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Essays on Crime and Tax Evasion

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ESSAYS ON CRIME AND TAX EVASION

BY

SEAN CHRISTOPHER TURNER

A Dissertation Submitted in Partial Fulfillment
of the Requirements for the Degree
of
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in the
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ACCEPTANCE

This dissertation was prepared under the direction of the candidate's Dissertation Committee. It has been approved and accepted by all members of that committee, and it has been accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Economics in the Andrew Young School of Policy Studies of Georgia State University.

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ABSTRACT
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By

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This dissertation consists of three essays addressing two issues related to crime and tax evasion. The first essay investigates the relationship between property and violent crime with law enforcement expenditures. The second essay examines the market structure in transition economies and the effects on firm-level tax evasion. The third essay investigates the incidence of tax evasion in a general equilibrium framework. The topics in all three essays are linked by their focus on criminal or illegal behavior. The essays also answer questions related to developing sound governmental policy and decision-making.

Chapter one attempts to identify the impact on crime of increasing law enforcement expenditures. We examine the specific channels the public has to influence crime (e.g., the level of expenditures, the number of police officers), to determine what role, if any, they may play in influencing crime rates for property crime and for violent crime. Conclusions in previous research are equivocal, and often do not adequately address the obvious simultaneity of crime and enforcement efforts. We use the Arellano-Bond system GMM estimation method to control for this simultaneity. Results from our preferred GMM estimation method show clearly that increases in law enforcement

expenditures help reduce crime rates; other methodologies typically give results that are not robust.

The second chapter extends previous empirical work evaluating the determinants of tax evasion by firms in which tax evasion may be similar to a tax advantage under the law. This chapter contributes to the tax evasion literature by identifying market structures in which it may be easier to evade or where high levels of evasion take place. Results indicate that fighting corruption is still an important factor in determining the level of evasion. However, the data also suggests a long run situation in which the tax advantage of evasion has been replicated and competed away; more competitive markets have lower levels of evasion whereas monopolistic markets have higher levels of evasion. Further, tax evasion will occur in more service oriented industries.

Chapter three develops and calibrates a general equilibrium model to investigate how tax evasion affects the incidence of taxes. Previous tax incidence work has considered tax evasion; however little has been done considering the distributional impact of tax evasion. There may be cases in which individuals, other than evaders, indirectly benefit or lose from tax evasion. This work contributes to the literature by clearly linking the individual or firm decision to evade to a general equilibrium analysis of tax evasion using microeconomic foundations. Including evasion decisions in tax incidence analysis has implications for both tax policy and enforcement agency decision making, and is an important step toward understanding how evasion affects the whole economy.

Introduction

This dissertation consists of three essays addressing two issues related to crime and tax evasion. The first essay investigates the relationship between property and violent crime with law enforcement expenditures. The second essay examines the market structure in transition economies and the effects on firm-level tax evasion. The third essay investigates the incidence of tax evasion in a general equilibrium framework. The topics in all three essays linked by their focus on criminal or illegal behavior. The essays also answer questions related to developing sound governmental policy and decision-making.

The first essay attempts to identify the impact on crime of increasing law enforcement expenditures. Crime pays if the expected marginal benefits of criminal activity outweigh the expected marginal costs, and the probabilities of apprehension and conviction play a decisive role in this calculus. Among the many channels that the public has to influence these probabilities are expenditures on police enforcement (e.g., the level of expenditures, the number of police officers), and we examine these specific channels to determine what role, if any, they may play in influencing crime rates for property crime and for violent crime. Conclusions in previous research are equivocal, and often do not adequately address the obvious simultaneity of crime and enforcement efforts. We use the Arellano-Bond system GMM estimation method to control for this simultaneity; we also use other methods commonly used in prior studies, in order to examine the robustness of a particular estimation method. Results from our preferred GMM estimation method show clearly that increases in law enforcement expenditures help reduce crime rates; other methodologies typically give results that are not robust. The policy implication is that increased enforcement expenditures may reduce crime but that it also matters how these expenditures are made.

The second essay extends previous empirical work evaluating the determinants of tax evasion by firms. Previous work by Nur-tegin (2008) included both standard and non-traditional determinants to tax evasion however; if tax evasion can be similar to a tax advantage under the law, as suggested by Martinez-Vazquez (1996), then replication and competition will consume and eliminate the direct tax advantage of evaded income (i.e., eliminate the positive expected profits of the evasion gamble). Recognizing this potential, the level of tax evasion may also be determined by current market conditions and industry category. Therefore, this chapter contributes to the tax evasion literature by identifying market structures in which it may be easier to evade or where high levels of evasion take place.

Survey data from 4,907 firms in 23 transition economies are analyzed. The results indicate that fighting corruption is still an important factor in determining the level of evasion. However, the data also suggests a long run situation in which the tax advantage of evasion has been replicated and competed away; more competitive markets have lower levels of evasion whereas monopolistic markets have higher levels of evasion. Further, tax evasion occurs more frequently in more service oriented industries.

The third essay develops and calibrates a general equilibrium model to investigate how tax evasion affects the incidence of taxes. Previous tax incidence work has considered tax evasion; however little has been done considering the distributional impact of tax evasion. There may be cases in which individuals, other than evaders, indirectly benefit or lose from tax evasion. This work contributes to the literature by clearly linking the individual or firm decision to evade to a general equilibrium analysis of tax evasion using microeconomic foundations. Including evasion decisions in tax incidence analysis has implications for both tax policy and enforcement agency decision making, and is an important step toward understanding how evasion affects the whole economy.

The purpose of using a CGE framework is to explore the potential for tax evasion to act like a tax advantage in the law as long as the expected value of the evasion gamble is positive. The standard portfolio approach introduced by Allingham and Sandmo (1972) assumes that the only benefits of tax evasion are the tax savings from unreported income. However, this may not be true. Individuals, other than evaders, may indirectly benefit or lose from tax evasion. If evasion is viewed as a tax advantage in the law, replication and competition will occur, thereby eliminating the direct tax advantage of evaded income as adjustments take place in the market through changes in the relative prices of commodities and factor inputs. These simulations allow the following questions to be answered: What impact does tax evasion have on general equilibrium effects in the presence of an input factor tax both in a perfectly competitive and monopoly scenario? How does welfare change with a partial factor tax when tax evasion is present? Finally, how do multiple partial factor taxes with evasion affect welfare in both a perfectly competitive and monopoly environment?

Chapter One: Crime and Law Enforcement Expenditures

Introduction

Technology in crime fighting has advanced significantly in recent years, including such elements as non-lethal weaponry, advanced street camera systems, silent alarms, and GPS locators. Due to these and other advances in crime fighting, budgetary requirements for police departments have changed.[1] It is now more apparent that crime rates depend not simply on the traditional factor of the number of police officers, but also that the specific ways in which law enforcement expenditures are allocated play a major role; that is, how should the total budget be spent in order to reduce crime rates? It is this issue that motivates our study. We examine the effects that police expenditures have on crime rates; we also examine the impact of the number of police officers on crime rates, to determine whether officers "deter" crime or whether they simply detect (or "label") individuals as criminals;[2] and we use a wide range of estimation methods, in order to test

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[1] Garicano and Heaton (2007) consider whether information technology (IT) improves public sector productivity through analysis of police IT programs and their effect on crime rates. They find insignificant results. However, there are several difficulties with this type of research. One issue is how IT is measured. Typically, IT is measured simply as whether or not agencies possess IT products for use; it is more relevant–but more difficult–to determine whether or not IT is actually utilized during daily operations. A second, related issue is whether law enforcement has time to use IT in its most productive capacity, and this issue is not also difficult to consider fully. Fameda et al. (2005) suggest that using programs such as COMSTAT and the like to conduct problem-oriented policing relies on the free time of officers to engage the software. They also suggest that officers are not always given proper directives from shift supervisors, so that unassigned time may be (missing) used in unproductive activities.

[2] Huff and Stahura (1980) assert that the various roles of law enforcement can be explained by the sign of the estimated coefficient on police employment:

- "Labeling"–police have a positive effect on reported crime rates. The more that is spent on police the more labeling of individuals as criminals occurs, as the police become more effective in detecting criminal activities. In this view, police are the social group created to define deviance through enforcement of law; by applying the rule of law the police effectively label individuals as deviant (Becker, 1963).
- "Deterrence"–police deter crime, and as such have a negative effect on crime rates.

the robustness of a particular estimation method. Results from our preferred estimation method show clearly that increases in law enforcement expenditures help reduce crime rates; other methodologies typically give results that are not robust.

The basic crime-and-punishment framework of Becker (1968) says that individuals behave rationally when deciding whether or not to engage in criminal activity. As long as the expected benefits from criminal activities, such as the income earned from criminal activities, outweigh the expected costs (e.g., foregone income from legal activities, social stigma, monetary fines), then "crime pays." Thus, public policy that increases the probability of being caught engaging in criminal activities may be desirable, although this will of course depend on the additional public costs incurred to increase the probability versus the benefits to society of reduced crime. Indeed, as concluded by Cohen, Rust, and Steen (2006), there is substantial support for, if not belief in, increased law enforcement expenditures. Their survey data suggests that the median respondent, when deciding how to allocate a fixed budget to crime control and prevention policies, would support increased spending on police (as well as spending on youth prevention and drug treatment for non-violent offenders).

The main decision variables that the public has at its disposal to influence the probability of being discovered and apprehended "…are its expenditures on police protection, new statutes (minimum mandatory sentencing), courts, etc." (Becker 1968). Indeed, Phillips and Votey (1972) find a U-shaped criminal "clearance ratio," where the "clearance ratio" is the ratio of the number of crimes cleared by arrest divided by the total

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The latter role implies that there is a negative relationship between the number of police officers and the crime rate; that former role suggests a positive relationship, essentially because more police means that more individuals are labeled/detected as criminals by the police.

number of crimes that have occurred, and they conclude that one possible reason for this is that policy makers need to provide more resources to fight crime.

The main purpose of our study is to identify what role law enforcement expenditures and police employment have on crime rates, specifically violent and property crime rates. Another purpose is to examine the effects of different estimation methods on the robustness of these impacts. Violent crime is composed of murder, non-negligent manslaughter, forceible rape, and aggravated assault; property crime includes burglary, larceny-theft, and motor vehicle theft. We estimate the factors that affect violent and property crime rates, including police employment, law enforcement expenditures, and various control variables. An important innovation in our work is the use of the dynamic generalized method of moments (GMM) estimation developed by Arellano and Bond (1991, 1998), in order to control for simultaneity between the dependent variable (e.g.,the crime rate) and the police employment and law enforcement expenditure variables. System GMM is especially useful when some variables are endogenous, it is difficult to find a proper instrument, the dependent variable is influenced by its previous values, and the panel spans a relatively short time period. We also use feasible generalized least squares, panel random and fixed effects, and pooled ordinary least squares methods in order to compare our results with the many approaches used in many previous studies.

