. That is, the results do not support the notion that the GST increased income under-reporting by married households with self-employment income. The results also do not support the claim that the GST would decrease tax evasion.

Limitations

The results presented above call into question many of the assumptions made in the parametric approach of the *Expenditure-Based Method*. That said, some caution needs to be exercised in interpreting these specific results, as the reliability of the estimate depends on the quality of the data. In particular, by using survey data, only those households that elected to take part in the survey can be studied. Households that are heavily involved in underground activity, particularly those households that are

[16] Average income under-reporting per married household with positive reported self-employment income is calculated by dividing total income under-reporting, reported in the first line of table 4, by the population size, also reported in table 4.

involved in illegal activity (for example, drug trafficking, human smuggling, and prostitution), are unlikely to participate in the survey or may elect to modify their reported amount of expenditures to ensure they are not perceived to be living beyond their means.

Caution must also be exercised in interpreting and comparing the results presented here to those obtained by alternate methods. The results presented here, income under-reporting by married households with self-employment income, should not be interpreted as representing a measure of the total underground economy. Households with self-employment income but with different demographic characteristics (e.g. households with children, single person households etc.) may engage in income under-reporting at different rates than married households. Additionally, income under-reporting by the self-employed, represents only a portion of underground activity. Finally, the method presented in this paper, estimates income that is not reported to tax authorities, which is quite distinct from measuring production or income that is missed by the statistical offices when they calculate the value of the national product. Many methods employed in estimating underground activity use the latter calculation. Giles and Tedds (2002), updated by Tedds (2005), provide a summary of the available Canadian estimates of underground activity, arranged according to methodology and calculation employed, should additional, independent comparisons be desired.

Conclusion

This paper proposes a nonparametric approach for estimating income under-reporting by households with self-employment income. The use of nonparametric methods is shown to have several advantages over previous parametric approaches. First, it enables the reporting function to vary across income levels and household characteristics. Second, it provided the ability to test, and find evidence against, the previously held hypothesis that the reporting function takes the linear form. Third, the framework allowed for an alternative approach to addressing the issue of permanent income. A further advantage of this method is the ease in which population estimates can be generated. In particular, the total amount of unreported income in the population could be obtained directly, whereas previous studies could only extrapolate this information by using national accounts data. Overall, the approach outlined in this paper calls into question many of the assumptions made in the parametric applications of the *Expenditure-Based Method.*

The approach outlined in this paper is illustrated by estimating the effect of the Canadian Goods and Services Tax on income under-reporting by married households with self-employment income. The results indicate that income under-reporting by married households with self-employment income neither increased nor decreased following the implementation of the GST. The results indicate that income under-reporting increased, in real (1996) dollar terms, from $2,462.70 per household in the 1980's to $3,015.71 per household in the 1990's, following the implementation of the GST, but that this difference is not statistically significant. Caution needs to be exercised in interpreting these specific results, as the reliability of the estimate depends on the

quality of the data and on the various assumptions made. Evidence is provided that supports the notion that the obtained estimates of income under-reporting reported in this paper are lower bound estimates.

The analysis presented in this paper indicates that further work is required in refining this method to improve consistency with available data and knowledge concerning participation in the underground economy. In particular, redefining the base group is warranted, as is exploring a relaxation of the assumption that requires the marginal propensity to consume out of unreported income to equal the marginal propensity to consume out of reported income. It may also be worthwhile to consider alternative forms of the reporting function. Finally, with respect to the Canadian estimates presented in this paper, this analysis can be conducted using a different dataset. The data for the FAMEX is collected in March/April of a given year, but covers expenditures for the previous year, and FAMEX data collectors make attempts to ensure that total expenditures are roughly equal to total income. (This and other issues related to the FAMEX data is briefly discussed in Appendix A.) The Family Food Expenditure Survey (FOODEX), on the other hand, uses the diary system to collect its data and no attempt is made to reconcile household expenditures with household income. This could result in more accurate data and, as such, it would may be interesting to compare the results obtained from the FAMEX data with those obtained using the FOODEX data. Unfortunately, the FOODEX data does not contain information on a household's savings behaviour.

TABLES

Table 1: Data Summary[1]

	1982 & 1986 Pooled FAMEX				1992 & 1996 Pooled FAMEX			
	Households with zero self-employment income							
	Sample Size=1604				Sample Size=1471			
	Mean	Std dev	Min	Max	Mean	Std dev	Min	Max
Gross Income ($)	60,343	25,541	14,877	159,661	64,741	28,103	16,131	183,370
Self-Employ. Income ($)	0	0	0	0	0	0	0	0
All Other Income ($)	60,343	25,541	14,877	159,661	64,741	28,103	16,131	183,370
Food Expend. ($)	6,660	2,552	926	18,672	6,103	2,551	495	19,678
Net change in assets & liabilities ($)	6,046	12,275	-32,892	83,869	6,086	13,732	-56,120	88,171
	Households with positive self-employment income							
	Sample Size=303				Sample Size=369			
	Mean	Std dev	Min	Max	Mean	Std dev	Min	Max
Gross Income ($)	55,808	27,372	15,041	137,853	60,545	29,283	15,244	184,000
Self-Employ. Income ($)	19,612	20,080	56	94,436	22,019	24,453	1	126,356
All Other Income ($)	36,196	28,216	0	132,936	38,527	27,139	0	132,674
Food Expend. ($)	6,365	2,727	1,400	17,536	6,061	2,681	1,489	18,359
Net change in assets & liabilities ($)	5,785	16,020	-46,205	76,870	5,582	13,907	-42,619	61,211

Notes: [1]Amounts are in real (1996) Canadian dollars and are rounded to the nearest dollar.

Table 2: Testing the Significance of ΔA_h

	1982 & 1986 Pooled FAMEX	1992 & 1996 Pooled FAMEX
$\hat{\beta}_{diff}$	1.053	1.047
$(s.e.)$	$(0.0408)^1$	$(0.0440)^1$
Test: $H_0 : \beta_{diff} = 0$ **vs.** $H_a : \beta_{diff} \neq 0$	p-value=0.000	p-value=0.000
Test: $H_0 : \beta_{diff} = 1$ **vs.** $H_a : \beta_{diff} \neq 1$	p-value=0.098	p-value=0.143

Notes: [1]Standard errors corrected for autocorrelation as discussed in the text.

Table 3: Testing Linearity of the Reporting Function

Test: $H_0 : y^*_{SE,h} = \theta y_{SE,h}$ **vs.** $H_a : y^*_{SE,h} = f(y_{SE,h})$

	1982 & 1986 Pooled FAMEX	1992 & 1996 Pooled FAMEX
V	1.306	2.863
p-value	0.096	0.002

Table 4: Estimates of Income Under-Reporting[1]

	1982 & 1986 Pooled FAMEX	1992 & 1996 Pooled FAMEX
Total amount of Income Under-Reporting[2] (90% Bootstrapped Confidence Interval)	\$0.619 billion (\$0.116B; \$1.086B)	\$1,198 billion (\$0.612B; \$2.358B)
Population Size[2]	251,386	397,189
Income Under-Reporting Per Married Household[2] (90% Bootstrapped Confidence Interval)	\$2,463 (\$428; \$4,278)	\$3,016 (\$1,542; \$5,936)

Notes [1]Amounts are in real (1996) Canadian dollars and are rounded to the nearest dollar.
[2]Calculated for married households that report positive self-employment income using the survey weights provided in the FAMEX by Statistics Canada to obtain population amounts.

FIGURES

Figure 1: Income Under-reporting in the Single Equation Expenditure-Based Method

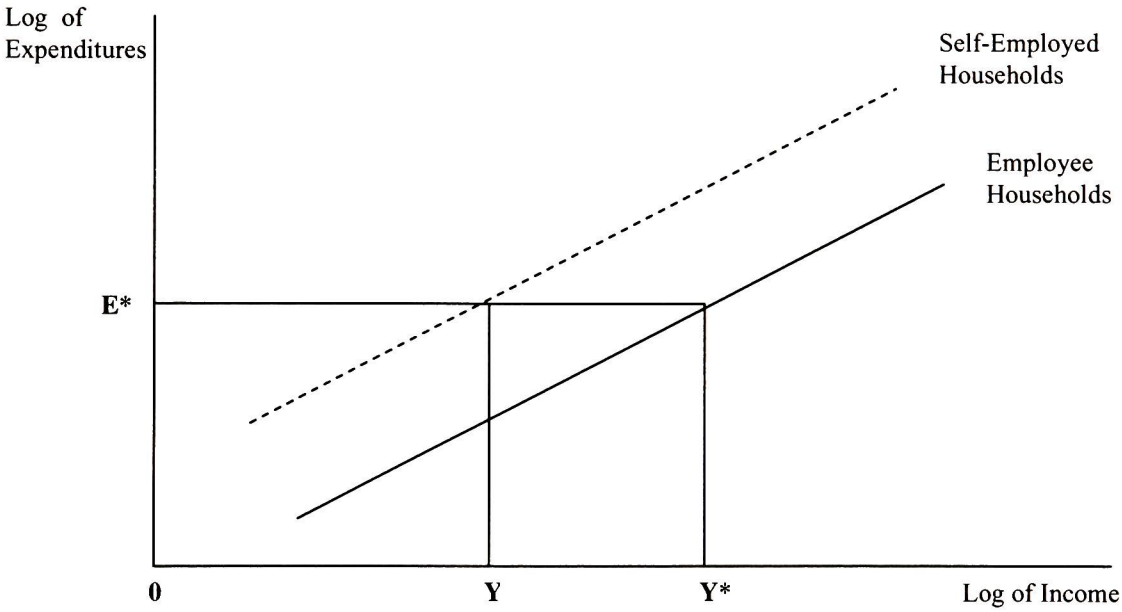
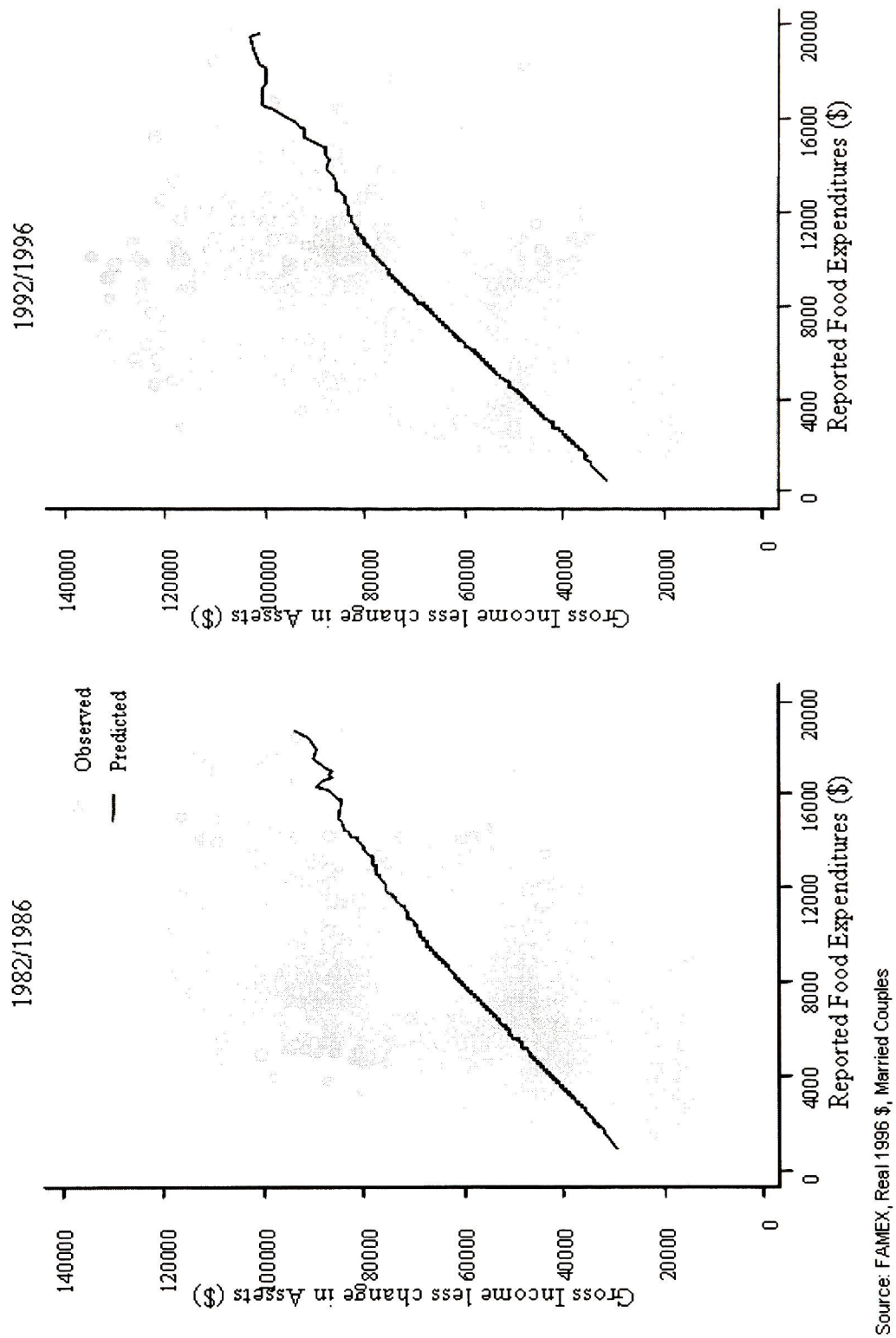
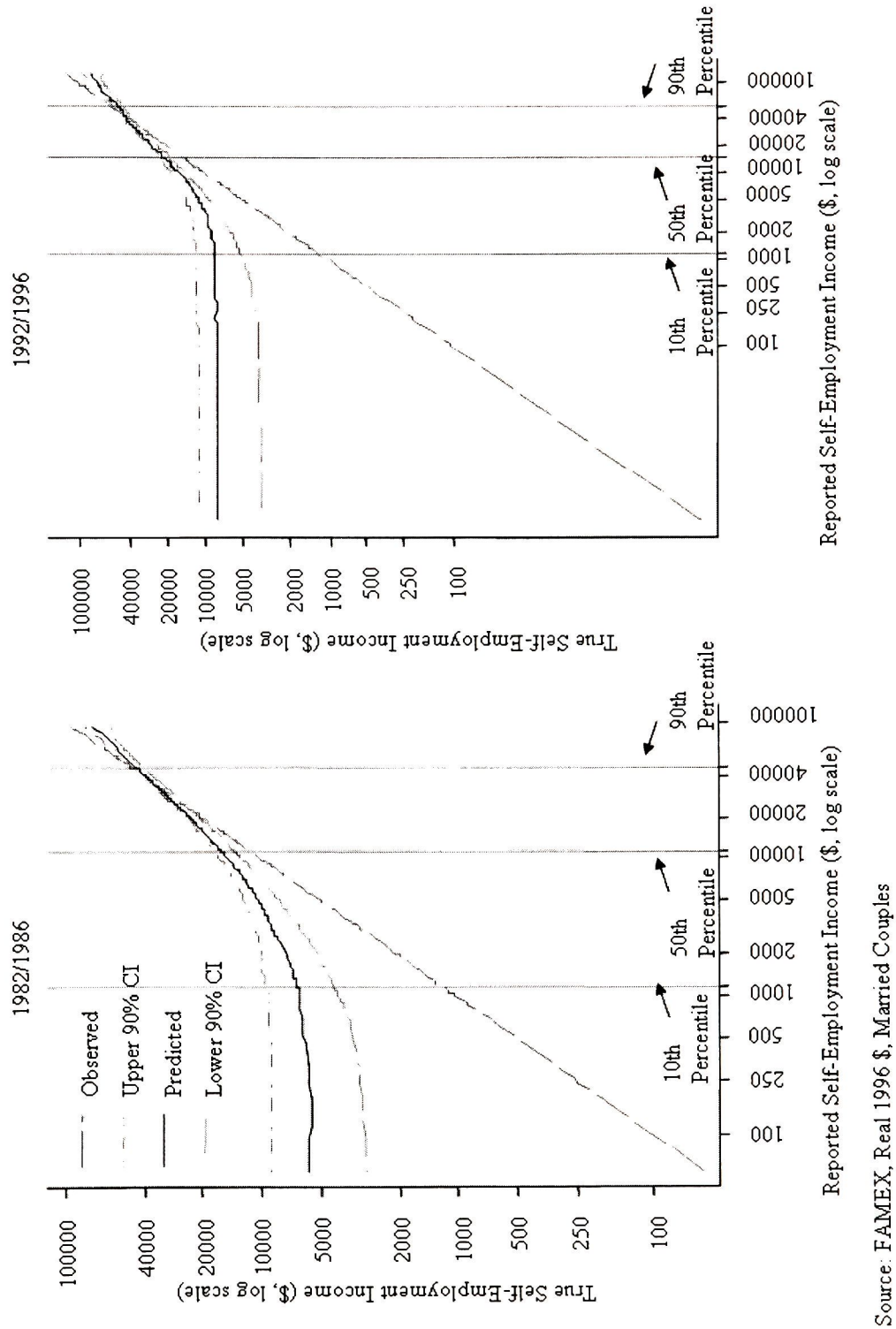


Figure 2: Inverse Food Engel Curves



Source: FAMEX, Real 1996 $, Married Couples

Figure 3: Estimated True Self-Employment Income (log scale)



Source: FAMEX, Real 1996 $, Married Couples

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APPENDICES

A. DATA

Unlike household income and expenditure surveys conducted in other countries, the FAMEX is a recall survey. That is, the data for the FAMEX is collected in March/April of a given year, but covers expenditures for the previous year. It is possible that the expenditure data used in the analysis may suffer from recall bias. In addition, data collectors make attempts to ensure that total expenditures are roughly equal to total income. In particular, income must balance expenditures to within 10% and records where expenditures exceed all sources of income by 20% or more are rejected. As a result, it is reasonable to assume that the estimates obtained for the underground economy using this method will be a lower bound estimate. The response rate for the FAMEX averages around 70%.

B. UNIT OF ANALYSIS

Ideally, the unit of analysis would be individuals, as it would avoid assuming households act as single decision makers and because in Canada, taxes are assessed on the individual rather than the household. In the FAMEX, however, expenditures are only surveyed at the household level and there are insufficient observations to conduct the analysis on single adult households. Additionally, as the FAMEX does not contain information regarding after-tax income by income source[33], the application was conducted using gross income. After-tax income is more desirable in this analysis as households are more likely to base their expenditures on after-tax income. Further, as previously mentioned, income tax in Canada is assessed on the individual rather than on the household. As a result, households with similar gross incomes, may not have comparable net income and hence may not have comparable expenditures, which would lead to a biased estimate of true gross income in the first step of the approach.

This analysis was also conducted on married households, living in both rural and urban areas. Limiting the analysis to households living only in urban areas, resulted in insufficient observations. It is extremely likely that households in urban and rural environments, have different levels of food expenditures at similar income levels for reasons that are unassociated with income under-reporting. For example, households in rural environments may be more likely to: grow food for consumption in a household

[33] That is, the FAMEX contains information by household on total gross income and total net income but household self-employment income and other income is only available in gross terms. As household self-employment income and other income is used to calculate true household self-employment income (shown in equation (3b) in the main text of this paper, the application described in this paper could only be conducted using gross income terms.

garden; face reduced food prices due to the presence of local producers and suppliers; and engage in the trade of goods and services for food products. To the extent that this is true, food expenditures for rural households with no self-employment income will act as a poor counterfactual for urban households with positive self-employment income and vice versa.

CHAPTER 4

KEEPING IT OFF THE BOOKS: AN EMPIRICAL INVESTIGATION INTO THE CHARACTERISTICS OF FIRMS THAT ENGAGE IN TAX NON-COMPLIANCE

Introduction

It is generally accepted that taxes and tax evasion are intrinsically linked; that one cannot exist without the other. As a result of a great deal of theoretical, experimental, and empirical research conducted over the last twenty years, there exists an extensive knowledge base regarding tax evasion by individuals. However, research regarding tax evasion[1] by businesses is, by comparison, surprisingly modest. This is startling, given the importance of businesses and their decisions not only in economic models but also in tax system and the economy as a whole.

There is some evidence to suggest that there is cause for concern, and that a substantial share of business income goes unreported to the relevant tax authorities. The United States Internal Revenue Service (IRS) routinely estimates the total amount of under-reported income and overstated deductions, and calculates the total loss of tax revenue, or the "tax gap". The latest data from the IRS (2004) regarding the "tax gap" related to business activities are for the 2001 tax year. These estimates indicate that: (1) the corporate tax gap amounted to $29.9 billion, of which corporations with over $10

[1] The focus of this paper is on illegal tax evasion and not legal tax avoidance. Tax evasion or tax non-compliance refers to income tax that is legally owed but is not reported or paid whereas tax avoidance refers to legal actions taken to reduce tax liability. Tax avoidance includes such activities as "...purchasing tax-exempt bonds, which is certainly legal, not at all nefarious, but also certainly done for tax reasons." (Slemrod 2004, 4)

million in assets contributed $25.0 billion; (2) the tax gap associated with business income earned by individuals amounted to $81.2 billion; (3) the self-employed evaded $61.2 billion in employment tax; and (4) corporations underpaid the amount of taxes due based on reported income by $2.3 billion. In total, businesses evaded $174.6 billion in taxes, which amounted to almost 10% of total taxes paid voluntarily. This is not an insignificant amount and yet should be considered a lower bound estimate because: it is based on twenty year old compliance rates; it does not include businesses that do not file tax returns (also known as non-filers, the hard-to-tax, ghosts or informal businesses); and/or it does not consider firms that are engaged in illegal activities. While these data are for the United States, it is not unreasonable to assume that firms evade taxes in every country around the world.

Given that there is some evidence which supports the notion that businesses engage in tax non-compliance, several questions arise and require investigation. First, do businesses around the world engage in tax evasion or is it confined to a few countries or regions? Second, does the legal status of the business (e.g. sole proprietorship, partnership, corporation, etc.) affect the incidence and/or intensity of tax evasion? If so, then it may be possible to effect changes in the legal system in order to increase tax compliance. Third, do businesses that engage in tax non-compliance share common and observable characteristics, or is there too wide a variety of shapes and sizes to permit a useful generalization about them? If it were possible to define a typical evader, the tax authority could target their auditing activities more accurately. Finally, while there is considerable agreement internationally about the factors that trigger tax non-compliance

(e.g. the tax burden, the degree of regulation, the level of enforcement, confidence in government, labour force characteristics, and morality), how do these features influence the intensity of non-compliance? With this information, policy makers could effect changes to increase the amount of tax revenues collected from businesses.

One of the main constraints to investigating and attempting to provide answers to these and related questions is the lack of data. Previously, the only data sources available were from tax audits. However, these sources were only available for a very small number of select countries, the data was costly to collect, and access to the data was limited. More recently, however, an alternative data source, that is conducive to investigating issues related to business tax non-compliance, has become available. The World Business Environment Survey (WBES) was launched in 1999 by the World Bank's Investment Climate and Institute Units. The survey was administered to more than 10,000 firms in eighty countries in late 1999 and early 2000, and provides responses to multiple questions on the investment climate and business environment. In particular, firms were asked several questions that permit an investigation into the linkages between firm characteristics, economic policy, governance, competitive environment, and other factors, as well as the extent and intensity to which firms are hiding output from the tax authority.

Batra *et al.* (2003) also use the WBES to investigate the determinants of under-reporting by firms. They estimate OLS regressions, including country fixed effects, and find that: (1) "...small or medium-size firms that produce for the domestic market (non-exporters), lack foreign investment, and are located in large cities (but not necessarily in

the capital) tend to engage more in unofficial activity" (Batra *et al.* 2003, 76); (2) the prevalence, though not the unpredictability, of corruption also significantly affects non-compliance; and (3) "...a firm's age, sector or mode of ownership do not influence [a firm's] under-reporting of revenue." (Batra *et al.* 2003, 78). Unfortunately, the authors do not link their choice of explanatory variables to the existing theoretical or empirical literature regarding firm tax non-compliance. As a result, some potential controls are overlooked and some controls may be mis-specified and/or its inclusion unclear to the reader. For example, the authors include a control for privately owned firms, but do not indicate how this is defined (e.g. does it include private corporations) and also results in the base category including a diverse range of firm organization categories. Both of these issues may result in firms being grouped together that the previous literature indicate may have differing compliance behaviour (e.g. public corporations). This paper surveys the existing theoretical and empirical literature of firm tax non-compliance and uses the information from these studies to build the empirical model explored in this paper.

In addition, Batra *et al.* (2003) do not exploit the nature of the dependent variable. The firm's response regarding under-reporting behaviour is grouped into categories. When a quantitative outcome is grouped into known intervals on a continuous scale, the data are said to be "interval-coded".[2] However, Batra *et al.* (2003) define the dependent variable as a binary outcome for each category and estimate the resulting equations by Ordinary Least Squares (OLS). In addition, the equations are not all identically specified.