Our results show that the relationship between enforcement and crime depends crucially on the estimation method. Approaches that do not control adequately for endogeneity issues do not give consistent and robust results. When endogeneity issues are appropriately considered, we find that, contrary to much previous work, increased law enforcement expenditures reduce both violent and property crime. We also find that greater police employment has a positive relationship with violent crime, indicating that the main role of police officers is that of labeling/detecting individuals as criminals and not of deterring criminal activities, so that more police on the street will lead to a higher level of reported crime.

The next section reviews some of the literature on police expenditures and crime. Section three explains our data set and methods. Section four presents our estimation results. We conclude in section six.

Significant Previous Work

Becker (1968) introduced the basic theoretical framework for the economic approach to crime.[3] He showed that individuals will engage in criminal activity until the marginal benefits of criminal activities equal the marginal costs of crime.[4] These benefits and costs are typically valued by the individual via an expected utility function, where the utilities in the different states of the world (e.g., caught and incarcerated versus undetected and unpenalized) are weighted by the probabilities of these states occurring. It is through these probabilities that the likelihood of detection and punishment enters into the individual's calculus. Since expanded enforcement operations can increase the probability of being caught and incarcerated and thereby increase the expected costs of crime, increasing the amount of law enforcement expenditures should have a negative effect on both violent and property crime.

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[3] Harris (1970), Stigler (1970), and Tullock (1969) also made significant contributions.
[4] These benefits and costs are typically valued by the individual via an expected utility function, where the utilities in the different states of the world are weighted by the probabilities of these states occurring. It is through these probabilities that the likelihood of detection and punishment enter into the individual's calculus.

Empirical work in this area has been extensive but has given quite mixed results, showing both a positive and negative relationship between police expenditures and crime.[5] In some early work, Carol and Pressman (1971) found a positive relationship between police expenditures and crime, which suggests that increasing the number of police officers is not the proper policy reaction to high crime rates. Other studies by Jones (1971), Kakalik and Wildhorn (1971), Allison (1972), and Pogue (1975) also found a positive relationship between expenditures and crime. Huff and Stahura (1980) suggest that this positive relationship between expenditures and crime arises because of the increased "labeling" that occurs through expanded police operations, where "labeling" means that police are mainly identifying criminals, so that greater expenditures serves essentially to increase the reporting of crime rates rather than to increase the deterring of crime.[6]

These studies generally used single equation models, and so did not consider the obvious potential for simultaneity between policy expenditures and crime; that is, crime influences the amount of police expenditures, and the amount of police expenditures can in turn influence the amount of crime that occurs in the jurisdiction. McPheters and Stronge (1974) introduced a simultaneous equations model of crime activities and law enforcement expenditures, and they instead found a negative relationship between enforcement and urban crime.

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[5] See McPheters and Stronge (1974) and Cameron (1980) for comprehensive reviews of previous research on law enforcement expenditures and deterrence theory, respectively.

[6] In related and older work, Hirsch (1959) develops a framework in which police expenditures depend on such things as population, density, size of jurisdiction, and a number of other variables reflecting service conditions and quality of service. Others like Pidot (1969), Weicher (1970), and Bahl, Gustely, and Wasylenko (1978) extend this expenditure determinant framework to include taste and service conditions. However, these studies are concerned with the determinants of expenditures in the face of growing metropolitan areas and changing tastes of individuals for local public goods, rather than with the potential deterrent versus labeling effects of police expenditures.

Much other work addressing simultaneity has mainly used metropolitan area, cross section data. For example, Decker (1980) and Loftin and McDowall (1982) did not find any significant relationship between law enforcement variables and crime rates, and Vanagunas (1979) found mixed results between direct criminal justice expenditures and crime rates. More recently, Levitt (1997) implemented two stage least squares (2SLS) estimation with gubernatorial and mayoral election cycles as instruments for police employment. His results show that greater police employment reduces the overall level of violent crime but has no effect on the individual categories of crime, and he concluded that the "optimal" number of police officers may have been chosen already. McCrary (2002) disagreed with Levitt's use of electoral cycles as an instrument variable because cycles "…do not induce enough variation in police hiring to identify the causal effect of police on crime." In replicating Levitt's (1997) estimates, McCrary (2002) also recognized measurement error in the dating of local election cycles as a cause of a weighting error in the estimation, and he found that the effects of the weighting error cause a significant change in standard errors. In response, Levitt (2002) reestimated his crime equation using fire fighters as an instrument for police employment, and still found a negative relationship between police and crime.

Other work also gives mixed results. Huff and Stahura (1980) used ordinary least squares (OLS) and 2SLS methods, and they found that suburban towns respond to high crime rates by increasing police expenditures, especially if violent crime increases. Cordner (1989) found that the size of a police agency is not significantly related to investigative effectiveness, which implies that the role of police is to deter rather than to label/detect crime. However, his empirical work focused only on Maryland communities, and generalization to the entire country is risky.

Greenwood and Wadycki (1973), Swimmer (1974), and Greenberg et al. (1983) also attempted to control for simultaneity problems. Greenwood and Wadycki (1973) used three stage least squares (3SLS) methods to control for the simultaneity of crime rates with police variables. Their estimation results indicated that police are more efficient in detecting than in deterring crime and that increases in both violent and property crimes lead to increases in police expenditures. Swimmer (1974), Fox (1979), and Greenberg et al. (1983) found somewhat similar results in which they control for simultaneity between expenditures and crime.

There is also some work that uses time series data. For example, Loftin and McDowall (1982) did not find any significant relationship between law enforcement variables and crime rates, using time series data on Detroit for the period 1926-1977. Similarly, Surette (1984) employed a time series analysis for Chicago for the period 1900-1973. His dependent variables were the number of police employees, felony and misdemeanour arrests, and vagrancy arrests; his independent variables included economic variables such as value added by manufacturers, the number of wage workers, the number of manufacturers. He did not find a significant relationship between the criminal justice measures (e.g., felony/misdemeanour arrests or number of police employees) and economic conditions. Cornwell and Trunbull (1994) used panel data for North Carolina counties over a seven-year period to addressed two endogeneity problems: unobserved heterogeneity and conventional simultaneity. Their results suggest that, relative to earlier studies, labor market and criminal justice strategies are considerably more important for deterring crime than the probability of detection and conviction; indeed, they conclude that the effectiveness of enforcement strategies has been "greatly overstated."[7]

Marvell and Moody (1996) also used time series methods to address the specification problem between crime and police. Using lags between police levels and crime rates and tests of causal direction using the Gragner causality test, they found causation in both directions; that is, the impact of police on crime is substantial while the effect of crime on the number of police is very slight. Marvell and Moody (1996) considered, but did not use, both the number of police and the level of police expenditures in their estimation. Kovandzic and Sloan (2002) replicated the Marvell and Moody (1996) study at the county level in Florida, with similar results.

More recently, Evans and Owens (2007) use the Community Oriented Policing Services (COPS) program grants as an instrument for the size of the police force in 2074 cities across the United States between 1990 and 2001. Their results indicate that the increase in police officers from grant awards generated significant reductions in property crimes (theft, burglary, and robberies) and aggravated assault. Evans and Owens (2007) do not consider changes or growth in the increase in police expenditures.

There is also some quasi-experimental studies by Di Tella and Schargrodsky (2004) and Klick and Tabarrok (2005), which finds evidence of police deterrence in terrorist-related activities. Following a terrorist attack on a Jewish center in Buenos Aires, police presence was increased in areas in which religious centers were located 24 hours a day. Di Tella and Schargrodsky (2004) find large reductions in car thefts within the same block as the posted officers; within two and three blocks of the protected block, their results indicate that the deterrent effect fell in magnitude. Klick and Tabarrok

[7] See also Land and Felson (1976) and Fox (1979) for empirical analyses of time series data.

(2005) examine the impact of changes in the terror alert level set by the Department of Homeland Security on daily crime data in Washington, D.C. from March 2002 to July 2003. They find that crime fell significantly when the terror alert level was increased; for example, when the terror alert level was increased from "yellow" (elevated alert) to "orange" (high alert), crimes in District 1 fell by 2.62 crimes per day (Klick and Tabarrok 2005).

Overall, as emphasized by Cameron (1988), Marvell and Moody (1996), and others, the literature presents quite mixed results on whether increasing police employment or police expenditures has any consistent impact on crime. Indeed, it is clear that there is no consensus of the causal effect of police on crime, in part due to ongoing debates about the validity of the instruments used in previous work to control for the simultaneity between crime and law enforcmement and also about the usefulness of alternative estimation methods.

In this chapter we attempt to identify the causal effect of police on crime by taking a different approach to the endogeneity and estimation issues. Specifically, we use dynamic GMM estimation methods that deal with endogeneity, and we compare our results with those of the alternative and previously used methods. We also utilize more recent data. The next section presents our approach for examining and extending this previous work.

Data and Methodology

Data Sources and Variables

We use state panel data for the period 1992 to 2003, including Washington, D.C.[8] We focus our analysis on state-level data for a 12-year period for several reasons. Technological advances since the 1980s have signficantly changed the way police operate, so that it may not be appropriate to say that a police officer in, say, 1980 has the skills and training of an officer in 2000. In addition, and as discussed below, it has been shown that the Arellano and Bond (1991, 1999) dynamic GMM estimator becomes unreliable with long time periods (Roodman 2006). For these reasons, we limit our analysis to a 12-year period. We also examine state data. Local level data have often been used in previous work, as have more aggregate national data. However, effective law enforcement policy requires understanding of the effects of law enforcement spending at all levels of government.

Among the many data sources used in our analysis are the U.S. Census, Uniform Crime Report (UCR), Bureau of Justice Statistics, and the National Archive of Criminal Justice Data. All nominal variables have been deflated to real values in 1982 dollars using the historical Consumer Price Index. Dependent variables are per capita violent and property crime, in separate equations. Our main independent variables include law enforcement expenditures, police employment, and arrests (broken down separately for violent crime arrests and property crime arrests); all in per capita terms.[9] Control variables are poverty, black, density, high school, college, and young. We also include in some specifications various lags for the relevant dependent variable as instruments in our GMM estimation; these lags are denoted L1, L2, and L3 for one, two, and three period

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[8] Several states have missing police expenditure/employment data in certain years, including Alabama, Delaware, Hawaii, and Massachusetts. These variables are left as missing in the data set.

[9] Law enforcement expenditures and police employment are separated in order to capture the independent effects of changes in expenditures and changes in the number of police officers.

lags, respectively. Finally, we include dummy variables for the appropriate time periods in order to control for time effects. All variables (and their sources) are defined in Table A1; descriptive statistics are in Table A2.