[2] When the intervals are unknown and have to estimated along with the other parameters, an ordered logit/probit is the preferred estimation framework.

The considerable statistical limitations of such a linear probability model are well known, and it is not clear if the results can be compared across regressions, given the different specifications. There is an estimation technique that has been developed specifically for interval-coded data. This estimation procedure is known as "interval regression" and is undertaken using maximum likelihood techniques. The interval regression technique is utilized in this paper and the extent to which various covariates affect the estimation results is also explored.

Overall, the findings reveal that firms which are sole proprietorships, partnerships or privately owned corporations report a smaller percentage of their sales to the tax authority, though these effects become insignificant when country controls are included in the specification. The previous literature has suggested that: (1) public corporations should be more compliant, but no such effect is found in this paper; and (2) firms in the service and construction sector should be less compliant, but it is found that firms in the service sector are more compliant and that there is no significant effect for the construction sector. There is no consensus in the previous literature about the relationship between firm size and under-reporting, but it is found, unambiguously, that small firms are less compliant than are large firms. Foreign owned firms, exporters, and firms that have audited financial statements are also more compliant, as was also found by other researchers, but, quite surprisingly, government ownership has an insignificant effect. Not surprisingly, organized crime, high taxes, and government corruption all result in lower compliance. Finally, the results indicate that firms around the world engage in tax non-compliance but, holding all else constant, compliance is highest in

OECD countries (notably Canada, France and Italy) and the lowest in Latin American (particularly, Haiti, Panama and Peru) and African & Middle Eastern (principally, Tunisia, Egypt, West Bank-Gaza, and Ghana) countries.

The paper begins with a brief review of the relevant tax non-compliance literature. The WBES is then described and the rationale for the empirical techniques is outlined. The results are then summarized and the paper ends with some concluding comments.

Literature Review

In this section, attention is focused on two critical aspects of the literature regarding tax evasion. First, a review of the development of the theoretical literature and the associated predictions is provided, commencing with the classical model of an individual's decision to evade taxes and how the model has been modified for firm behaviour. Second, there have been a few empirical papers that explore firm tax non-compliance, and this literature is summarized along with the key findings. This literature will help shape the empirical model utilized in this paper.

Theoretical Studies

As noted above, extensive literature exists on tax evasion by individuals and the seminal contribution was provided by Allingham and Sandmo (1972).[3] Their model was

[3] The Allingham-Sandmo (1972) model has been extended in a number of dimensions over the last thirty years (e.g. Watson 1985, Trandel and Snow 1999, Mookherjee and P'ng 1989, Border and Sobel 1987,

sparse but surprisingly robust in modeling an individual's decision to evade taxes and, if so, how much to evade. The model leads to four propositions about the incidence of tax evasion: (1) the rate of return to evasion is positively related to the incidence of tax evasion; (2) individuals with higher risk aversion tend to evade less; (3) individuals with higher personal income tend to evade more; and (4) and compliance is positively related to the probability of being audited and the size of the penalty if caught.[4] The first and third propositions leads one to conclude that, in the context of business tax non-compliance, the self-employed, sole-proprietors and other small businesses would be less likely to evade taxes than large businesses. The fourth proposition leads to the opposite conclusion, given that large businesses and corporations are normally subjected to audits at a higher rate than are smaller businesses.[5] However, the true effect of these propositions is muddied when the choice is not only the level of evasion but also the level of output, as with most businesses, and when there is no direct link between the owner's income, risk preference, audit probability, and evasion decisions. This is particularly true for businesses where evasion decisions are made by managers and not the owner(s).

Given the above discussion, the reasons driving many businesses to evade taxes, is likely different from that of individuals and, hence, should be modeled differently. There is a much smaller pool of literature that addresses tax non-compliance by

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Scotchmer 1987, Cremer, Marchand and Pestieau 1990, and Sanchez and Sobel (1993)) and this literature is nicely surveyed by Andreoni, Erard, and Feinstein (1998) and Slemrod and Yitzhaki (2002).

[4] The relationship between tax rates and tax evasion, however, is uncertain. A higher tax rate implies less income which, according to the model, implies less evasion. On the other hand, an increase in the tax rate implies that the "return" from evasion increases as well, assuming a constant penalty, which implies more evasion. As a result, the two forces are of opposite tendency which makes the net result uncertain.

[5] For example, in the United States corporations with more than $10 million in assets face an audit rate of nearly 100 percent.

businesses.[6] The majority of this work utilizes the basic framework of the Allingham-Sandmo (1972) model, but the key variation in these models is that they explore how the tax rate, probability of detection, and penalty rate affect the two choices of evasion and output.[7] In these models, it is found that: (1) reported sales decrease as the tax rate increases; (2) a rise in taxes increases the market price of the good, but by less than the amount of the tax, since some of the tax increase is absorbed through increased evasion; and (3) an increased probability of detection or penalty, increases the proportion of sales declared and the market price of the good. As opposed to the propositions of the Allingham-Sandmo (1972) model, there is an unambiguous positive relationship between the tax rate and tax evasion. Further, it should be noted that these results hold, regardless of whether the market, in which the firm is operating, is competitive or monopolistic.

The preceding literature, however, continues to assume that an individual is at the centre of the tax decision. That is, the above noted firm models assume that the firm *owner* makes the tax reporting decision. This assumption, however, likely only applies to small, closely-held businesses and the outcomes predicted by the Allingham-Sandmo (1972) model may not apply to other types of businesses, notably those businesses where financial decisions, including those related to taxes, are not made by the owner/shareholder but, rather, by their agents. With this in mind, Chen and Chu (2002) extend the standard model to include a firm that hires a risk-averse manager who is offered some form of compensation (e.g. stock options, bonuses, etc.) as an incentive to

[6] Cowell (2003) provides an excellent review of this literature.
[7] There is no agreement in this literature if the firm in these models should be modeled as risk-averse or risk neutral.

engage in tax evasion on behalf of the firm. As opposed to the finding of the Allingham-Sandmo (1972) model, that an individual will only evades taxes if the rate of return from evasion is greater than the rate of return from compliance, Chen and Chu's model implies that a firm will evade tax only when the expected profit from evasion is *significantly* greater than that from reporting honestly. This is because tax evasion by a business actually involves the interaction of many persons and is much more complicated than individual income tax evasion.

Crocker and Slemrod (2003) focus particularly on large, publicly held corporations and propose a model of corporate tax evasion in the context of the contractual relationship between the shareholders of a firm and the chief financial officer (CFO), who determines the firm's deductions from taxable corporate income. The incentives of the CFO to engage in tax evasion are affected by the nature of the compensation arrangement. The model implies that corporate tax evasion is reduced when penalties are imposed on the CFO directly, as opposed to the shareholder; and that tax evasion increases if the CFO's compensation contract optimally adjusts to offset the penalties imposed when evasion is detected.

Previous Empirical Studies of Business Tax Non-Compliance

Unfortunately, the empirical analysis of business tax evasion is not extensive, mainly due to a lack of data. There have, however, been a small number of empirical studies that will be summarized here.

One of the first empirical examinations into business tax non-compliance focused on the self-employed. The self-employed are commonly believed to have lower compliance rates than wage and salary earners. Smith *et al.* (1986) obtain estimates that indicate that in 1982 the self-employed in Great Britain understated their income in the range of 30 to 36%. Pissarides and Weber (1989), using the same data, improve on Smith's approach and find that the self-employed under-reported their income by 90%. This modified approach was subsequently applied by: (1) Apel (1994) who estimates that the self-employed in Sweden under-reported their income by 25% in 1988, though this figure rises to 35% for the self-employed who own firms that are unincorporated (which supports the proposition that the legal organization of the business does affect the tax evasion decision); (2) Mirus and Smith (1997) concentrate their analysis on Canada and obtain an estimate of 12.5% for the year 1990; and (3) Schuetze (2002), who also applies the approach to Canada, finds that the self-employed under-reported their income by between 11 and 23% over the period from 1969 to 1992 and that the construction and service occupations are more likely to be involved in tax non-compliance. Lyssiotou et al. (2004) propose further modifications and conclude that the self-employed in Great Britain in 1993 under-reported their income by 118% if they were in blue collar occupations and 64% if they were in white collar occupations. Finally, Tedds (2005) introduces a nonparametric framework to the approach and found that the gap between true and reported self-employment income is larger for households at the lower end of the self-employment income distribution, a result which runs contrary to the theoretical prediction of the Allingham-Sandmo (1972) model.

A self-employed person, however, can register their business in a variety of forms, including a corporation, which, based on the theoretical literature, likely affects their tax compliance behaviour. Unfortunately, only Apel (1994) explored the relationship between tax non-compliance and the legal form of the business, largely due to the lack of information on the latter in the data employed by these studies.

Smith and Adams (1987) examine the extent of tax non-compliance by informal suppliers in six "at risk" sectors[8] using results from a survey commissioned by the U.S. Internal Revenue Service (IRS) on the expenditures made by consumers on goods and services provided by these suppliers. For the 1992 tax year, the authors find that unreported income by these informal suppliers amounted to approximately US$59.6 billion and that informal suppliers tend to report only about 20% of their net business income.

Using firm level data from a 1997 survey of private manufacturing firms in Poland, Romania, Russia, Slovakia, and the Ukraine, Johnson *et al.* (2000) investigate the relationship between government corruption, criminal activities, and firm tax compliance. The dependent variable (percentage of sales that are unreported to the tax authority) is similar to that used in this paper from the WBES (discussed below), except that it is a continuous variable (rather than grouped data as in the WBES). The authors found a positive and significant relationship between under-reporting of sales and bribing of corrupt officials, but no relationship between under-reporting of sales and protection

[8] They were: home repairs and additions, domestic services, auto repair, music lessons, appliance repairs, cosmetic services, and catering.

payments to the mafia, tax payments, or efficiency of the legal system. Finally, firm tax non-compliance is greater in Russia and the Ukraine than in the other countries.

Several studies have investigated business tax non-compliance using data from tax audits. Probably the most comprehensive tax audit dataset in the world is that available through the U.S. IRS Tax Compliance Measurement Program (TCMP).[9] Rice (1992) used TCMP data from 1980 to investigate tax compliance by small corporations (defined as corporations with assets between $1 and $10 million). His findings suggest four key results. First, compliance is higher among publicly traded corporations, which he attributes to the requirement that publicly traded corporations must disclose more information to the public about their operations.[10] Second, high profit companies are more likely to under-report their income, and corporations whose profits are below the industry mean tend to resort to non-compliance, perhaps as a means of limiting costs. Third, the marginal tax rate is negatively associated with compliance. Finally, firm size and tax non-compliance are positively related, and corporations engaging in tax non-compliance appear to be geographically bundled. Joulfaian (2000), using TCMP data from 1987, found that non-compliant corporations are three time more likely to be managed by executives who have evaded personal taxes. TCMP data has also been used

[9] The TCMP features data from a random sample of individual and small corporate income tax returns filed in a given year that were subject to intensive audits by experienced examiners. For certain groups, such as non-filers and proprietors who tend to not report a significant amount of their income, the results from special research studies are used to supplement TCMP data. Finally, data for large corporations are obtained from routine operational audits.

[10] Tannenbaum (1993), however, disagrees with this statement and instead argues that higher compliance could be the result of managers in these corporations having greater independence from the owners.

to explore tax evasion by the self-employed and these studies include Christian (1994), Erard (1992), and Joulfaian and Rider (1998).

Giles (2000) discusses some of the factors that determine the probability of non-compliance among a very large population of New Zealand businesses that were audited by the Inland Revenue Department in that country between 1993 and 1995. Contrary to Rice, Giles finds that an increase in the scale of the business, regardless of how this is measured, unambiguously raises the probability of *compliance*, once other characteristics are controlled for. That is, businesses that are relatively small, in terms of sales revenue or before-tax profit, are more likely to evade taxes than are large corporations, all other things being equal. Businesses in the "construction", "wholesale trade", "retail trade", "accommodation", and "cafes and restaurants" sectors exhibited below-average compliance rates over the study period. He also considered several other characteristics that were found to be important in reducing the tax compliance rate among New Zealand businesses. Relatively "inefficient" businesses tended to be less compliant than more efficient ones, where efficiency was defined as either "return on net assets", or "activity ratio" (sales as a percentage of net assets). In addition, businesses which were registered off-shore were generally *more* compliant than their on-shore counterparts, again once the analysis controlled for other attributes. Finally, it was found that in general, an aggressive use of legitimate tax-minimization instruments (such as the deduction of interest and depreciation costs, and the writing-off of bad debts) tended to be associated with compliant behaviour.

Many countries use tax holidays to attract foreign investment by providing a limited period of tax exemptions and reductions for qualified investors. Chan and Mo (2000) examine the effect of tax holidays on foreign investors' tax non-compliance behaviour in China. They analyzed 583 tax audit cases, made available by the Chinese tax authorities, on corporate tax non-compliance by foreign investors. Their results indicate that the corporate taxpayers tax holiday position significantly affects non-compliance, notably: (1) companies in the pre-holiday position are least compliant; (2) companies are most compliant in the tax exemption period that has a zero tax rate and a heavy penalty for evasion; (3) domestic market-oriented companies have a higher rate of non-compliance than their export-oriented counterparts; and (4) wholly foreign-owned and manufacturing-oriented companies have higher compliance than joint ventures and service-oriented companies.

This literature makes it clear that a businesses legal organization (private versus public, and owner versus employee managed) likely affects the decision to evade taxes but other factors, such as firm size, have ambiguous effects or, at the very least, vary across countries. Therefore, it seems worthwhile to conduct a worldwide study of firms tax compliance behaviour.

Data

In 1998, the World Bank Group launched its World Business Environment Survey (WBES). The WBES used many of the same questions from the enterprise

survey conducted for the *1997 World Development Report*[11] (World Bank 1997) but expanded the number of businesses and countries surveyed and the questions/issues covered. During late 1999 and early 2000, face to face interviews[12] were conducted with either the firm managers or owners of 10,080 firms in eighty countries (plus the West Bank and Gaza).

The purpose of the survey was to assess and compare the business environment in a large number of countries. To achieve this goal, the survey gathered information regarding the firm's characteristics, such as size and ownership structure, as well as responses to multiple questions on the investment climate and the local business environment as shaped by domestic economic policy, governance, regulatory, infrastructural, and financial impediments, as well as assessments of public service quality. A more detailed description of the survey can be found in Batra *et al.* (2003). After eliminating observations with non-response related to key variables (described below), a maximum sample size of 6,025 firms remains.

Dependent Variable

As was indicated above, the intent of this paper is to explore the relationships between firm characteristics and tax compliance using firm-level data collected from around the world. How can the WBES be used to investigate firm tax compliance? The WBES asks each firm the question

[11] Unfortunately, this dataset neither contains detailed information on characteristics of the firms nor the key variable of interest contained in the WBES dataset. As a result, it cannot be appended to the WBES dataset.

[12] With the exception of Africa where interviews were predominantly conducted by mail.

> *What percentage of total sales would you estimate the typical firm in your area of activity reports for tax purposes? Possible answers: (1) less than 50%; (2) 50-59%; (3) 60-69%; (4) 70-79%; (5) 80-89% (6) 90-99%; and (7) all (100%).*[13]

The distribution of answers is given in Table 1. This table shows that 60% of firms worldwide indicate that the typical firm fails to report their sales in full to the tax authority and, of those firms, over 19% of them fail to report more than half their sales. This shows that business tax compliance is a significant issue. Not surprisingly, there appears to be some difference in perceived tax non-compliance across regions, as is shown in Figure 1. In particular, in OECD countries only approximately 40% of firms are perceived to under-report their sales to the tax authority and of those, approximately 50% fail to report only up to 10% of their sales. Further, compared to other regions, firms in Latin America and Asia perceive that significantly more firms fail to report less than 50% of their sales. In addition, there are significant differences in perceived firm tax compliance across countries. Given these differences, the effects of country and region specific dummy variables on the results will be investigated in the empirical analysis.

Explanatory Variables

As was outlined above, previous empirical work using audit data found relationships between tax non-compliance and various firm characteristics, which these

[13] In the WBES, the dependent variable is actually coded as follows: *What percentage of total sales would you estimate the typical firm in your area of activity reports for tax purposes? Possible answers: (1) all (100%); (2) 90-99%; (3) 80-89%; (4) 70-79%; (5) 60-69%; (6) 50-59%; and (7) less than 50%.* The order of the responses is revered solely for expositional clarity.

relationships will also be explored using this data. The firm characteristics that will be included as explanatory variables include dummies for: industry sector, and firm size, age, ownership, exporter, whether the firm's financial statements are audited, legal ownership, and number of competitors. In the secondary analysis, the effect of various perceived business obstacles on tax compliance will be investigated, including access to capital, taxes, and regulations, organized crime, government corruption, inflation, and exchange rates. As the sample size decreases due to non-response with the inclusion of these latter explanatory variables, they are only included in a secondary regression.

Table 2 categorizes the maximum 6,025 observations, sorted by region and displayed by country. Table 3 provides a summary of the key variables. All of the explanatory variables used in the analysis are dummy variables and these are discussed below.

Legal Status

Firms in the WBES are categorized as being either: sole proprietorships, partnerships, cooperatives, private corporations, public corporations, or other. The first two categories (sole proprietorship and partnership) are much more likely to operate with the owner making the tax evasion decisions, so these firms are grouped together for this analysis. The remaining categories are treated individually, particularly as it is unclear if a cooperative would behave more like a private or public corporation. The excluded category is "other". Based on the literature, it is expected that publicly traded corporations will be the most compliant. In most countries, publicly traded corporations

have a greater probability of being audited; and are subject to public disclosure requirements and independent financial auditing, which tends to expose any under-reporting behaviour to the authorities. As audit levels and detection probability are greater, compliance should be higher.

Sector

Firms are categorized into one of four possible industry sectors. They are: services, agriculture, construction, and manufacturing. The omitted category is manufacturing and it is expected that, as found previously, firms in the services and construction sector will be less compliant than others. One of main reasons for this is that businesses located in the construction and services sectors typically provide services through informal arrangement frequently involving cash transactions, which is conducive to under-reporting. Other sectors, such as manufacturing and agriculture, involve fewer cash transactions.

Size

Rice (1992) and Giles (2000) each investigated the relationship between a firm's size and tax non-compliance. Rice (1992) defined a firm's size according to the dollar amount of assets it held and found a positive relationship between firm size and tax non-compliance. Whereas, Giles (2000) used a firm's sales revenues and before tax-profits, and found a negative relationship between firm size and tax non-compliance. These measures of firm size are not available in the WBES. Instead, this paper investigates a

firm's size as defined in terms of the number of employees. A small firm is one with fewer than 50 employees, a medium-sized firm has between 50 and 500 employees and a large firm has over 500 employees: The omitted category is firms with between 50 and 500 employees. The relationship between firm's size and tax compliance remains unclear.

Competition

While not previously investigated, it is possible that there is a positive relationship between the number of competitors in a given market and tax non-compliance. For example, firms in highly competitive markets may resort to tax non-compliance in order to reduce costs and allow the firm to set a lower price for their goods and/or increase the firm's profits. The WBES asks firms how many competitors they face in their market. Possible answers are; none, between one and three; and more than three. The omitted category is firms with between one and three competitors.

Age

The WBES includes information on the firm's age - specifically, if the firm is less than five years old, between five and fifteen years old, and greater than fifteen years old. The effect of a firm's age on tax compliance is ambiguous. For example, younger firms may be less compliant because they may have more competitors, may be struggling to turn a profit, and/or may view tax evasion as a way to cut costs. On the other hand,

young firm may be more reliant on external financing, which could cause them to be more compliant.

Other Characteristics

Other firm characteristics include indicators of whether the firm is foreign or government owned, an exporter, and whether it subjects its financial statements to audits. Based on previous findings, all of these indicators are expected to be negatively related to non-compliance. Dummies controlling for region as well as country (listed in Table 2) are also investigated. The omitted categories are the OECD and the United States respectively.

Perceived Obstacles

In addition to recording information regarding the firm's characteristics, the WBES also asks a number of questions about the firm's perceptions of various constraints in the business environment, which likely influence operational decisions including tax compliance. While many of these variables have a low response rate, several have a relatively higher response rate. In particular, firms are asked if the following items present an obstacle or are a constraint to conducting business: access to capital[14], inflation, exchange rate, political instability, organized crime, taxes, and

[14] Andreoni (1992) argues that "...individuals facing binding borrowing constraints may use tax evasion to transfer resources from the future to the present. Even if a person finds tax evasion undesirable in the absence of borrowing constraints, it could become desirable if a borrowing constraint is binding. Tax evasion, therefore, may be a high-risk substitute for a loan." (Andreoni 1992, 35-36). The same argument can apply to firms and hence its inclusion in this analysis.

regulations. If these issues are perceived by the firm as affecting their ability to conduct business, then they may result in the firm engaging in tax non-compliance in order to reduce costs and be more competitive.

In addition, firms are asked if: (1) it is common to pay some "irregular" additional payments to government officials; and if (2) laws and regulations that affect the firm are interpreted inconsistently by the government or courts. If corruption is common, then among other effects, it will increase the cost of business, reduce morality, and reduce a firm's confidence in government; all of which are likely to have a negative relationship with tax compliance. The relationship between tax compliance and inconsistency in the application of laws and regulations is more ambiguous. If a firm can individually garner the favour of the government(s) and/or courts in the interpretation and application of laws and regulations, then this may reduce tax non-compliance. On the other hand, if the firm does not benefit from this inconsistency, then it may resort to tax non-compliance. Taking account of these explanatory variables reduces the number of available observations to 4,561.

Data Strengths and Weaknesses

Using the WBES dataset to investigate business tax non-compliance has advantages and disadvantages compared to employing tax audit data.[15] The main disadvantage of the WBES is that the questions of interest are asked about the perceived behaviour of other firms, rather than the behaviour of the firm being interviewed, and this

[15] Audit data also have several disadvantages, which are discussed by Rice (1992).

may result in response bias. However, there are two things to consider. First, respondents likely base their response, at least in part if not in whole, on their own behaviour, which would minimize the bias. Second, as the firms are being asked about the behaviour of other firms rather than their own, they will not feel stigmatized by the interviewer and/or fear possible repercussions when responding to the questions. In addition, the WBES does not explicitly allow for the possibility of over-reporting. Rice (1992) found that about 6% of all corporations overstate their taxable income to some extent. Firms may over-report due to a misinterpretation of tax laws, to avoid a tax audit, to secure financing, or particularly for public corporations, to appear more competitive. In the WBES, firms that over-report will likely be included in the full compliance category. Finally, the WBES does not allow for the tax gap to be calculated. The tax gap is the difference between the taxes paid and the taxes that should have been paid. Such a calculation is useful in determining the amount of tax revenues lost to non-compliance. A disadvantage shared by both the WBES and audit data is that neither data source includes "ghosts" (Erard and Ho, 2001), firms that operate solely in cash and avoid normal business obstacles and regulations.

The main advantages of the present dataset include the fact that: (1) audit data are not widely available, unlike the WBES, which covers eighty countries; (2) audit data only include firms that are selected (for diverse reasons) or caught by the tax authorities, while the WBES is a random sample of firms; and (3) the WBES includes additional information that is not included in tax audits. In particular, factors that firms perceive as

business obstacles, such as taxes and regulations, which may effect a firm's decision to under-report, are included.

Empirical Framework

The survey question which forms the basis for our dependent variable and is described above refers to categories. As a result, a firm's perceived reporting behaviour is not directly observed. Rather, firms are categorized on the basis of the percentage of sales that they perceive to be unreported. When a quantitative outcome is grouped into known intervals on a continuous scale, the data is said to be "interval-coded". An ordered probit (or logit) is ideal when the dependent variable is discrete, ordinal in nature, and when the categories or thresholds are unknown.[16] In this case, the thresholds are estimated along with the model's coefficients and the variance of the error term is normalized to be one. It is possible, however, to modify the ordered probit model so that the thresholds are fixed at their known values and only the models' coefficients and the error variance are estimated. This estimation procedure is known as "interval regression" and is undertaken using maximum likelihood techniques. Its key advantage over the ordered probit is that it provides an asymptotically more efficient estimator as it uses the known threshold information and involves estimating fewer parameters. It is also preferred to OLS, as OLS on the grouped dependent variable model is inconsistent.

[16] That is, for an ordered logit model, while it can be said that two is greater than one, it cannot be determined if the difference between two and one is somehow twice as important as the difference between one and zero. The latter is not true of interval coded data.