What are the roles of law enforcement expenditures and police officers in criminal activities? The traditional economics-of-crime perspective is that increasing law enforcement expenditures will increase the costs of engaging in criminal activity by increasing the probability of detection. In this view, the coefficient on law enforcement expenditures in a crime rate equation should be negative; similarly, police employment should enter the equation with a negative sign. However, an alternative view is that greater enforcement expenditures and more police officers mainly serve to increase the labeling/detecting of crime, with little impact on deterring crime, so that these enforcement variables are expected to enter crime equations with a positive sign. Indeed, as emphasized earlier, the empirical evidence is mixed. Our measures of police employment (*Police Employment*) and of law enforcement expenditures (*LE Expenditures*) can therefore have either a positive or negative impact on crime rates.[10] We also include the number of arrests of each type of crime, *VCArrests* for violent crime arrests and *PCArrests* for property crime arrests. As with *Police Employment* and *LE Expenditures*, both measures of arrests can also exhibit either positive or negative impacts on crime rates, depending on the relative strength of deterrence versus labeling effects. All of these variables are allowed to be endogenous.

Our main demographic control variables are *Black, Young, Poverty*, and *Density*, and are introduced because crime rates vary with demographics (Cornwell and Trunbull 1994). We anticipate that the sign of *Black* will be positive (Jackson and Carroll 1981).

[10] Law enforcement expenditures include expenditures for current operations for police protection only.

The expected sign of *Young* is also positive because most people who become criminally active do so at young ages, so that the larger the population between ages 10 and 39 the higher is the crime rate. *Poverty* is also expected to have a positive sign, in large part because those individuals living in poverty have a lower opportunity cost of crime compared to others who are not. *Density* is included to capture the differences in crime among states that are much more densely populated than states that are not. We expect that the higher is the density of an area the higher is the crime rate. We also include as control variables the number of high school graduates (*High School*) and of college graduates (*College*). Individuals with high school or college educations may have a high cost of engaging in criminal activities for various reasons, such as loss of current and future employment opportunities, social stigma, and the like, so that an increase in educational attainment should have a negative impact on crime. All variables are converted into per capita terms.

System Generalized Method of Moments

Previous studies have (with some exceptions) generally utilized cross-sectional methodologies. We implement the Arellano and Bond (1991, 1998) dynamic GMM estimation method in order to control for endogeneity and time series issues, following the approach in Roodman (2006). This approach is based on several main assumptions:

- The process may be dynamic, with current realizations of the dependent variable influenced by past ones.
- There may be arbitrarily distributed fixed individual effects in the dynamic, so that the dependent variable consistently changes faster for some observational units than others. This aspect argues against cross-section regressions, which essentially assume fixed effects away, and in favour of a panel set-up where variation over time can be used to identify parameters.
- Some regressors may be endogenous.

- The idiosyncratic disturbances (or those apart from the fixed effects) may have individual-specific patterns of heteroskedasticity and serial correlation.
- The idiosyncratic disturbances are uncorrelated across individuals.

Some secondary concerns include the possibility that some regressors may be predetermined but not strictly exogenous (e.g., the regressors may be independent of current disturbances but still influenced by past ones), that the number of time periods of available data may be small, and that the only instruments available are "internal" (or based on lags of the instrumental variables).

In general form, the model is written as:

$$y_{it} = \alpha * y_{i,t-1} + x'_{it} * \beta + \varepsilon_{it} \qquad (1.1)$$

where

$$\varepsilon_{it} = \mu_i + \upsilon_{it}$$

$$E[\mu_i] = E[\upsilon_{it}] = E[\mu_i \nu_{it}] = 0$$

and where y_{it} is the dependent variable, x_{it} is a vector of explanatory variables, and (α, β) are parameters. Subscripts denote state *i* and time period *t*.[11] The error term ε_{it} has two orthogonal components: fixed effects μ_i and idiosyncratic shocks υ_{it}. To change equation (1.1) into a difference GMM, the equation is transformed by first differencing to get:

$$\Delta y_{it} = \alpha * \Delta y_{i,t-1} + \Delta x'_{it} * \beta + \Delta \upsilon_{it} \qquad (1.2)$$

With equation (1.2), the fixed effects have been differenced out; however, there is endogeneity from the lagged variable since $y_{i,t-1}$ in $\Delta y_{i,t-1} = y_{i,t-1} - y_{i,t-2}$ is correlated

[11] Note that equation (1) is written with only one lag; however, more lags can be included.

with $\upsilon_{i,t-1}$ in $\Delta\upsilon_{it} = \upsilon_{i,t} - \upsilon_{i,t-1}$. For the same reason any variable in Δx_{it} that may have been exogenous prior to first differencing could now be endogenous. The logical instrument is $y_{i,t-2}$, which is correlated with $\Delta y_{i,t-1}$ but not with $\Delta\upsilon_{it}$; this assumes that there is no serial correlation in the error that would cause the instruments to be invalid.

In order to limit the instrument count, one can limit the number of lags used by collapsing the lag matrix, which replaces the zeros with lagged variables. The regressions conducted in our analysis limit the lags by collapsing the lag matrices, by conducting a two-step rather than a one-step estimator for efficiency, and by using as instruments using differences and levels of lagged variables thought to be endogenous. See Roodman (2006) for a detailed discussion.

In our analysis, property and violent crime are defined as the dependent variables; independent variables include *LE Expenditures*, *Police Employment*, *Arrests*, and the various control variables. The specific form of equation (1) is then written as:

$$C_{it} = \beta_0 + \beta_1 C_{i,t-1} + \beta_2 LEExpenditures_{it} + \beta_3 PoliceEmployment_{it} + \beta_4 Arrests_{it} + \beta_5 X_{it} + \varepsilon_{it} \qquad (1.1)'$$

where C_{it} is total crime (violent or property), *LE Expenditures*$_{it}$ is law enforcement expenditures, *Police Employment*$_{it}$ is police employment, *Arrests*$_{it}$ is the number of arrests for the crime in question (violent or property crime), and X_{it} are the control variables. The crime lags, expenditures, employment, and arrests are treated as endogenous to the model, while the rest of the variables are treated as exogenous. Equation (1.1)′ is transformed by first differencing to generate an equation similar to equation (1.2).

Note that our dynamic GMM estimator is our preferred estimation method, using the Arellano and Bond (1991, 1998) estimator for system GMM in STATA . In order to examine the robustness of our GMM estimates, as well as to allow comparisons to previous work, we also estimate panel feasible generalized least squares (FGLS) , random effects (RE), fixed effects (FE), and pooled ordinary least squares (POLS) estimators.

Some Potential Issues

There are two broad issues that may influence our results and thus the effect of enforcement on crime.

First, crime data are in some sense incomplete. Two types of crime data are collected in the Uniform Crime Report (UCR) data: "Part I" offenses include murder non-negligent manslaughter, forcible rape, aggravated assault, burglary, larceny-theft, and motor vehicle theft; and "Part II" offenses include but are not limited to simple assault, fraud, vagrancy, and driving under the influence. Part I offenses are reported to the FBI by contributing agencies; however, only the most severe crimes are counted for data collection purposes. For example, an individual may commit and be charged with multiple crimes, including aggravated assault and robbery, but only robbery would be counted in the UCR data.[12] Also, only arrest data are collected for Part II offenses, and the total offenses cleared for this category are not counted. The causal effect of police on

[12] Reporting bias may also be a concern using UCR data, although Levitt (1998) reports that this bias is relatively small and that its presence cannot account for the failure of previous studies to find a negative relationship between police and crime rates.

Part II offenses may be substantial, but the UCR does not collect total offense data for Part II offenses.

Second, dynamic GMM suffers from limitations that can reflect the somewhat "black box" aspects of the approach, at least if the approach is applied mechanically. Due to the lack of consensus on valid instruments, we must draw instruments from the data using lags of the endogenous variables. For instance, a "good" instrument for $y_{i,t-1}$ is $y_{i,t-2}$, and Stata by default specifies 1 lag and deeper for the transformed equation and 0 lag for the levels equation. However, lag limits in system GMM allow for changes in lags as instruments for appropriate specification; indeed, in our work here, we override this default using the lag suboption command (Roodman 2006), and we present our lag limits for both per capita violent and property crime in Appendix Tables 1 and 2. The lag limits syntax is written as *laglimits(a b)*; thus a lag structure identified as laglimits(2 .) specifies 2 lags and deeper as instruments for the transformed model and 1 lag and deeper for the levels equation (Roodman 2006). For lags of the crime levels, we begin with the first lag and deeper to use as instruments (a=1 in Appendix A; Table A5). In selecting the laglimits *a* and *b*, we begin first by calculating the annual growth in violent and property crime. We then look at the change in growth from year to year, and make a determination based on when there is a significant change in the directionality or magnitude of growth. The lag level for crime begins at 1 year and deeper because each year there is a significant change in the growth of crime.[13] Per capita *LE Expenditures* growth significantly changes in 1997; growth in 1996 is 0.05 percent and -1.04 percent in

[13] Note that specifying laglimits(1 .) for L1 VC is equivalent to asking for laglimits(2 .) for VC.

1997. Therefore, we request lags 6 and deeper for instruments. A similar process is performed for *Police Employment* and *Arrests*.

We test for exogeneity of our instruments using the Sargan and Hansen tests. However, neither test should be relied upon too faithfully because each is subject to some weaknesses. In particular, as the instrument count grows the tests grow weaker. It is also difficult for finite samples to estimate the variance matrix because the moments are quadratic in the instrument count making the entire estimated variance matrix quartic in time. If it is the case that the finite sample does not have enough information, then the estimated variance matrix can be singular, and a generalized inverse matrix must be used instead. It is important to note that this does not lead to poor estimates; however, it does weaken both the Sargan and Hansen tests for overidentifying restrictions, leading to perfect p-values of 1.0 (Roodman 2006). In our estimation of both crime equations, we use a generalized inverse matrix, but we do not have perfect p-values on our Hanson J statistic.[14] Roodman (2006) points out that there is little guidance in the literature on what would be "too many" instruments and that the bias may still be present even when the instrument count is small.

Estimation Results[15]

Table A3 presents all regression results for violent crime, and Table A4 presents similar results for property crime.

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[14] We implement a two-step GMM estimation that uses the Hansen J-statistic to test for over-identifying restrictions.

[15] Note that the results for the control variables are not presented in the tables. Even when these variables are statistically significant, they tend not to be economically significant. All estimation results are available upon request.