The following is the general setup of the model and is based on the discussion contained in Stewart (1983) and Wooldridge (2002, 508-509). The responses for the dependent variable are coded 1, 2, 3, 4, 5, 6, and 7 to capture seven distinct sales under-reporting categories. Let y_i denote the observable ordinal variable coded in this way and let y_i^* denote the underlying variable that captures the sales under-reporting of the ith firm. This can be expressed as a linear function of a vector of explanatory variables x_i using the following relationship:

$$y_i^* = x_i'\beta + u_i, \quad u_i \sim N(0,\sigma^2). \tag{1}$$

It is assumed that y_i^* is related to the observable ordinal variable y_i as follows:

$$\begin{aligned}
y_i &= 1 \text{ if } 0 \le y_i^* < 50\%^{17} \\
y_i &= 2 \text{ if } 50\% \le y_i^* < 60\% \\
y_i &= 3 \text{ if } 60\% \le y_i^* < 70\% \\
y_i &= 4 \text{ if } 70\% \le y_i^* < 80\% \\
y_i &= 5 \text{ if } 80\% \le y_i^* < 90\% \\
y_i &= 6 \text{ if } 90\% \le y_i^* < 100\% \\
y_i &= 7 \text{ if } 100\% \le y_i^* < \infty.
\end{aligned} \tag{2}$$

[17] It could be argued that this interval should be between 1 and 50 because firms that report 0% of their sales would likely be operating completely as "ghosts" and would not have been selected for an interview since there would be no formal record of the firm. Treating the interval in this way, however, does not affect the results.

The last interval is treated as open-ended to account for possible sales over-reporting. If it is further assumed that $y_i^* \mid x_i'\beta \sim N(x_i'\beta, \sigma^2)$, then the seven possible components of the general log likelihood function for the i[th] individual is expressed as:

$$\begin{aligned} L_i = {} & I[y_i = 1] \times \log_e\{\Phi(\frac{50 - x_i'\beta}{\sigma}) - \Phi(\frac{0 - x_i'\beta}{\sigma})\} + I[y_i = 2] \times \log_e\{\Phi(\frac{60 - x_i'\beta}{\sigma}) - \\ & \Phi(\frac{50 - x_i'\beta}{\sigma})\} + I[y_i = 3] \times \log_e\{\Phi(\frac{70 - x_i'\beta}{\sigma}) - \Phi(\frac{60 - x_i'\beta}{\sigma})\} + I[y_i = 4] \times \\ & \log_e\{\Phi(\frac{80 - x_i'\beta}{\sigma}) - \Phi(\frac{70 - x_i'\beta}{\sigma})\} + I[y_i = 5] \times \log_e\{\Phi(\frac{90 - x_i'\beta}{\sigma}) - \\ & \Phi(\frac{80 - x_i'\beta}{\sigma})\} + I[y_i = 6] \times \log_e\{\Phi(\frac{100 - x_i'\beta}{\sigma}) - \Phi(\frac{90 - x_i'\beta}{\sigma})\} + \\ & I[y_i = 7] \times \log_e\{\Phi(\frac{\infty - x_i'\beta}{\sigma}) - \Phi(\frac{100 - x_i'\beta}{\sigma})\} \end{aligned} \tag{3}$$

where Φ denotes the cumulative distribution function of the standard normal, $\Phi(\infty) = 1$, $\log_e(\cdot)$ denotes the natural logarithmic operator, and I[·] is an indicator function that takes the value of one when the statement in the square brackets is true and zero when it is false. The relevant part of the log-likelihood is then triggered by the indicator function for whether the individual falls within one of the seven categories in question. The maximum likelihood procedure now involves the estimation of the β parameter vector and the ancillary standard error parameter σ.

Unlike the situation with the ordered probit estimation, the estimated coefficients from an interval regression are interpretable as if y_i^* is observed for each i and estimated $E(y^* \mid x) = x\beta$ by OLS. That is, the estimated coefficients can be interpreted as the marginal effects (i.e. the change in percentage of sales reported given a change in the

independent variable, holding all else constant). It should be noted that the estimates contained in the β parameter vector are only interpretable in this way due to the assumption that y* given x, satisfies the classical linear model assumptions. If these assumptions do not hold then the interval regression estimator of β would be inconsistent. As a result, it is important to test the key assumptions of functional form, homoskedasticity, and normality.

Diagnostic Tests

Machin and Stewart (1990) discuss diagnostic tests for (pseudo) functional form for an ordered probit, which is easily modified for the interval regression model, and Chesher and Irish (1987) outline diagnostic tests for normality and homoskedasticity for the grouped data model. These tests are all score (or Lagrange Multiplier) tests for which the test statistics take the form

$$\xi = 1'F(F'F)^{-1}F'1 \tag{4}$$

where 1 is an n-dimensional vector of ones, and F is a matrix with row order n where each row contains the score contributions for all the parameters of the model. ξ can be easily calculated as n times the non-centered R^2 from a regression of 1 on the columns of F.

The construction of the F matrices for these tests, which are described below, are based on computations of the pseudo-residuals. Usually, residuals are defined as the difference between the observed and estimated values of the dependent variable. However, the estimated values of the dependent variable obtained in the interval

regression have no counterpart in the data. Chesher and Irish (1987) provide the computational details for the pseudo-errors for the grouped model, denoted for the i^{th} individual as:

$$u_i = \frac{\phi(\frac{a_{(j-1)i} - x_i'\beta}{\sigma}) - \phi(\frac{a_{ji} - x_i'\beta}{\sigma})}{\sigma[\Phi(\frac{a_{ji} - x_i'\beta}{\sigma}) - \Phi(\frac{a_{(j-1)i} - x_i'\beta}{\sigma})]} \tag{5}$$

where $\phi(\cdot)$ denotes the probability density function for the standard normal, and a_{j-1} and a_j denote the known interval parameters for individual i (e.g. if $y_i=2$ then $a_{j-1}=50$ and $a_j=60$). The pseudo-residuals, e_i, are obtained by replacing the unknown parameters in (5) with their maximum likelihood estimates.

For the homoskedasticity and non-normality tests, higher-order moment residuals are required, specified as:

$$M_{ri} = \frac{(\frac{a_{(j-1)i} - x_i'\beta}{\sigma})^r \phi(\frac{a_{(j-1)i} - x_i'\beta}{\sigma}) - (\frac{a_{ji} - x_i'\beta}{\sigma})^r \phi(\frac{a_{ji} - x_i'\beta}{\sigma})}{\sigma[\Phi(\frac{a_{ji} - x_i'\beta}{\sigma}) - \Phi(\frac{a_{(j-1)i} - x_i'\beta}{\sigma})]} \tag{6}$$

The higher-order moment residuals are obtained by replacing the unknown parameters in (6) with their maximum likelihood estimates. The first four moment residuals are required for the desired tests and are defined as follows:

$$\begin{aligned} e_i^1 &= e_i \\ e_i^2 &= \hat{M}_{1i} \\ e_i^3 &= 2e_i^1 + \hat{M}_{2i} \\ e_i^4 &= 3e_i^2 + \hat{M}_{3i} \end{aligned} \tag{7}$$

The F matrix, or score contributions, is obtained by multiplying the pseudo-residuals by the various auxiliary variables in question.

Pseudo-Functional Form Test

The (pseudo) functional form test is a modified version of the RESET test (Ramsey 1969). F is given as

$$F = (e^1 x, e^1 \hat{y}^{*2}, ..., e^1 \hat{y}^{*K}, e^2) \tag{8}$$

where x includes a column of 1's if the grouped model contains an intercept and $\hat{y}^{*K}$ is the Kth power of $\hat{y}^* = x'\hat{\beta}$. That test statistic ξ is distributed as $\chi^2(K-1)$.

Test for Homoskedasticity

For the test of heteroskedasticity of unknown form, F is given as

$$F = (e^1 x, e^2 xx')^{18} \tag{9}$$

That test statistic ξ is distributed as $\chi^2(K)$ where K is the number of columns in x.

Non-Normality Test

Finally, F in the usual $\chi^2(2)$ test for zero skewness and/or excess kurtosis is given by

$$F = (e^1 x, e^2, e^3, e^4) \quad . \tag{10}$$

[18] When an intercept is estimated so that x always contains a unit element, e^2 is redundant in the test for homoskedasticity.

It should be noted that if either or both of the assumptions of normality and homoskedasticity are rejected, then the Huber (1967) "sandwich" estimator of the variance can be used in place of the conventional Maximum Likelihood variance estimator. This estimator is expressed as:

$$Var(\hat{\beta}) = [I(\hat{\beta})]^{-1}(x_i' u_i^2 x_i)[I(\hat{\beta})]^{-1} \tag{5}$$

where $I(\hat{\beta})$ is the information matrix for the $\hat{\beta}$ vector, computed at the maximum likelihood estimates.

While it is worthwhile considering the results of the aforementioned tests, caution should be exercised when interpreting the associated results. Orme (1990) has questioned the use of such score tests in the context of a simple binary probit and demonstrated their poor finite sample properties in this setting. In particular, he notes that there is upward size-distortion. Assuming that these findings extend to the group model estimated in this study, the tests may indicate that the model does not satisfy the classical linear model assumptions when in fact it does.

Results

Estimation was undertaken using STATA 8.2 and was conducted using the 'INTREG' command. The command needs two variables, denoted y_1 and y_2, to define the dependent variable. In particular, y_1 and y_2 are used to hold the endpoints of the interval. As our data are right-censored, the upper endpoint of ∞ is represented by a

missing value. Table 4 provides the concordances between y_i, the associated interval, y_1, and y_2. The model for the analysis is:

$$\begin{aligned} y_i^* = {} & \alpha + \beta_1 PROP_i + \beta_2 COOP_i + \beta_4 CORP_i + \beta_5 PUBCORP_i + \beta_6 SERVICE_i + \\ & \beta_7 AGR_i + \beta_8 CONSTRUC_i + \beta_9 SMALL_i + \beta_{10} LARGE_i + \beta_{11} LESS5_i + \\ & \beta_{12} OVER15_i + \beta_{13} NOCOMPET_i + \beta_{14} MORE3COMPET_i + \beta_{15} FOREIGN_i + \\ & \beta_{16} GOVOWN_i + \beta_{17} EXPORT_i + \beta_{18} AUDIT_i \\ & [+\beta_{19} FIN_i + \beta_{20} INSTABILE_i + \beta_{21} ORGCRIME_i + \beta_{22} TAX_i + \\ & \beta_{23} CORRUP_i + \beta_{24} INFLAT_i + \beta_{25} EXCHANGE_i + \beta_{26} LAWS_i] \\ & (+ \sum_{t=27}^{32} \beta_t REGION_i, + \sum_{n=27}^{106} \beta_n COUNTRY_i]) + u_i, \qquad i = 1...N \end{aligned} \tag{4}$$

Table 3 provides a description of the above noted variables and Table 2 denotes the countries and regions available in the data. The model is estimated with and without the "perception" variables, which are the variables in the square brackets, and with and without either controls for region or country. This produces a total of six possible models.

The associated results are presented in Table 5. The first three columns relate to models without the perception variables. Model 1 is the base model, while Model 2 includes regional controls, and Model 3 includes country controls. The last three columns relate to models with the perception variables included. Model 4 is the base model, while Model 5 includes regional controls, and Model 6 includes country controls. The results for the diagnostic tests are presented near the end of the table. In all cases, the null of homoskedasticity is rejected and the Huber (1967) "sandwich" estimator of the variance is used in place of the conventional MLE variance estimator. The null: (1) of normality for those models that include country controls; and (2) for the pseudo

functional form test for all models except 1 and 4 is not rejected. On the basis of these last two test results, Models 1, 2, 4, and 5 should be treated with caution as they fail to meet the necessary assumptions for estimator consistency. These results provide some evidence that Models 3 and 6 meet the necessary assumptions required for consistent estimates, particularly in light of Orme's (1990) finding.

Various goodness of fit measures are also presented at the bottom of Table 5 for the relevant models. Larger (less negative) log-likelihood values are indicative of a better fit. However, only log-likelihood values across models with the same samples can be compared. That is, the log-likelihood values for Models 1, 2 and 3 can be compared and for Models 4, 5, and 6 but not, for example, Models 2 and 5. The R-square, for technical reasons, cannot be computed in the same way in interval regressions as it is in OLS regression. Various pseudo R-square measures, however, have been proposed, but there is no generally accepted measure. Veall and Zimmermann (1996) recommend the measure of McKelvey and Zavoina (1975), which is reported in the various results tables.[19] The log-likelihood function and the R-square measure are larger for those regressions that include the country controls. Tests of the joint significance of the explanatory variables are all significant and the region/country controls are also jointly significant. As a result of the goodness of fit and diagnostic tests, the preferred models are models 3 and 6.