Consider first the results for violent crime. Using dynamic GMM methods, we find that *LE Expenditures* has a negative and significant impact on violent crime at the 1 percent level when including one, two, and three lags of previous violent crime. The negative coefficient on enforcement expenditures is consistent with the deterrent effect of enforcement. In the first GMM estimation (column 1) with a single violent crime lag (*L1 VC*), increasing per capita law enforcement expenditures by $1000 will cause a reduction in per capita violent crime of 1.54. This may appear to be a small number; however, it amounts to an average annual reduction of 8,213 violent crimes. When an additional violent crime lag (*L2 VC*, column 2) is added, the coefficient on *LE Expenditures* becomes larger in magnitude, so that an increase in per capita law enforcement expenditures of $1000 now leads to a reduction of 1.89 violent crimes per capita (or 10,080 violent crimes). Adding another violent crime lag (*L3 VC*, column 3) to the regression does not change the statistical significance or the negative sign on *LE Expenditures*, although its magnitude falls somewhat. It is of some interest that *LE Expenditures* does not have a consistent impact on per capita violent crime in the alternative estimation methods of columns 4 through 7. Clearly, the specific estimation method has an important effect on the reliability of the estimation results.

Police Employment has a consistent and positive impact on violent crime in the GMM estimates of columns 1, 2, and 3, indicating that the role of police in society is to label/detect individuals as criminal rather than to deter crime. It should be emphasized that this result does not mean that increasing the number of police officers in a jurisdiction leads to more violent crime; rather, it means that increasing the number of police officers will increase the reporting of violent crime. Importantly, the alternative estimation methods in columns 4 through 7 again generate quite different results. Police employment has a positive and significant effect on violent crime in the random effects (RE) estimation (column 5), but its impact in the other estimation methods is not statistically significant and varies in sign.

Controlling for endogeneity also alters the impact that arrests have on violent crime; *VC Arrests* switches signs and falls in overall magnitude in GMM estimation (columns 1, 2, and 3), while with the alternative estimation methods in columns 4 through 7 *VC Arrests* generally has a positive and significant impact on violent crime. Recall that a negative coefficient on the arrest variable indicates a deterrent effect of arresting individuals on the amount of violent crime.

In sum, when comparing the dynamic GMM results to the other panel data methodologies in Table A3, the coefficient on the law enforcement expenditures variable sometimes switches sign and is generally much different in magnitude; that is, with these other, more standard estimation methods (e.g., feasible generalized least squares (FGLS) , random effects (RE), fixed effects (FE), pooled ordinary least squares (POLS), increased law enforcement expenditures has an erratic impact on violent crime. With GMM methods, however, *LE Expenditures* has a consistent, statistically significant, and negative effect on violent crime.[16]

As for other variables, *Poverty* and *Black* are positive across estimation methods, as expected; when compared with other panel methodologies, the GMM results are smaller in magnitude. In contrast, *Young* switches signs across methods, and both education variables also switch signs and become significant in the GMM specification.

[16] GMM results have the same sign as random and fixed effects; however, the GMM coefficient is smaller in magnitude.

A positive sign on *Young* suggests that states with a large youth populations will have higher levels of violent crimes because individuals are more likely to engage in criminal activities at younger ages. The negative coefficient on *College* reveals that individuals with college degrees will have a higher cost of engaging in violent crime and so will resist participation in criminal activities. Finally, lags of per capita violent crime are positive and significant, pointing out that violent crime has the expected contagion effect.

Table A4 presents the property crime regressions. We find similar results as in the violent crime regressions. Law enforcement expenditures are inversely related to property crimes in the GMM results, indicating that an increase in expenditures will reduce the amount of property crime. The first GMM regression (column 1) shows that a $1000 increase in per capita expenditures leads to 22.60 fewer per capita property crimes on average. Adding a second property crime lag to the regression increases the magnitude of the law enforcement expenditures coefficient; a $1000 increase in per capita expenditures now leads to 23.67 fewer per capita property crimes. *Police Employment*, unlike the violent crime results, now has a negative impact on crime. For example, the GMM results in column 1 show that adding one police officer per capita will bring about 3.04 fewer per capita property crimes.

We also find that increased arrests for property crimes (*PC Arrests*) deters further property crime, although in no specification is the property crime arrest variable significant. *Poverty*, when significant, is positive and smaller in magnitude with GMM estimation than with most of the other estimation techniques. *Young, High School*, and *College* are significant using system GMM methods, and *College* has switched sign when compared with FLGS or POLS methods. As with violent crime results, individuals with college degrees have a higher cost of engaging in crime and as such resist participation in criminal activities. *High School* is significant and positive in the GMM regressions, implying that a high school education does not increase the cost of criminal activity like a college degree. Similar to violent crime, we find that *Young* is consistently positive across estimation methods, indicating that criminal activity occurs at younger ages. Finally, including property crime lags shows that previous property crime causes future property crime. As with the violent crime results, we find evidence of contagion.

Of some interest, when we compare the GMM regressions to the other methodologies in Table A4, we again find that these other approaches often give different results, with estimated coefficients changing in sign, significance, and magnitude. For example, *LE Expenditures* changes sign, as does *PC Arrests*. These differences suggest that dynamic GMM is controlling for some unobserved endogeneity.

Because both crime regressions are two-step GMM estimation, we can ignore the Sargan test for over-identifying restrictions and focus on the Hansen J statistic. The null hypothesis for this test is that the over-identifying restrictions are valid. Since both violent and property crime have insignificant Hansen J statistics for all GMM estimations, the over-identifying restrictions are valid. These tests are quite sensitive to the number of instruments, so that as we increase the number of instruments the test grows weaker. In both crime equations, using the Hansen statistic, we fail to reject the null; the over-identifying restrictions are therefore valid, and our instruments are exogenous. It could be argued that the instrument count is high in our estimation; however, the literature does not specify a threshold for instrument count because the bias of over-fitting is present even with a low instrument count. Again, see Roodman (2006) for additional discussion. Further, at no point does our instrument count exceed N or NxT, which would weaken the test.

The Arellano and Bond (1991, 1998) GMM estimator also tests for first- and second-order autocorrelation in the first differenced residuals. It is expected that there will be first-order autocorrelation in the first differences because the differenced errors contain a lagged variable.[17] Second-order autocorrelation should not have this issue, and the test involves checking whether the lags used as instruments are appropriate and completely exogenous.[18] If second-order autocorrelation is present, then the instruments are inappropriate for the model. In both violent and property crime estimations (with one exception), the test for second-order autocorrelation is insignificant, indicating that the lagged instruments are valid. In the third GMM per capita violent crime equation, the test for second-order autocorrelation is signficant at the 5 percent level, which indicates that the instruments in this specification, using three lags of the dependent variable, are invalid.

It should be noted that we have also estimated the various models using the aggregate levels for each variable in log form, with largely similar results; that is, increasing law enforcement expenditures reduces both violent and property crimes, and increasing police employment has a labeling effect on crime.

In sum, our preferred GMM findings indicate that increasing the total amount of law enforcement expenditures leads to a reduction in both violent and property crime. The role of police officers seems to be one of labeling rather than detering violent crime,

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[17] $\Delta\varepsilon_{it} = \varepsilon_{it} - \varepsilon_{i,t-1}$ and $\Delta\varepsilon_{i,t-1} = \varepsilon_{i,t-1} - \varepsilon_{i,t-2}$ share $\varepsilon_{i,t-1}$, so they are expected to be correlated.

[18] The AR(2) test is checking the relationship between $\varepsilon_{i,t-1}$ in $\Delta\varepsilon_{it}$ and $\varepsilon_{i,t-2}$ in $\Delta\varepsilon_{i,t-1}$. If the test is significant, then there is first-order autocorrelation in levels, and the instruments are not exogenous.

while police officers seem to have some deterrent effect on property crime. Arrests deter both violent and property crime, although arrests are not significant in the property crime estimates. However, alternative estimation methods often give conflicting and contradictory results.

Summary and Future Extensions

We find that, when appropriate estimation methods are used, increasing police expenditures lowers crime rates for both violent and property crime. This finding is contrary to much previous work with alternative estimation methods, which found that increasing expenditures leads to more identification of crime. We also find that the main role of police officers seems to be one of labeling individuals as criminal, rather than one of deterring violent crime. This result implies that police are reactive rather than proactive to incidents of violent crime, meaning that they respond to rather than prevent crime.[19] Further, we find that arresting more individuals for violent crimes serves society mainly by deterring individuals from committing further acts of crime. Property crime arrests have a negative effect on crime, although in none of the GMM specifications are these effects significant. Finally, we find differences between the Arellano and Bond (1991, 1998) dynamic GMM estimator, which controls for the endogeneity in the crime equations, and the results of other estimation methods.

Overall, our findings do not imply that more or less money should be spent on law enforcement. They do show that the manner in which money is spent – on more officers versus on more general law enforcement – has an impact on violent and property crime.

[19] Note that our police employment variable does not capture any level of police productivity.

Future research should extend this analysis to crimes that society might view as less serious and more responsive to police variables.[20] Another extension should try to capture the productivity of police officers; doing so may show that police play some role as a deterrent to criminal activity.[21] It would also be useful to use data that are disaggregated to local jurisdictions (rather than use state data as done here). Such disaggregation would introduce the need to include a spatial dimension to the analysis. These extensions are left to future work.

[20] Vice crimes include prostitution, drug use, and racketeering; white collar crime includes tax evasion and fraud, insider trading, and the like.
[21] Conway and Lohr (1994) lend credence to police productivity when they show that victims are more likely to report crime based on previous victimization experience. Deterrence cannot exist if police do not do their job to the best of their abilities; police presence will not deter if criminals do not know that the police will actually do their jobs well, thereby affecting probabilities of detection and incarceration.

Chapter Two: Tax Evasion and Market Structure in Transition Economies

Introduction

Tax evasion limits a government's ability to raise revenues in order to meet budget requirements. The Internal Revenue Service (IRS) estimates in the United States that underreporting by corporations in 1998 was $37.5 billion where total tax receipts were $204.2 billion (Crocker and Slemrod 2005). In developed countries it is estimated that between 5 and 25 percent of potential tax revenues are evaded. This evasion estimate increases to between 30 and 40 percent of potential tax revenues when discussing developing nations (Franzoni 2000). Tax evasion, whether perpetrated by individuals or firms, can result in significant losses in government revenues, can alter the distribution of the tax burden, and can impede fiscal policy by limiting decision options.

The inefficiencies and shifting of the tax burden due to evasion are well documented in the literature. Evasion may lead to higher and more distortionary tax rates, provide further incentive to move to the underground economy, divert resources to unproductive activities used to remain clandestine to the enforcement agencies, and impede economic growth (Andreoni et al. 1998; Slemrod 2004; Johnson et al. 2000).

Understanding the factors that affect evasion decisions are paramount to forming economic policy. The literature has focused almost entirely on the individual tax evasion, and has largely ignored business tax compliance. Nur-tegin (2008) builds on current literature by empirically evaluating the determinants of business tax compliance in transition economies using the World Bank and the European Bank for Reconstruction and Development's (ERBD) 2002 Business Environment and Enterprise Performance

Survey (BEEPS). He includes both traditional and non-traditional determinants of tax compliance are included, such as tax rates, complexity of the tax system, corruption, firm size, and the like. Nur-tegin's (2008) results indicate corruption is a significant determinant of tax evasion, supporting previous literature that showed that firms enter the shadow economy when the government cannot control corruption. This chapter extends Nur-tegin's (2008) work to include measures of differing degrees of competition and industry environment.

When individuals evade taxes, they first make a decision under uncertainty in which they may be caught evading and will be forced to pay a fine (e.g., costs of evasion). Second, they no longer bear the burden of the tax, and they receive a benefit in the form of tax savings (e.g., benefits of evasion). To be clear, tax savings are the taxes on evaded income that the individual retains and may be used for consumption. If a firm or an entrepreneur evades taxes, they have the ability to pass all or part of the tax savings to consumers in the form of lower prices. Further, it must be the case that the expected profits firms make with evasion are greater than the profits they would have made had they been fully compliant. If the market in which evasion is occurring is competitive (so that there are no barriers to entry), then new firms or entrepreneurs will enter the market until, at the margin, the expected profits of evading equal the certain profits when complying. Any disequilibrium in this case will result in a reallocation of resources and firms, until equilibrium between the evading and compliant sectors is restored. Evasion coupled with competition will lead to the tax savings dissipating as more firms compete and the tax savings are transferred to consumers in the form of lower prices.

Service industries compared to product industries may allow for more opportunities to evade because no tangible product is produced to be sold in the market. Service industries also provide an opportunity for multiple cash transactions, which go unreported to the tax authority. If the industry is highly competitive; the benefits of tax evasion may be competed away by new entrants to the market or by existing firms replicating evasion behavior.

Consider an example to illustrate the tax advantage of evasion and how it may be eliminated through replication and competition. To become a taxi cab driver in New York City an individual needs to possess a taxi cab medallion issued by the government.[22] The medallion is difficult to obtain, and the city limits the total medallions available to all drivers. Limiting the number of medallions is a barrier to entry for individuals desiring to become a taxi driver. If a taxi driver picks up a fare and is paid in cash, he/she may evade the total or a portion of the fare. Thus their expected value of the evasion gamble is positive, and the standard result predicted by the portfolio approach is that the benefits of evasion are the tax savings from unreported income, which are kept by the taxi driver. If we were to eliminate the taxi cab medallion thus eliminating the barrier to entry, new taxi drivers will enter the market due to the tax advantage of evading taxes (positive expected value of the evasion gamble). Competition between drivers will occur, and the fare price (and the resulting income to taxi operators) will be competed down until the tax advantage disappears. The benefit of evasion in this case has been

[22] See http://www.nyc.gov/html/tlc/medallion/html/background/main.shtml (accessed October 14, 2008) for more details.

transferred to passengers in the form of lower fare prices.[23] This example illustrates that differing degrees of competition are key to understanding how the benefits of evasion are transferred through changes in the relative prices of commodities and factor inputs.[24] It is important to note that it is implicitly assumed that the price of the medallion is something less than the discounted value of future evasion; otherwise the government would be recover future lost revenues. Therefore, the determinants of tax evasion should include industry information and differing degrees of competition.

Significant Previous Literature[25]

The seminal work on tax evasion is Allingham and Sandmo (1972) (the A-S model hereafter), together with Srinivasan (1973). These were followed by numerous contributions that extended the analysis in many different directions. Cowell (1990) is one of the earliest surveys of the tax evasion literature; however, he only covers the literature through 1989. Andreoni, Erard, and Feinstein (1998), Alm (1999), Slemrod and Yitzhaki (2002), and Cowell (2003) cover more of the recent literature. Sandmo's (2005) retrospective piece illustrates the basics of the A-S model, and then goes on to address its weaknesses given more recent contributions in the evasion literature such as including labor supply decisions (black market labor) and black market labor demand. Slemrod (2007) reviews what we know about "the magnitude, nature, and determinants of tax evasion," and also about the policy implications of addressing public finance issues

[23] This example is not limited to taxi cab drivers. Tax evasion by illegal immigrants, domestic help, and other occupations, with competition may result in the evasion benefits being transferred to the high income individual who purchases services from these individuals.
[24] Karlinger (2008) builds an oligopoly game model, and shows that competition affects the size of the underground economy in which evasion may take place.
[25] For a complete literature review on the determinants of tax evasion, see Nur-tegin (2008).

when evasion creates further distortions.[26] The literature review here begins with an overview of theoretical models followed by determinants of tax evasion germane to developing and transition economies.

Theoretical Tax Evasion Models

Allingham and Sandmo's (1972) and Srinvasan's (1973) portfolio approach to tax evasion outlines the individual's decision to evade income taxes. Assuming that individuals are risk averse, the condition necessary for an interior solution is a function of the probability of detection, the tax rate, and the penalty rate. Comparative statics reveals that increasing the probability of detection or the penalty rate on undeclared income will increase tax compliance. Also, as individuals become wealthier, they will be more inclined to engage in risky behavior, if absolute relative risk aversion is decreasing in income. Finally, the A-S model shows that the effect of tax rates on evasion is ambiguous due to conflicting income and substitution effects. If the tax rate increases, then the income effect reduces compliance because income falls with greater taxes and (with decreasing absolute risk aversion) individuals become more risk averse with lower income. However the substitution effect is positive because the return to evasion is larger with a higher tax rate.

Yitzhaki (1974) points out that the ambiguous result of a change in the tax rate only occurs because of the assumption that the penalty is applied to evaded income and not evaded tax, as is the case in the United States and Israeli tax law. He shows that in this case the relative price of income is no longer a function of the tax rate no matter what

[26] "Once the reality of tax evasion is recognized, the incidence and efficiency of a tax system may depend critically on which side of the market *remits* the tax to the government and which side must report its transactions to the government" (Slemrod 2007).

is the state of the world, so that the substitution effect now disappears. The paradox of Yitzhaki's (1974) result is that it goes against intuition about how people will react to high tax rates. The common belief is that higher marginal tax rates encourage evasion because the individual faces a large gain from underreporting income from the tax collector. The contradiction is that as tax rates increase so does the penalty for evasion. The A-S model has "…a positive substitution effect on evasion because the net penalty—the difference between the penalty rate and the regular tax rate—goes down when the tax rate increases."

Marrelli (1984) develops a model similar to the A-S model for a monopolistic firm's decision to evade indirect taxes. The firm must decide whether to shift the tax onto consumers, evade the tax by only declaring a portion of the total revenue, or choose a combination of shifting and evading. He shows that an increase in the probability of detection leads to an increase in tax compliance Further, the entrepreneur will evade and, when able, will shift the tax onto the consumer just as if s/he was not evading. Worthy of note is the result that the output of the firm is not dependent on the probability of detection and the penalty. Marrelli and Martina (1988) extend Marrelli's 1984 work to include oligopolistic markets, and find the same changes in tax compliance from a change in probability of detection or in the tax rate.

Virmani (1989) analyzes indirect tax evasion in competitive markets, and finds that tax evasion is associated with production distortions that will affect optimal commodity tax policy. He shows that under certain conditions increases in the penalty rate can result in increases in evasion in an industry where partial evasion occurs. This suggests that tax rates in industries in which evasion is present should be set at relatively low rates, and in some cases whole industries may need to be exempted. He also shows that there are threshold tax rates in which no evasion takes place, partial evasion takes place, and full evasion occurs. Virmani (1989) points out that if firms are small in size and the threshold tax rate to be honest (fully tax compliant) is zero, then firms will evade at all tax rates. This implies that the size of the firm is related to tax evasion behavior.

Related to Virmani (1989), Gordon (1990) considers evasion through cash transactions, and shows that firms will increase their cash price and reduce evasion when facing increases in the probability of audit and tax rates. Increases in the tax rate alone, however, may or may not result in increases in evasion due to conflicting forces; the desire to pass the higher tax onto the consumer in the form of higher cash prices and declare more taxes versus the increased incentive to evade because tax rates are higher.

Firms may not only evade indirect taxes but may also evade income taxes, something that the A-S model cannot handle because of the contractual relationship of shareholders and managers of firms. The A-S model does not separate ownership from control of the firm, which is critical to corporate tax evasion analysis. Chen and Chu (2002) and Crocker and Slemrod (2005) are two recent papers that examine this issue, and they conclude that the evasion will depend on who is penalized for this activity.

A recent World Bank working paper describing data collected through a survey of both formal and informal businesses in South Africa show that firms are less likely to register with the tax authority and comply with tax laws if they have major problems with organized crime, infrastructure, and low levels of employee skills and education. A more important result related to this paper by Collidge and Ilic (2009) is that firms reported that they would be less likely to register for tax purposes if they "perceive that a significantly high share of other businesses 'similar' to themselves are not paying taxes 'at all." This indicates that firms in markets/industries with high levels of evasion will also evade in order to stay competitive. Therefore, the level of market competition is an important determinant of tax evasion and worth including in the regression analysis. If general equilibrium effects have competed away the benefits of evasion in competitive markets, then the coefficient of competition will be negative; if the general equilibrium effects have not competed away the benefits of evasion in competitive markets, then this coefficient will be positive. Coolidge and Ilic's (2009) results indicate that there is merit to the Martinez-Vazquez (1996) intuition where firms existing in markets with some competition will tax evade if they perceive a significant number of other firms are doing the same.

Tax Evasion in Developing and Transition Economies

The hard-to-tax (HTT) literature also directly applies to this analysis despite the fact that HTT groups include more than just tax evaders. HTT groups can be generally defined as small and medium sized firms, professionals, and farmers. Taxpayers that fall into this group can function in the formal or informal sector of the economy. The ability of the hard-to-tax to function in both the formal and informal sectors makes their tax information difficult, even impossible, to obtain. Thus, the economic analysis of the HTT is related to the shadow economy and the tax evasion literatures.