[19] The McKelvey and Zavoina (1975) R-square is computed in STATA with the 'fitstat' command.

The main results will now be discussed. The coefficients represent the marginal effects and can be interpreted as the impact of the firm's characteristic or perception variable in percentage terms on the share of sales that are reported for tax purposes. A positive (negative) estimate means that the variable is associated with greater tax compliance (non-compliance). In those specifications that do not include country controls, the coefficient associated with firms that are sole proprietorships/partnerships and corporations is negative. The results for Models 1 and 2 indicate that sole proprietorships report approximately 5 to 5.5 percentage points less of their sales to the tax authority, and this rises to between 6 and 7.5 percentage points in Models 4 and 5. These variables, however, are not significant in the models with country controls, the preferred models based on the diagnostic and goodness of fit tests. The other categories for the legal characteristics of the firm are insignificant in all specifications. In particular, it is interesting to note that it is revealed that public corporations are not significantly more compliant than other types of firms as was found by Rice (1992).

Most of the industry sectoral controls are insignificant with the exception of the service sector, which is positive across all specifications. Firms in the service sector report between 2 and 4 percentage points more of their sales to the tax authority. This result is contrary to that of Giles (2000) who found that firms in the service sector are more likely to be non-compliant.

Firm size is a significant indicator of the degree of compliance across all specifications. Small firms (less than 50 employees) report approximately 3.4 to 4.8 percentage points less of their sales while large firms (more than 500 employees) report

approximately 3 to 4 percentage points more of their sales. Giles (2000) reports a similar result, whereas Rice (2002) found firm size and tax non-compliance were positively related. Firm age and the number of competitors a firm has, are insignificant in most of the specifications.

Both Giles (2000) and Chan and Mo (2000) found that foreign owned firms are more compliant, and the results in Table 5 provide further support for this result. Foreign owned firms report approximately 4 to 6.2 percentage points more of their sales and this result is significant across all specifications. Chan and Mo (2000) report that export-oriented firms are more compliant and, at least in those specifications that do not include country controls, similar results are found. The coefficient associated with firms that export is positive and this indicates that exporters report between 2 to 3 percentage points more of their sales to the tax authority. Finally, firms that have their financial statements audited are significantly more tax compliant. These firms report between 5.7 and 10 percentage points more of their sales, and this result is significant across all specifications. The relationship between internal audit controls of the firm and tax compliance has not been investigated in previous empirical work.

Firms that perceive organized crime, the exchange rate, and high taxes and regulations as obstacles to doing businesses and report that government corruption is common, report less of their sales to the tax authority. These results are significant across all specifications. In comparison, Johnson *et al.* (2000) also found a positive relationship between non-compliance and government corruption but failed to find a relationship between compliance and organized crime and tax payments. Our results

indicate that government corruption has the largest effect resulting in firms reporting approximately 11.3 to 13.3 percentage points less of their sales followed by organized crime at 5.8 to 10.6 percentage points less. High tax rates and burdensome regulations reduce reporting by between 5.2 and 5.8 percentage points and exchange rates reduce reporting by between 3.2 and 4.4 percentage points. A positive relationship between inconsistency in the interpretation in laws and regulations and tax compliance is found, but only in those specifications that exclude country controls.

The region controls are also highly significant and negative, though of smaller magnitudes in the regression that includes the perception variables (Model 5). This indicates that the perception variables are picking up behaviour previously ascribed to the region controls. The results for Model 5 will be highlighted, which indicate that firms in Latin America are the least compliant, reporting 12.9 percentage points less of their sales, followed by Africa at 7.3 percentage points, Asia at 5.2 percentage points and Transition Europe at 3.8 percentage points less. The coefficient for the Former Soviet Union dummy variable is statistically insignificant.

Table 5 also includes the coefficients for the country controls, considered in Models 3 and 6. Again, the inclusion of the perception variables leads to changes in the reported coefficients so the results for Model 6 will be presented in detail.

— Africa: firms in Cameroon and Madagascar are the most compliant, reporting 13.4 and 17.6 percentage points more of their sales, while firms in Tunisia, Egypt, the West Bank-Gaza, and Ghana the least compliant.

— Asia: firms in India and Singapore are the most compliant, reporting approximately 20 percentage points more of their sales, while firms in Bangladesh and Cambodia are the least compliant, reporting 15.9 and 13.5 percentage points less of their sales respectively.

— OECD: not surprisingly, firms in the OECD are generally very compliant but firms in Canada, France and Italy are the most compliant, reported in ascending order. However, the result related to Italy is somewhat surprising since Italy is perceived to have a substantial underground economy.

— Transition Europe: Slovakia is the least compliant with firms reporting almost 40 percentage points less of their sales followed by Turkey and Croatia at 10 percentage points while firms in Slovenia are the most compliant reporting 22.8% more of their sales followed by Romania at 10.6 percentage points.

— Latin America: most will be unsurprised that firms in Haiti are the least compliant out of all other Latin American countries, reporting over 40 percentage points less of their sales. Haiti is followed by Panama, Bolivia, and Trinidad and Tobago where firms report 19.6, 17.2, and 15.3 percentage points less of their sales, respectively. Chile, El Salvador, Nicaragua, and Uruguay are among the most compliant in the region.

— Former Soviet Union: contrary to the findings of Johnson *et al.* (2000), no difference is found in reporting by firms among the various countries in Soviet Union with the exception of Belarus, which is more compliant. All of the other results are statistically insignificant

The regions included in this dataset are quite diverse and it is very plausible that the relationship between firm characteristics, and the perception variables, and tax compliance may be quite different across regions. It would have been interesting to estimate our models separately for each region, but the sample sizes in these models were found to be very low, especially for the specifications that include the perception variables. Consequently, these results are not reported.

Conclusion

Very little is actually known about firm tax compliance due to a lack of detailed and readily available data. The purpose of this paper was to use a unique and recently available dataset that contained information on firms from around the world to investigate some of the factors that effect business tax compliance. This is one of the first studies to examine firm tax compliance using worldwide data. The majority of previous empirical studies were confined to examining firms within a particular country, using tax audit data.

Overall, evidence is presented that shows that firms in all regions around the world engage in tax non-compliance, but that there is substantial variation within regions. In addition, while convincing results that the legal organization of a business affects tax compliance is not found, large firms, firms in the service sector, and firms that are foreign owned, are exporters and/or have their financial statements audited are found to be more compliant. On the other hand firms that are small and who report that organized

crime, high taxes, and government corruption are obstacles for doing business are less compliant.

The findings do suggest a role for public policy, as well as actions to be considered by the tax authority and items the require further study. First, the findings suggest that administrations interested in reducing business tax non-compliance should consider reducing taxes, eliminating government corruption, and minimizing organized crime activities. Admittedly, taking action of these issues is complex and involves more than just the tax authority. Second, tax authorities should consider auditing small firms at a higher rate and requiring all firms to have their financial statement audited by a third party. Finally, based on this study, it is not entirely clear why large firms, firms that are foreign owned, and firms that export are more compliant. Further exploration into these relationships appears to be a worthwhile venture.

TABLES

Table 1: Univariate Frequencies of Percentage of Sales Reported to Tax Authorities

	<50%	50-59%	60-69%	70-79%	80-89%	90-99%	100%
Frequency	696	489	365	514	685	826	2,450
Percent	11.55%	8.12%	6.06%	8.53%	11.37%	13.71%	40.66%
Observations	6,025						

Table 2: Countries Surveyed, Categorized by Region, and Number of Observations in Each Country

Country	Observations	Country	Observations
Africa and Middle East		**Transition Europe**	
Botswana	57	Bosnia and Herzegovina	84
Cameroon	35	Bulgaria	77
Côte d'Ivoire	36	Croatia	81
Egypt	56	Czech Republic	86
Ethiopia	39	Estonia	96
Ghana	36	Hungary	93
Kenya	55	Lithuania	27
Madagascar	27	Poland	178
Malawi	25	Romania	97
Namibia	34	Slovak Republic	22
Nigeria	41	Slovenia	96
Senegal	15	Turkey	98
South Africa	70	Total	1035
Tanzania	32	**Former Soviet Union**	
Tunisia	36	Armenia	82
Uganda	54	Azerbaijan	82
West Bank and Gaza	13	Belarus	80
Zambia	40	Georgia	73
Zimbabwe	59	Kazakhstan	75
Total	760	Kyrgyzstan	88
Asia		Moldova	82
Bangladesh	36	Russia	429
Cambodia	216	Ukraine	157
China	81	Uzbekistan	93
India	137	Total	1241
Indonesia	68	**Latin American and Caribbean**	
Malaysia	41	Argentina	76
Pakistan	69	Belize	21
Philippines	89	Bolivia	71
Singapore	85	Brazil	72
Thailand	286	Chile	79
Total	1108	Colombia	89
OECD[1]		Costa Rica	46
Canada	94	Dominican Republic	65
France	70	Ecuador	50
Germany	55	El Salvador	60
Italy	71	Guatemala	49
Portugal	80	Haiti	67
Spain	85	Honduras	46
Sweden	79	Mexico	42
United Kingdom	57	Nicaragua	65
United States[1]	77	Panama	49
Total	668	Peru	77
		Trinidad and Tobago	64
		Uruguay	64
		Venezuela	61
		Total	1213

Notes: [1]Denotes the omitted category in estimation.

Table 3: Data Summary

Variable	Acronym	Mean	Standard Deviation	Minimum	Maximum
% of Sales Reported	REPORT	2.962	2.161	1	7
Legal Organization of Company					
Sole Prop. & Partnerships	PROP	0.373	0.484	0	1
Cooperatives	COOP	0.037	0.188	0	1
Corporation	CORP	0.317	0.465	0	1
Public Corp.	PUBCORP	0.116	0.320	0	1
Other Business[1]	OTHER	0.157	0.364	0	1
Industry Sector					
Manufacturing[1]	MANUFAC	0.377	0.485	0	1
Service	SERVICE	0.433	0.496	0	1
Agriculture	AGR	0.026	0.159	0	1
Construction	CONSTRUC	0.070	0.255	0	1
Firm Size					
Small	SMALL	0.410	0.492	0	1
Medium[1]	MED	0.405	0.491	0	1
Large	LARGE	0.185	0.388	0	1
Firm Age					
<5	LESS5	0.262	0.440	0	1
5-15[1]	5TO15	0.378	0.485	0	1
>15	OVER15	0.360	0.480	0	1
Number of Competitors					
No Competitors	NOCOMPET	0.096	0.295	0	1
1-3[1]	1TO3	0.398	0.489	0	1
>3	MORE3COMPET	0.506	0.500	0	1
Other					
Foreign Owned	FOREIGN	0.204	0.403	0	1
Gov. Owned	GOVOWN	0.076	0.265	0	1
Exporter	EXPORT	0.374	0.484	0	1
Fin. Statements Audited	AUDIT	0.634	0.482	0	1
Secondary Parameters – Perception					
Financing	FIN	0.805	0.396	0	1
Political Instability	INSTABILE	0.842	0.365	0	1
Organized Crime	ORGCRIME	0.840	0.367	0	1
High Taxes & Regulations	TAX	0.738	0.440	0	1
Corruption	CORRUP	0.622	0.485	0	1
Inflation	INFLAT	0.896	0.306	0	1
Exchange Rate	EXCHANGE	0.549	0.498	0	1
Laws & Regs In consistent	LAWS	0.422	0.494	0	1

Notes: [1]Denotes the omitted category in estimation.

Table 4: Definition of the Dependent Variable for the Interval Regression Model

y_i	Associated Interval	y_1	y_2
1	(0, 50]	0	50
2	(50, 60]	50	60
3	(60, 70]	60	70
4	(70, 80]	70	80
5	(80, 90]	80	90
6	(90, 100]	90	100
7	(100, ∞]	100	.