Das-Gupta (1994) developed a theoretical model of the HTT based on the number of income generating transactions in one year. Individuals with many transactions, such as an independent contractor, have income that is less risky because the tax authority does not have the ability to detect other transactions simply because it is able to see one single transaction. Alm, Martinez-Vazquez, and Schneider (2004) point out that it is easy to find counterexamples of firms that have multiple transactions each year and do not fall into the category of the hard-to-tax.[27]

Hard-to-tax groups may in fact exist in markets where engaging in some sort of evasion activities can lead to the transfer of benefits (e.g., the taxi cab example). They are a source of significant revenue losses, especially in developing countries, and their presence imposes limits the sophistication of the tax structure. The hard-to-tax may also cause resource allocation inefficiencies from several sources: because they engage in cash, barter, or other means of carrying out transactions; because of losses in economies of scale since small transactions are less likely to be detected; and because of over-allocation of labor and other resources to the HTT sector due to the differential tax burdens.[28]

The next section describes the data that we use to estimate the impact of market structure of tax evasion.

Data and Variables

The World Bank and ERBD's 2002 Business Environment and Enterprise Performance Survey (BEEPS) contains over six thousand firm-level responses in 27

[27] For further details on the hard-to-tax, see Alm, Martinez-Vazquez, and Schneider (2004).
[28] Over-allocation of labor and other resources to the HTT sector will only occur if resource decisions depend on tax evasion opportunities (Alm Martinez-Vazquez and Schneider 2004). Yaniv (1988, 1995) shows that the factor input decisions for production, under certain conditions, are separable from the evasion decision. Panteghini (2000) shows that separability fails to hold if firms fail to obtain an interior solution or if unfavorable events affect investment decisions (e.g., "Bernanke's bad news principle"). In this case, potential audit (bad news) affects investment decisions, which in turn affects production decisions.

transition economies. Due to a significant lack of observations four countries were dropped from the dataset; Serbia and Montenegro, Bosnia, Turkey, and Macedonia. The remaining 23 countries provide 4,907 observations.[29] These countries are:

Countries - Transition Economies

Albania	Kazakhstan	Tajikistan
Armenia	Kyrgyzstan	Ukraine
Azerbaijan	Latvia	Uzbekistan
Belarus	Lithuania	
Bulgaria	Moldova	
Croatia	Poland	
Czech Republic	Romania	
Estonia	Russia	
Georgia	Slovak Republic	
Hungary	Slovenia	

Respondents report information on a battery of questions.[30] The data are assembled from three different sources, with the majority derived from the 2002 BEEPS questionnaire. Tax rates for payroll taxes, value added tax, and the top marginal corporate income tax rate are collected from Global Reform of Income Taxation.[31] Finally, the Cumulative

[29] Some missing observations were replaced with country specific averages to allow STATA to execute the regression analysis.
[30] For countries in Central and Eastern Europe and the Commonwealth of Independent States, see http://www.ebrd.com/pages/research/analysis/surveys/beeps.shtml (accessed July 1, 2010).
[31] I am indebted to Klara Sabirianova Peter for providing this dataset.

Tax Reform Index is collected to provide a measure of reform for each country in the analysis (Martinez-Vazquez and McNab 1997).[32]

Variables of interest include separate variables for competition, monopoly power, and industry. Each is related to discovering the extent to which market structure or industry matter in a firm's decision to evade taxes.

Martinez-Vazquez (1996) describes the general equilibrium outcome in which the benefits of tax evasion are competed away through replication of new entrants in a particular market where evasion is taking place. In the short-run, if evasion is taking place in a particular industry and is there are little to no barriers to entry, then replication of evasion type activities will occur, resulting in increased competition in the evading sector. In this case, the competition variable would be expected to have a positive coefficient indicating the attraction to the market of individuals who have a positive expected value of the evasion gamble. The converse of this is a long-run situation in which the benefits of evasion (tax savings) have been competed away and the benefits of evasion gamble are no longer positive.

The competition variable is measured from question 21 in the BEEPS survey data and is phrased as follows:

> "Now I would like to ask you a hypothetical question. If you were to raise your prices of your main product line or main line of services 10% above their current level in the domestic market (after allowing for any inflation) which of the following would best describe the result assuming your competitors maintained their current prices?"

[32] See Table A6 for a complete list of variables and how they are measured.

Answer One Only

Our customers would continue to buy from us in the same quantities as now	1
Our customers would continue to buy from us, but at slightly lower quantities	2
Customers would continue to buy from us, but at much lower quantities	3
Many of our customers would buy from our competitors	4

The measure for monopoly power comes from the BEEPS survey, from the following question 23:

> "Considering your main product line or main line of services in the domestic market, by what margin does your sales price exceed your operating costs (i.e., the cost materials plus wage costs but not overheads and depreciation?"[33]

Monopoly power is expected to have a positive effect on tax evasion because barriers to entry will prevent competitors from entering and consuming the benefits of evasion. This effect should remain constant regardless of the short-run/long-run dynamic.

The last market structure variable included in the regression analysis accounts for differences between industries. One would expect tax evasion may be easier in more service oriented industries than in more manufacturing industries. In order to account for this, BEEPS asks question 2a through 2h:

> "What percentage of your sales comes from the following sectors in which your establishment operates?"[34]

Mining and Quarrying
Construction
Manufacturing

[33] The answer is a percentage reported by the respondent.
[34] These categories must sum to 100 percent.

Transport Storage and Communication
Wholesale, Retail, Repairs
Real Estate, Renting and Business Service
Hotels and Restaurants
Other

Conceivably, a firm could have 12.5 percent of their sales in each industry, but this is not the case in the data. Most firms are at the extremes in the sense that they either have 100 percent of their sales in one industry or none. There are cases when a firm may be splitting between two industries such as manufacturing and wholesale, retail, and repairs, but rarely did a firm report that it had sales divided among three or more industries. This suggests that most firms are concentrated in one industry, so that the industry variable will identify whether the firm is service oriented or producing some product.

For the purposes of this chapter it is assumed that mining and quarrying, manufacturing, construction, and wholesale, retail, and repairs are production industries identifying the remaining four as service industries. One may argue that some of these industries may have a service component to them, but the survey does not provide significant detail on this issue.

The competition, monopoly power, and industry variables proxy for the market structure in the cross section of firms in transition economies covered in the BEEPS survey. They provide information on the effect of market structure on tax evasion and, if significant, they suggest potential policy implications for certain markets where tax evasion is more prevalent.

Table A6 lists all the variables and associated definitions used in the regression analysis. The dependent variable is firm level tax evasion, developed from question 58, asking firms to estimate what percent of annual sales are reported by the typical firm in their industry for tax purposes. Each firm is therefore reporting what they believe is firm tax compliance. If a firm believes the typical firm reports only half of their total annual sales for tax purposes, given a perception of existing corruption, they may decide to similarly declare half their total annual sales for tax purposes. Therefore, firms are implicitly responding to a question about their own compliance behavior. The dependent variable is transformed to represent tax evasion by subtracting the reported tax compliance from question 58 percent from 100. Transforming the tax compliance variable allows us to address possible sample selection bias (discussed below). The tax rates represent a significant source of tax revenues to transition economies included in the analysis, and include the payroll tax (*SST*), value added tax (*VAT*), and the corporate income tax (*CIT*). The remaining variables are important determinants of tax evasion activities in developing and transition economies. First, there are two corruption variables: general corruption (*Corrgen*) and corruption related to tax payments (*Corrtax*), both developed from BEEPS questions 56g and 55, respectfully. There is also an index for reform progress developed by Martinez-Vazquez and McNab (1997), called the "cumulative reform index" (*CRI*). Martinez-Vazquez and McNab's (1997) cumulative reform index (*CRI*) measures the tax reform effectiveness of each country in the analysis during the transitional period of 1989 through 1996. The index is the sum of scores ranging from zero to 3 in each of the following areas[35]:

1. *Timing of Tax Reform* - the period of time from the start of the transitional process of the implementation of a tax reform program that included a modern VAT
2. *Preparation of Tax Reform* - the average period of time allotted for preparation of legislation and preparation for implementation

[35] Reform areas and definitions are quoted directly from Martinez-Vazquez and McNab (1997).

3. *Stability of the Tax System* - frequency of changes in the tax laws since the initial reform program

4. *High Tax Rates* - positive deviation of the maximum rates for the primary revenue sources from the average maximum rate for the primary revenue sources of all CIT's (Countries in Transition)

5. *Prevalence of Tax Holidays* - significance of tax holidays and special treatments

6. *Complexity* - number of Enterprise Profit Tax brackets

The lower the *CRI* the more reformed is the transition economy. Martinez-Vazquez and McNab (1997) suggest some caution in the use of the index because it is subject to data limitations and subjectivity. However, the index does provide insight into the degree of reform that has occurred in the transition economies in this study. It would be expected to find lower probabilities of tax evasion in countries with a high reform index, however, the results are insignificant. A positive coefficient on *CRI* implies that the less reformed is a country, the higher is the level of tax evasion. There is potential for rapid reform to cause individuals and firms to be overwhelmed with changes, increasing the opportunity cost of tax compliance and leading to higher levels of tax evasion.

A firm size dummy (*Size*) takes on a value of one if there are 50 or less full-time employees and zero otherwise. The expectation is that smaller firms will be able to remain clandestine and hidden from the tax authority, and therefore will be more likely to engage in tax evasion. The level of enforcement is measured by a dummy variable indicating that the firm has its records audited by an outside firm/individual (*Enforce*). A significant negative coefficient indicates that enforcement of current tax laws through an independent auditor deters tax evasion. The extent to which the tax administration is an obstacle to business growth can determine whether a firm evades or complies with current tax regulations. This is captured through a BEEPS question addressing how much an obstacle the tax administration can be to business growth for each firm (*TaxAdmin*). *Fairness* measures the degree to which firms perceive the court system as fair and impartial in resolving business disputes. If the courts are not perceived as fair and impartial, there will be an incentive to evade taxes. A screening question on the legal organization of the firm determines whether or not the firm is privately owned (*Owner =1)* or otherwise (*Owner =0*). Presumably, privately owned firms will be more likely to evade than state-owned firms. Finally, in order to run the standard Heckman selection equation (as discussed below), an exclusion restriction is required that is necessary for the first-stage probit. The exclusion restriction is a measure of the level of influence that the firm had in recently enacted laws or regulations that impact the firm's business (Nur-tegin 2008).

Methodology

Heckman Selection Model

The relationship between tax evasion and the various factors is summarized in the following linear model:

$$y_i = x_i'\beta + \varepsilon_i, \tag{2.1}$$

where the dependent variable, y_i, is a proxy for tax evasion by firm *i* and derived from question 58 in the BEEPS data, x_i is a vector of explanatory variables, and ε_i is the error term. Question 58 asks firms to reveal potentially delicate information about tax compliance by typical firms in the same area of business and implicitly their own tax compliance. Sample selection arises because there is potential for firms to report full compliance by other businesses, fully aware that evasion takes place in the market and may even evade themselves.[36] Firms reporting full compliance will result in censoring of the dependent variable at zero (100 - percent of reported annual sales for tax purposes). In other words, the percent of annual sales evaded (y_i) is zero when firms report full compliance. Dishonest firms reporting full compliance creates a sample selection problem because there will be systematic towards zero. The truthfulness of a firm's response to Question 58 may be evaluated based on topic related to tax evasion; specifically, a question addressing bribery of officials for tax related purposes (Nur-tegin 2008).

Sample selection mechanisms result in non-random samples due to sample design or behavior of sample units (e.g. non-response on surveys) (Woolridge 2002). Transforming the tax compliance question into a tax evasion makes a selection model an appropriate choice. To do this we follow Nur-tegin (2008), and subtract the percent of sales reported for tax purposes from 100 resulting in the percent of sales evaded from the tax authority. Therefore, full compliance results in this variable equaling zero. If all firms responding to the survey are being honest, then sample selection will not be a problem; however, sample selection becomes a problem when firms are dishonest about how much tax evasion takes place. It is not sample selection in the sense that the dependent variable is censored due to non-response, but sample selection due to dishonesty in that firms are reporting full tax compliance. A firm's truthfulness regarding tax evasion can be evaluated based on its response to a question regarding a type of corruption related to tax evasion. Specifically, we assume that, if a firm is not honest

[36] 55.06 percent of the respondents report full compliance.

about bribery to evade taxes, then it is likely that it will also be dishonest about tax evasion (Nur-tegin 2008). This seems a safe assumption given that it is widely accepted that corruption and bribery in transition countries increases distrust in the government and contributes to a lack of voluntary tax compliance (Martinez-Vazquez and McNabb 1997). Therefore, if the reason that firms report more tax compliance is completely random, then no sample selection bias exists (Woolridge 2002).

We use Heckman's (1976) selection model to handle these selection issues. The model is as follows:

$$\begin{aligned} y_i &= x_i\beta + u_{1i} \\ z_i\gamma + u_{2i} &> 0 \end{aligned} \qquad (2.1')$$

where the bottom equation is the selection equation and x_i is a strict subset of z_i, and z_i contains an exclusion restriction affecting the first stage probit equation but not the second stage regression on y_i. In our case we represent the selection equation as an equality with BEEPS question 56g regarding their acknowledgement of bribery that takes place in order to successfully evade taxes. The model is thus altered to become:

$$\begin{aligned} y_i &= x_i\beta + u_{1i} \\ h_i &= z_i\gamma + u_{2i} \end{aligned}, \qquad \text{where} \quad \begin{aligned} &u_1 \sim N(0,\sigma) \\ &u_2 \sim N(0,1) \\ &corr(u_1,u_2) = \rho \end{aligned} \qquad (2.1'')$$

The variable y_i measures true representations of firm *i*'s beliefs only if h_i is observed. If bribery occurs, then firm *i* will believe that there is a low probability of prosecution and will be more likely to reveal the truth about their evasion activities (Nur-tegin 2008). The variable h_i is defined to equal 1 if firm *i*'s responds to bribery to officials for tax evasion purposes is seldom or more. Therefore,

$$h_i = \begin{cases} 1, & if \;\; h_i > 1 \\ 0, & if \; h_i \leq 0 \end{cases} \tag{2.2}$$

Under the model's assumption, we use this specification to estimate the following conditional probability:

$$E(y_i | x, u_{2i}) = x_i\beta_i + E(u_{1i} | x, u_{2i}) = x_i\beta_i + E(u_{1i} | u_{2i}) = x_i\beta_i + \gamma_i u_{2i} \tag{2.3}$$

where the second equality follows because the model assumes that (u_{1i}, u_{2i}) are independent from the matrix ***x*** (Woolridge 2002). If $\gamma_1 = 0$, then the errors are uncorrelated and there is no sample selection problem; ordinary least squares (OLS) errors will not be biased, and estimates of beta will be consistent. If $\gamma_1 = 1$ and we use iterated expectations, then equation (2.3) becomes:

$$E(y_i | x, h_i) = x_i\beta_i + \gamma_i E(u_{2i} | x, h_i) = x_i\beta_i + \gamma_i \psi(x, h_i) \tag{2.3$'$}$$

Because the selected sample is where $h_i = 1$; $\psi(x, h_i) = \psi(x, h_i = 1)$, and given the selection equation, we can write

$$E(y_i | x, h_i = 1) = x_i\beta_i + \gamma_i \lambda(x_i z_i) \tag{2.4}$$

where $\lambda = \dfrac{\phi(z_i\hat{\gamma})}{\Phi(z_i\hat{\gamma})}$ is the inverse Mills ratio for observation *i* and provides a consistent beta and variance estimates using OLS (Woolridge 2002).

The ultimate purpose of using the Heckman's two-step estimate is to use the significance of the inverse Mills ratio to test for sample selection. If the inverse Mills ratio is insignificant, then it can be argued that sample selection is not a problem and OLS results are consistent.[37]

Finally, there is potential for heteroskedastic residuals in the sample with OLS estimation. This requires a correction suggested by Davidson and MacKinnon (1993) and produces conservative confidence intervals.[38]

Estimation Results

The results from the Heckman two-step model are presented in Table A7. The inverse Mills ratio is insignificant at all levels indicating that sample selection bias is not an issue and that ordinary least squares does not present biased results.[39] The ordinary least squares results, presented in Table A8, have hetereoskedastic-consistent robust standard errors, and, compared to the Heckman model (Table A7), they show some differences among the coefficients.

The payroll tax variable (*SST*) decreases in magnitude but is still significant at the 5 percent level with OLS estimation. Also, the value-added tax (*VAT*) variable in the Heckman model (Table A7) becomes inconsistent in the OLS results (Table A8). It is expected that increases in taxes would result in increased tax evasion. Nur-tegin (2008) notes that this negative result is consistent with the assumption that individuals are risk-averse. If the penalty of evasion is assessed on evaded taxes, then increases in the tax rate increase the penalty of evasion and agents may become more compliant. The corporate income tax (*CIT*) coefficient reduced in magnitude but, it increases in

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[37] We run maximum likelihood to check that rho (corr(u_{1i}, u_{2i})) is within the acceptable range of (-1,1) and to indicate that the Heckman procedure is an appropriate fit for the data.
[38] STATA 9.2 statistical package is used to run the regressions.
[39] Note that the *Mining* variable is not included in the regression due to multicollinearity.

significance using OLS. Again, the negative sign indicates that agents are risk averse; increasing the tax rate increases the expected penalty and reduces tax evasion.

The remaining variable coefficient results are as expected and highly significant using heteroskedastic robust standard errors. Table A9 lists the variables significant at the 5 percent level or better.

An increase in the complexity of the tax system (*Complex*) will decrease tax compliance, as expected. The coefficient indicates that a ten percent increase in the time senior management spends dealing with public officials regarding the application and interpretation of law and regulations will increase tax evasion by 1.05 percent.

The next two variables address corruption related to tax collections (*Corrtax*) and general corruption (*Corrgen*). *Corrtax* is positive and significant at the 1 percent level, and the magnitude of the coefficient indicates a large effect on tax evasion, so that increases in unofficial payments to government officials for tax purposes increase the level of tax evasion. *Corrgen* is smaller in magnitude but has the same increasing effect on tax evasion as *Corrtax*, with a ten percent increase in general corruption leading to an 8.5 percentage point increase in tax evasion. Both variables point out that corrupt governments are more likely experiencing high amounts of tax evasion and underground activity.

Enforce is highly significant and, as expected, more enforcement through auditing reduces the amount of tax evasion. In developing and transition countries enforcement may be inadequate to deter firms or individuals from evading taxes. This is evidence of the importance of tax enforcement agencies, which may or may not be part of the tax administration agencies in each country.

Similarly, *Fairness* is also highly significant and negative; the fairer and more impartial the court system is in handling business disputes, the lower is the level of tax evasion. It is not surprising that this variable has such a significant result due to the potential to experience corruption in developing and transition economies that extends to the judicial system.

The smaller the firm (*Size*) the easier it is to remain clandestine and to evade taxes without being detected by the tax authority. This result is not surprising in the transition economies included in the data set where there is potential for a significant amount of tax evasion. Firms will want to stay small in order to continue to evade without the fear of being caught by the tax authority and fined for evading.

The results also indicate that privately owned firms (*Owner*) are more likely to evade taxes than state owned firms. State owned firms may be subject to government oversight and regular audits, increasing the cost of evading taxes relative to private firms.

As for our market variables, market competition (*Competition*) does not necessarily reduce the amount of tax evasion. Even so, a negative coefficient indicates that the benefits of evasion have been transferred away from tax evaders to consumers. Recall that there may be a short-run long-run dynamic to tax evasion. In the short-run, a firm or entrepreneur will enter a competitive market and benefit from tax evasion until the expected gamble is competed away. If this was the case in 2002, *Competition* would be positive; the more competitive the market the higher the amount of tax evasion. In the long-run, tax evading firms will compete with one another and reduce the benefits of evasion until the expected profits of evading equals the certain profits when complying. Any increase in market competition would not increase tax evasion. This does not imply that tax evasion has ceased to be taking place. Firms in a tax evading sector will still need to evade in order to stay competitive with the rest of the market in which they operate. Once the benefits of evasion have been competed away, the expected profits of evading taxes will equal the certain profits of complying shifting the benefits to consumers in the form of lower prices. In a perfect world, panel data with firm level output prices would have been ideal to illustrate this effect however; the BEEPS survey does not collect this data. Despite the lack of price data, the long-run scenario is consistent with finding a negative coefficient on the competition variable, as illustrated in Table A8-A10. This result is not surprising given that the average age of firms reporting in the BEEPS data is 14 years. This provides some evidence that the benefits of evasion have been competed away in the long-run in highly competitive industries.

The hotel and restaurants industry category (*Hotel and Restaurant*) is the only industry with significant results. Though more detailed industry information would be ideal, one could imagine that in a hotel or restaurant there may be employees paid in cash by firms. If a firm pays some employees in cash, then firm is able to reduce its operating costs by the amount of the tax savings, and so passes this savings onto customers. This implies that the coefficient on *Hotel and Restaurant* will be positive. The regression results support this intuition, and indicate that there is a higher probability of tax evasion in the hotel and restaurant industry. The rest of the industry variables included are more product industries than service industries. It was expected that *Construction*, *Transport*, and the *Other* industry category would have significant results.

The monopoly power variable (*Monopoly*) is positive and significant at the 10 percent level, as expected. The literal interpretation of this coefficient; a ten percent increase in the monopoly power variable will increase tax evasion by 0.56 percentage points. This is an expected outcome indicating that a firm with monopoly power will be able to continue evade taxes without the fear of replication and competition from new entrants or other firms in the industry. New entrants would face a barrier to entering the industry and are not able to compete. Firms existing in the industry may also face a barrier in understanding the way in which the evading firm is able to avoid compliance with tax law.