Table 5: Estimation Results

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	**88.080**	**101.333**	**94.358**	**108.054**	**114.017**	103.914
	(2.056)***	**(2.409)*****	**(4.419)*****	**(3.165)*****	**(3.387)*****	(5.672)***
			Legal Organization of Company[1]			
Sole Prop. &	**-5.174**	**-5.410**	-1.782	**-6.128**	**-7.756**	-1.322
Partnerships	**(1.642)*****	**(1.652)*****	(1.786)	**(1.755)*****	**(1.805)*****	(1.995)
Cooperatives	-0.287	-1.988	1.614	0.347	-2.393	2.201
	(3.035)	(2.958)	(2.915)	(3.245)	(3.248)	(3.391)
Corporation	**-3.008**	**-3.438**	-0.201	**-4.395**	**-7.107**	-1.638
	(1.571)*	**(1.612)****	(1.778)	**(1.678)*****	**(1.755)*****	(1.982)
Public	2.333	-0.664	2.055	0.673	-3.367	1.235
Corporation	(1.931)	(2.019)	(2.074)	(2.119)	(2.250)	(2.346)
			Industry Sector[2]			
Service	**4.165**	**2.089**	**2.264**	**3.316**	**2.785**	**2.709**
	(1.086)***	**(1.070)***	**(1.023)****	**(1.195)*****	**(1.189)****	**(1.151)****
Agriculture	**4.205**	2.007	2.358	1.553	0.494	0.752
	(2.006)**	(1.996)	(1.896)	(2.299)	(2.321)	(2.197)
Construction	1.647	0.346	-0.730	2.498	1.907	0.515
	(1.607)	(1.599)	(1.497)	(1.730)	(1.727)	(1.655)
			Firm Size[3]			
Small	**-4.334**	**-3.925**	**-4.762**	**-3.402**	**-3.510**	**-3.920**
	(1.130)***	**(1.113)*****	**(1.066)*****	**(1.235)*****	**(1.231)*****	**(1.212)*****
Large	1.140	**3.244**	**4.183**	**2.950**	**4.140**	**4.545**
	(1.467)	**(1.446)****	**(1.353)*****	**(1.609)***	**(1.610)****	**(1.517)*****
			Firm Age[4]			
<5	0.711	1.019	0.971	1.328	1.027	1.147
	(1.167)	(1.166)	(1.086)	(1.286)	(1.310)	(1.234)
>15	1.776	**2.430**	-0.231	-0.053	0.850	-0.162
	(1.186)	**(1.201)****	(1.162)	(1.301)	(1.336)	(1.310)
			Number of Competitors[5]			
No Competitors	1.943	1.9447	**3.381**	-1.670	-1.456	1.110
	(1.859)	(1.812)	**(1.697)****	(1.949)	(1.926)	(1.868)
>3	**-2.899**	-1.729	-0.881	-0.250	-2.222	-1.057
	(1.061)***	(1.273)	(1.290)	(1.187)	(1.490)	(1.519)
			Other			
Foreign Owned	**4.865**	**6.215**	**5.402**	**4.019**	**4.306**	**3.695**
	(1.324)***	**(1.308)*****	**(1.244)*****	**(1.476)*****	**(1.476)*****	**(1.424)*****
Gov. Owned	0.032	-1.291	1.100	0.205	-0.948	1.519
	(1.931)	(1.879)	(1.761)	(2.201)	(2.170)	(2.095)
Export	**2.395**	**1.973**	0.790	**3.192**	**2.842**	1.855
	(1.096)**	**(1.097)***	(1.062)	**(1.207)*****	**(1.232)****	(1.223)
Audits	**7.396**	**10.020**	**6.356**	**7.527**	**8.800**	**5.704**
	(1.136)***	**(1.171)*****	**(1.149)*****	**(1.250)*****	**(1.297)*****	**(1.295)*****
			Secondary Parameters – Perception			
Financing	-	-	-	-0.868	-0.192	-0.005
				(1.447)	(1.452)	(1.396)
Political	-	-	-	0.379	0.935	-0.598
Instability				(1.644)	(1.646)	(1.604)

(This table is continued on the next page)

Table 5 Continued

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Organized Crime	-	-	-	**-10.647**	**-9.233**	**-5.796**
				(1.170)***	**(1.189)*****	**(1.174)*****
Taxes & Regs.	-	-	-	**-5.528**	**-5.834**	**-5.175**
				(2.111)***	**(2.132)*****	**(2.090)****
Corruption	-	-	-	**-13.342**	**-13.051**	**-11.358**
				(1.099)***	**(1.114)*****	**(1.106)*****
Inflation	-	-	-	2.678	2.311	1.300
				(1.715)	(1.712)	(1.725)
Exchange Rate	-	-	-	**-3.817**	**-3.222**	**-4.410**
				(1.371)***	**(1.381)****	**(1.367)*****
Laws & Regs.	-	-	-	**2.013**	**2.147**	1.671
In consistent				**(1.036)***	**(1.042)****	(1.015)
			Region[6]			
Africa & Middle	-	**-21.035**	-	-	**-7.310**	-
East		**(2.020)*****			**(2.474)*****	
Transition	-	**-9.554**	-	-	**-3.812**	-
Europe		**(2.081)*****			**(2.534)***	
Asia	-	**-22.962**	-	-	**-5.207**	-
		(1.954)***			**(2.312)****	
Latin America	-	**-19.161**	-	-	**-12.908**	-
		(1.831)***			**(1.925)*****	
Former Soviet	-	**-11.068**	-	-	-2.663	-
Union		**(2.132)*****			(2.375)	
			Country[7]			
			Africa & Middle East			
Botswana	-	-	**-11.448**	-	-	-8.107
			(5.508)**			(7.062)
Cameroon	-	-	-5.014	-	-	**13.364**
			(5.964)			**(7.527)***
Cote d'Ivoire	-	-	-2.481	-	-	6.368
			(5.951)			(7.868)
Egypt	-	-	**-38.744**	-	-	**-30.289**
			(4.723)***			**(6.739)*****
Ethiopia	-	-	-6.340	-	-	3.809
			(6.487)			(9.040)
Ghana	-	-	**-13.425**	-	-	-10.673
			(6.617)**			(7.380)
Kenya	-	-	-6.627	-	-	3.445
			(5.441)			(6.088)
Madagascar	-	-	-1.339	-	-	**17.637**
			(8.618)			**(10.679)***
Malawi	-	-	-9.675	-	-	4.511
			(7.490)			(9.251)
Namibia	-	-	**-12.705**	-	-	1.650
			(7.038)*			(8.335)
Nigeria	-	-	**-10.009**	-	-	10.302
			(5.681)*			(7.455)

(This table is continued on the next page)

Table 5 Continued

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Senegal	-	-	-10.772	-	-	10.207
			(8.014)			(21.433)
South Africa	-	-	**-9.270**	-	-	-3.805
			(5.381)*			(6.308)
Tanzania	-	-	-9.189	-	-	3.578
			(7.627)			(9.152)
Tunisia	-	-	**-39.647**	-	-	**-35.614**
			(6.152)***			**(13.499)*****
Uganda	-	-	0.337	-	-	9.972
			(5.499)			(6.841)
West Bank-Gaza	-	-	**-23.098**	-	-	**-21.761**
			(7.896)***			**(9.195)****
Zambia	-	-	-8.855	-	-	2.788
			(5.951)			(7.590)
Zimbabwe	-	-	-8.893	-	-	3.892
			(5.493)			(6.550)
			Asia			
Bangladesh	-	-	**-32.571**	-	-	**-15.863**
			(6.089)			**(7.497)****
Cambodia	-	-	**-23.586**	-	-	**-13.553**
			(4.736)***			**(5.536)****
China	-	-	**-40.528**	-	-	-
			(5.679)***			
India	-	-	6.395	-	-	**20.330**
			(4.701)			**(5.478)*****
Indonesia	-	-	**-10.626**	-	-	1.868
			(5.558)*			(6.435)
Malaysia	-	-	**-16.994**	-	-	-8.228
			(6.830)**			(7.632)
Pakistan	-	-	**-21.470**	-	-	-5.378
			(5.755)***			(6.410)
Philippines	-	-	-7.623	-	-	4.477
			(5.393)			(5.968)
Singapore	-	-	**23.842**	-	-	**20.975**
			(7.003)***			**(7.443)*****
Thailand	-	-	**-21.984**	-	-	-
			(4.339)***			
			OECD			
Canada	-	-	**15.446**	-	-	**14.707**
			(5.336)***			**(5.986)****
France	-	-	**16.509**	-	-	**18.438**
			(5.719)***			**(6.407)*****
Germany	-	-	**-11.642**	-	-	-8.010
			(4.739)**			(5.485)
Italy	-	-	**23.494**	-	-	**25.493**
			(6.122)***			**(6.813)*****

(This table is continued on the next page)

Table 5 Continued

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Portugal	-	-	4.061	-	-	2.805
			(5.199)			(5.878)
Spain	-	-	7.149	-	-	8.441
			(5.400)			(6.075)
Sweden	-	-	8.692	-	-	5.679
			(4.986)*			(5.553)
UK	-	-	8.629	-	-	9.024
			(6.575)			(7.083)
			Transition Europe			
Bosnia	-	-	6.903	-	-	4.532
			(5.558)			(6.442)
Bulgaria	-	-	**-9.983**	-	-	-2.576
			(5.566)*			(6.509)
Croatia	-	-	**-15.271**	-	-	**-10.518**
			(5.120)***			**(5.919)***
Czech Rep	-	-	-0.829	-	-	2.929
			(5.194)			(6.030)
Estonia	-	-	-4.368	-	-	-1.338
			(4.623)			(5.422)
Hungary	-	-	-2.542	-	-	3.777
			(5.115)			(6.022)
Lithuania	-	-	**-55.315**	-	-	**-55.428**
			(5.251)***			**(5.918)*****
Poland	-	-	3.663	-	-	6.670
			(4.653)			(5.557)
Romania	-	-	1.097	-	-	**10.553**
			(4.645)			**(5.480)***
Slovakia	-	-	**-52.784**	-	-	**-39.279**
			(5.249)***			**(7.032)*****
Slovenia	-	-	**21.004**	-	-	**22.808**
			(5.369)***			**(6.106)*****
Turkey	-	-	**-20.149**	-	-	**-10.254**
			(4.894)***			**(5.688)***
			Latin America & Caribbean			
Argentina	-	-	**-11.528**	-	-	-8.117
			(5.378)**			(6.037)
Belize	-	-	-9.944	-	-	-9.310
			(8.820)			(8.796)
Bolivia	-	-	**-24.693**	-	-	**-17.154**
			(5.443)***			**(6.066)*****
Brazil	-	-	-8.792	-	-	-2.489
			(6.192)			(6.766)
Chile	-	-	**19.429**	-	-	**19.148**
			(6.132)***			**(6.648)*****
Colombia	-	-	**-13.675**	-	-	-6.950
			(6.218)**			(6.889)

(This table is continued on the next page)

Table 5 Continued

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Costa Rica	-	-	**-13.329**	-	-	-5.413
			(5.868)**			(6.227)
Dominican	-	-	**-15.465**	-	-	6.308
Republic			**(5.401)*****			(5.932)
Ecuador	-	-	**-18.607**	-	-	-5.397
			(6.228)***			(6.960)
El Salvador	-	-	10.334	-	-	**15.846**
			(6.833)			**(7.212)*****
Guatemala	-	-	**-11.383**	-	-	-5.287
			(6.140)*			(6.727)
Haiti	-	-	**-52.132**	-	-	**-40.420**
			(5.659)***			**(6.450)*****
Honduras	-	-	8.990	-	-	6.418
			(7.106)			(8.349)
Mexico	-	-	-5.407	-	-	5.274
			(7.256)			(8.132)
Nicaragua	-	-	3.588	-	-	**10.255**
			(6.693)			**(7.544)**
Panama	-	-	**-26.292**	-	-	**-19.619**
			(7.092)***			**(7.518)*****
Peru	-	-	**-11.063**	-	-	-1.693
			(5.210)**			(5.955)
Trinidad&Tobago	-	-	**-17.070**	-	-	**-15.326**
			(5.311)***			**(5.827)*****
Uruguay	-	-	**13.446**	-	-	**9.722**
			(7.115)*			**(8.158)**
Venezuela	-	-	-7.497	-	-	1.143
			(6.321)			(6.874)
			Former Soviet Union			
Armenia	-	-	-0.933	-	-	5.994
			(5.049)			(5.926)
Azerbaijan	-	-	**-10.216**	-	-	-4.313
			(5.567)*			(6.089)
Belarus	-	-	**10.474**	-	-	**14.198**
			(5.253)**			**(5.917)****
Georgia	-	-	-2.249	-	-	8.774
			(5.865)			(6.513)
Kazakhstan	-	-	-1.343	-	-	9.308
			(5.829)			(7.029)
Kyrgyzstan	-	-	**-8.823**	-	-	-0.243
			(4.488)**			(5.573)
Moldova	-	-	-7.465	-	-	7.238
			(5.453)			(6.432)
Russia	-	-	**-11.948**	-	-	-4.284
			(4.216)***			(5.088)
Ukraine	-	-	-4.037	-	-	3.633
			(4.814)			(5.588)

(This table is continued on the next page)

Table 5 Continued

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Uzbekistan	-	-	**-11.854 (5.145)****	-	-	-5.221 (6.116)
			Diagnostic Tests			
Pseudo Functional Form Test[8] [d.o.f.; P-Value]	14.936 [3; 0.002]	7.798 [3; 0.050]	5.866 [3; 0.118]	16.759 [3; 0.001]	6.870 [3; 0.076]	24.980 [3; 0.00]
Homoskedasticity Test[9] [d.o.f.; P-Value]	108.152 [17; 0.000]	3428.278 [22; 0.000]	5849.945 [96; 0.000]	77.724 [25; 0.000]	2616.940 [30; 0.000]	4429.594 [104; 0.000]
Normality Test [d.o.f.; P-Value]	295.348 [2; 0.000]	135.718 [2; 0.000]	1.174 [2; 0.556]	27.954 [2; 0.000]	11.009 [2; 0.004]	5.332 [0.070]
			Goodness of Fit			
Pseudo Log-Likelihood Value	-10273.028	-10162.527	-9729.695	-7501.096	-7475.952	-7213.586
McKelvey & Zavoina Pseudo R^2	0.035	0.086	0.145	0.082	0.087	0.154
LRT-OS[10]	321.296	542.299	1407.963	630.514	680.803	1205.532
[d.o.f.; P-Value]	[17; 0.000]	[22; 0.000]	[96; 0.000]	[17; 0.000]	[22; 0.000]	[96; 0.000]
LRT-AV[11]	-	221.002	1086.666	-	50.288	575.020
[d.o.f.; P-Value]		[5; 0.00]	[79; 0.00]		[5; 0.00]	[79; 0.00]
σ	32.994	32.190	29.457	31.072	30.806	28.628
(s.e.)	(0.425)	(0.415)	(0.394)	(0.487)	(0.482)	(0.459)
Observations		6025			4561	

Notes: § Robust standard errors (s.e.) corrected for heteroskedasticity are noted in parenthesis.
† ***,** and * denote statistical significance at the 1%, 5% and 10% level respectively.
± d.o.f. denotes degrees of freedom.
‡ Omitted category is [1] "Other", [2] "Manufacturing", [3] "Medium", [4] "Between 5 and 15", [5] "Between 1 and 3", [6] "OECD", [7] "United States".

[8] The functional form test uses as auxiliary variables the fitted values from the interval regression raised to polynomials of up to the fourth order.

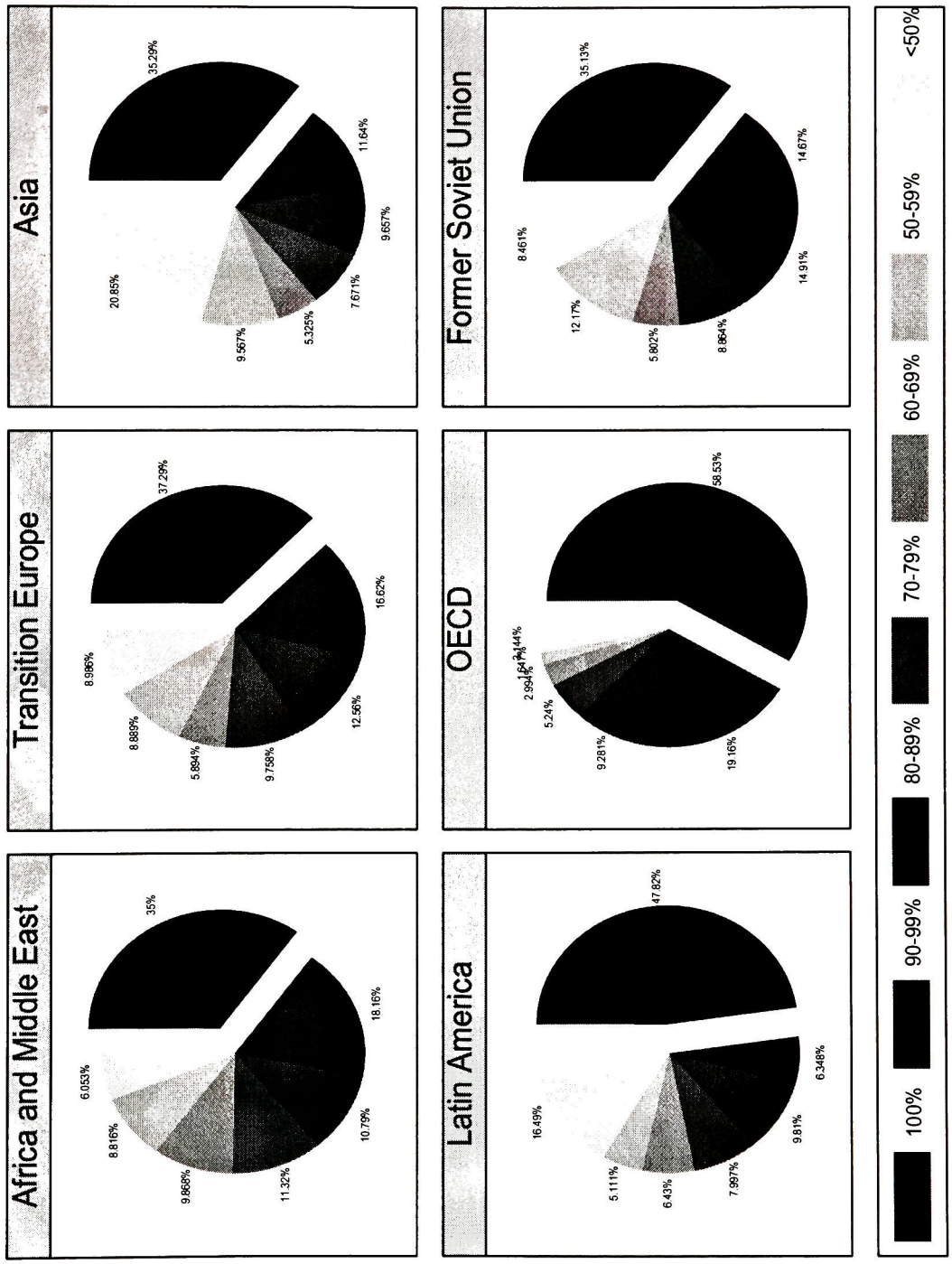
[9] The homoskedasticity test uses all the original regressors as auxiliary regressors.

[10] Likelihood Ratio Test (LRT) of the overall significance (OS) of the model tests the joint significance of the explanatory variables. It is calculated as $LRT=-2(L^R-L^U)$ which is distributed as χ^2 with k degrees of freedom where is the number of dependent variables (not including the constant term) in the unrestricted regressions. The restricted regression includes only a constant.

[11] Likelihood Ratio Test (LRT) of the joint significance of the additional variables (AV) (those added to the Model 1 or 4 specifications). It is calculated as $LRT=-2(L^R-L^U)$ which is distributed as χ^2 with k degrees of freedom where is the number of additional dependent variables (not including the constant term) in the unrestricted regressions. The unrestricted regression is the model specified in the column in which the statistic is calculated. The restricted regression is Model 1 or 4 accordingly.

FIGURES

Figure 1: Percentage of Sales Reported to Tax Authorities



Source: World Business Environment Survey

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CHAPTER 5

CONCLUSION

This dissertation examines the underground sector of the economy, a sector that remained largely unstudied until the last two decades. While there is a general perception that the underground economy is sizeable and growing, little is truly known about this sector, the types and values of the activities that constitute it, the agents that participate in it, and the factors that lead to increase and decreased involvement in underground activity. Using a variety of different data sources and empirical methodologies, the three essays in this dissertation attempt to add to the knowledge by providing empirical measures of underground activity.

The first paper examines the underground economy from a macroeconomic perspective. The methodology employed, treats the underground economy as a latent variable, since the size of the underground economy is, by definition, unobservable, and uses information contained within relevant indicator and causal variables to estimate the Canadian underground economy. One of the key advantages of this macroeconomic method is that it produces a time-path of the underground economy. Most other methods that have been employed to measure the underground economy only produced an estimate for one particular point in time. The main disadvantage to this approach is that the measure produced is an aggregate measure that cannot be broken-down into various underground activities.

The findings suggest that the value of the broadly defined underground economy in Canada grew from about 7.5% of Gross Domestic Product (GDP) in 1976 to about 15.3% in 2001. In real (1997) dollar terms, it increased from about $38 billion to $159 billion per annum. Evidence is also provided which supports the notion that the underground economy and the observed economy are complements rather than substitutes. In addition, the results suggest that taxes and the self-employed are important causal factors of underground activity.

Based on the results from the first paper which indicates that self-employment income is an important driver of the value of the underground economy, the second paper explores income under-reporting by the Canadian self-employed. This paper uses microeconomic data and nonparametric techniques and estimates income under-reporting by self-employed households, by comparing their income and expenditures bundles with households that are assumed to have no ability to under-report their income. The key advantage of using nonparametric techniques is that it allows the reporting relationship to vary across households. The main disadvantage of using nonparametric techniques is that they require large amounts of observations.

The results show that the self-employed do, in fact, under-report their income and that this behaviour is more prevalent among households with low amounts of self-employment income. The second paper also explores the effect of the Goods and Services Tax (GST) on income under-reporting. The results indicate that income under-reporting by married households with self-employment income neither increased nor decreased following the implementation of the GST. That said, it is important to note

that the reliability of these estimates depends particularly on the quality of the data. The paper presents evidence that support the notion that the obtained estimates of income under-reporting revealed in this paper are lower bound estimates.

The self-employed represent just one type of business entity with the ability to under-report income. The third paper investigates under-reporting behaviour by all types of businesses using worldwide survey data. The few empirical studies regarding firm tax compliance used data from tax audits. The main advantages of the dataset used in this paper over tax audit data include the fact that: (1) audit data are not widely available while the data used in this paper covers eighty countries; (2) audit data only includes firms that are selected (for diverse reasons) or caught by the tax authorities, while the data used in this paper is a random sample of firms; and (3) the data used in this paper includes additional information that is not included in tax audits. In particular, factors that firms perceive as business obstacles, such as taxes and regulations, and which may effect a firm's decision to under-report.

The previous literature has suggested that: (1) public corporations should be more compliant, but no such effect is found in this paper; (2) firms in the service and construction sector should be less compliant, but it is found that firms in the service sector are more compliant and that there is no significant effect for the construction sector; and (3) there is no clear relationship between firm size and under-reporting, but this paper finds, unambiguously, that small firms are less compliant than large firms. Foreign owned firms, exporters, and firms that have audited financial statements are also more compliant and organized crime, high taxes, and government corruption all result in

lower compliance. Finally, the results indicate that firms around the world engage in tax non-compliance but, holding all else constant, compliance is highest in OECD countries (notably Canada, France, and Italy) and the lowest in Latin American (particularly, Haiti, Panama, and Peru) and African and Middle Eastern (principally, Tunisia, Egypt, West Bank-Gaza, and Ghana) countries.

Overall, the conclusions drawn from this thesis have important policy implications. The first paper suggests that the underground economy in Canada is sizable and continues to grow, despite the increased enforcement efforts of Canada Revenue Agency (CRA). In addition, it shows that the underground economy responds positively to marginal tax rates, the amount of self-employment income, labour force participation, the overall crime rate, and regulatory reform. Additionally, CRA's enforcement activities under the Underground Economy Initiative (UEI) have been largely unsuccessful. The second paper provides evidence that self-employment income is dramatically understated, a fact that should be incorporated not only into economic models but also government programs that base qualification on reported income. In addition, since it is found that the gap between true and reported income is larger for households with lower amounts of reported self-employment income, audit activities should be direct towards these types of households. The third paper suggests that administrations interested in reducing business tax non-compliance should consider reducing taxes, eliminating government corruption, and working to minimize organized crime activities. In addition, tax authorities should consider auditing small firms at a higher rate and requiring all firms to have their financial statement audited by a third party.

In closing, this dissertation has shown how it is possible to use formal modeling techniques and generally available data to generate a least some information about the underground economy. It has also shown that it is essential that the underground economy be monitored and studied, and that policies that influence the underground economy's magnitude and direction be explored. Finally, this dissertation has shown that the standard view of the economic world (and the models used to describe it) must be modified to take the underground economy into account. In short, much remains to be done.