Finally, the tax administration (*Taxadmin*) and the cumulative reform index (*CRI*) variables are both insignificant. Though *Taxadmin* does not directly measure corruption, the BEEPS question asks the degree to which the tax administration is a hindrance to growth and operation of the firm. If there is a high degree of corruption throughout a country, then it would be expected that the tax administration is also corrupt and would interfere with the operation and growth of local businesses. The coefficient on *Taxadmin* is positive, indicating that "more" tax administration is an obstacle to business operations and growth, and that it is associated with a higher probability of tax evasion; however, the variable is insignificant.

Summary

The results in this chapter provide evidence of the importance of traditional tax evasion variables but also of the market structure and the industry in which tax evasion may take place. Martinez-Vazquez (1996) identifies that the benefits of evasion may be replicated and competed away, thus transferring the benefits to consumers in the form of lower prices. This implies that there is a short-run/long-run dynamic to the problem: in the short-run replication causes more competitive markets to have higher rates of tax evasion, but in the long-run the benefits of evasion will be competed away and firms in competitive markets will not benefit from further evasion activities. This chapter finds evidence of a long-run situation in which the benefits of evasion have been replicated and competed away. This is plausible given that firms reporting in the survey have an average age of 14 years. Further, there is evidence that more monopoly is associated with more evasion (in terms of the percentage of sales that the firm will evade). This is expected because firms with monopoly power are protected from replication and competition by barriers to entry.

Consistent with previous work, the results still indicate that the presence of enforcement and the existence of corruption in transition economies are critical to the firm's tax evasion decision. This result supports previous theoretical work, and it suggests that in countries where corruption is rampant, businesses will enter the underground economy to avoid the added costs that comes with dealing with corrupt government officials. As noted by Nur-tegin (2008), the countries reporting in the BEEPS survey still suffer from significant levels of corruption, and a suggested policy would be to focus on reducing corruption and increasing enforcement efforts.

Overall, the impact of understanding market structure, presented in this chapter, is that policy can be designed with the knowledge that in certain industries the existence of evasion will benefit consumers more than evaders. The important component for the government to understand when forming policy is that taxes distort prices and the presence of tax evasion alters these distortions. The presence of corruption and tax evasion may lead to high distortionary taxation (i.e., increasing taxes in compliant markets). The government needs to satisfy budget constraints to meet expenditure requirements and may increase or create taxes causing further distortions. Therefore, understanding the effects of tax evasion and market structure in an economy is paramount to designing robust tax policy.

Chapter Three: Tax Evasion Incidence; Who Benefits from Evasion?

Introduction and Motivation

The purpose of this chapter is to explore how tax evasion affects the incidence of taxation. When an individual successfully evades a tax, they no longer bear the direct burden of the tax. However, evasion can lead to subsequent changes in product and factors prices, so that the true incidence does not end with the initial tax. We define tax evasion incidence in this chapter as the incidence of a tax in the presence of tax evasion. When individuals evade taxes, they make a decision under uncertainty in which they may be caught evading and will be forced to pay a fine (e.g., the costs of evasion). If successful, however, they no longer bear the burden of the tax, and so they receive a benefit in the form of tax savings (e.g., the benefits of evasion). To be clear, tax savings are the taxes on evaded income that the individual retains and may be used for consumption. Similarly, if a firm or an entrepreneur evades taxes, then its expected profits with evasion are greater than the profits it would have made had they been fully compliant. If this is true and if the market in which evasion is occurring is also competitive with no barriers to entry; then new firms or entrepreneurs will enter the market until, at the margin, the expected profits of evading equals the certain profits when complying. Any disequilibrium in this case will result in a reallocation of resources and firms until equilibrium between the evading and compliant sectors is restored. Evasion coupled with competition will lead to the tax savings dissipating as more firms compete and as the tax savings is transferred to consumers in the form of lower prices. However, these types of competitive adjustments are not typically considered in the analysis of evasion.

As a result, it is necessary to extend previous work by building and testing a model of tax evasion incidence that includes the following qualities: general equilibrium, uncertainty, and differing degrees of competition. This chapter develops this model, thereby contributing to the literature by clearly linking the individual or firm's decision to evade to a general equilibrium analysis of tax evasion using microeconomic foundations. We build upon Harberger's (1962) general equilibrium model of corporate income tax incidence, and incorporate a measure of evasion, uncertainty, and differing degrees of competition in a computational framework. This differs from Harberger's (1962) classic incidence model in that we build a system of non-linear equations that include firm level tax evasion and uncertainty. Analysis of the change in the computational equilibrium between models with no-evasion, with evasion, and with evasion with increased competition allows a deeper understanding of the general equilibrium effects of tax evasion. We are able to show how relative prices change due to evasion, and, depending on the degree of competition in a given industry, how the traditional benefit of evasion may be shifted away from the tax evading sector via changes in output prices. Testing the model involves calibrating and solving the model using computable general equilibrium methods. Including evasion decisions in tax incidence analysis is an important step toward understanding how evasion affects the economy.

The literature on tax incidence is vast and covers many different areas of public finance. However, tax evasion incidence has not received the same attention. The common Allingham and Sandmo (1972) portfolio approach to tax evasion assumes that the only benefit to evasion is the tax savings from unreported income. This may not be true. As argued above, there may in fact be cases in which individuals, other than evaders, indirectly benefit or lose from tax evasion. In the standard portfolio approach individuals make decisions under uncertainty and maximize their expected utility of income by choosing how much income to declare to the tax authority. Martinez-Vazquez (1996) asserts that tax evasion can be viewed as a "tax advantage" in the law if the expected value of the evasion gamble is positive. Replication and competition will occur, thereby eliminating the direct tax advantage of evaded income.[40] The process of adjustment will take place in the market through changes in the relative prices of commodities and factor inputs. The traditional Allingham and Sandmo (1972) portfolio approach has been able to answer many questions about tax evasion, but it is unable to capture these general equilibrium effects.

Consider an example to illustrate the tax advantage of evasion and how it may be eliminated through replication and competition. Illegal immigrants within the United States will often stand outside of hardware stores and gasoline stations searching for day work. Access to transportation acts as a barrier to entry to the market for day workers. When this occurs, a day worker will charge a cash price for their services and may evade all or most of the daily wage, so that the expected value of the evasion gamble is positive. The standard result predicted by the portfolio approach is that the benefits of evasion are the tax savings from unreported income, which are entirely kept by the day worker. If access to transportation is easy, thereby eliminating the barrier to entry, more day workers may stand outside of hardware stores and gasoline stations. Competition

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[40] As noted by Cowell (2003), "If the rate of return to evasion is positive, then everyone evades tax." This will lead to replication and competition if the market in which evasion occurs allows entry by new entrepreneurs.

between day workers will occur and bid down wages until a reservation wage is reached and the tax savings are eliminated. In this adjustment process, the benefits of evasion are transferred to the consumers of day labor. This example illustrates that not only is uncertainty important to the analysis, but differing degrees of competition are also key to understanding how the benefits of evasion are transferred through changes in the relative prices of commodities and factor inputs.[41]

Traditional tax incidence models do not incorporate risk into the incidence effects, and this inclusion of uncertainty is the only distinction between the incidence of a legal tax advantage and tax evasion. As Martinez-Vazquez (1996) notes, "The differences in the incidence adjustments to legal tax advantages and tax evasion opportunities lie in the way they impact taxpayers' budget constraints." Evasion incidence may also shed light on issues relating to vertical and horizontal equity, especially in the presence of tax policies aimed at equitable redistribution of income. Skinner and Slemrod (1985) note that, depending on how easy it is to hide capital or labor income, the true distributional effects of taxation may be quite different than implied by standard incidence analysis.[42] However, if the advantage of evasion is replicated and competed away, as suggested by Martinez-Vazquez (1996), then a general equilibrium model of tax evasion incidence is warranted.

The rest of the chapter is organized as follows. The next section reviews previous literature beginning with a definition distinguishing between evasion and avoidance

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[41] Karlinger (2008) builds an oligopoly game model and shows that competition affects the size of the underground economy in which evasion may take place and an important consideration in tax evasion incidence.

[42] Skinner and Slemrod (1985) also point out that tax evasion can lead to more economic efficiency if it is the case that the evading sector would not even exist if taxed. A simple example that they give is a weekend job that one would not pursue if the income earned were taxed, since the cost would outweigh the benefits in monetary terms.

followed by a discussion of an individual's and firm's decision to evade. Section three develops a non-linear computable general equilibrium model containing tax evasion, uncertainty, and differing degrees of competition. Section four discusses the social accounting matrices and model calibration, and section five presents the sensitivity analysis and counterfactual simulations. We conclude with a summary and a discussion of future extensions.

Significant Previous Literature

The seminal work on tax evasion is Allingham and Sandmo (A-S hereafter) (1972), together with Srinivasan (1973). These papers were followed by numerous contributions that extended the analysis in many different directions. This review of the literature does not cover all of the various extensions that have been done since the A-S model, but identifies previous literature related to developing a model of the incidence of tax evasion. Cowell (1990) surveys the early tax evasion literature; Andreoni, Erard, and Feinstein (1998), Alm (1999), Slemrod and Yitzhaki (2002), and Cowell (2003) are more recent surveys. Sandmo's (2005) retrospective piece illustrates the basics of the A-S model, and then goes on to address its weaknesses given more recent contributions in the evasion literature, such as labor supply decisions (e.g., black market labor) and black market labor demand. Slemrod (2007) also reviews what we know about the magnitude, nature, and determinants of tax evasion, and the policy implications of addressing public finance issues when evasion creates further distortions.[43]

[43] "Once the reality of tax evasion is recognized, the incidence and efficiency of a tax system may depend critically on which side of the market *remits* the tax to the government and which side must report its transactions to the government" (Slemrod 2007).

This literature review begins with a brief overview of the difference between evasion and avoidance. The next subsection is an in-depth analysis of the A-S model at the individual level followed by the firm level analysis in the third section. We then review previous work on tax incidence analysis to include the measurement of incidence, partial equilibrium analysis, and the rationale for a general equilibrium analysis.

Evasion versus Avoidance

Justice Oliver Wendell Homes distinguished between evasion and avoidance in Bullen v. Wisconsin, 240 U.S. 625 (1916) in the following passage:[44]

> "When the law draws a line, a case is on one side of it or the other, and if on the safe side is none the worse legally that a party has availed himself to the full of what the law permits. When an act is condemned as an evasion, what is meant is that it [240 U.S. 625, 631] is on the wrong side of the line indicated by the policy if not by the mere letter of the law" (Bullen v. Wisconsin (1916), 240 U.S. 625).

Therefore, the difference between tax evasion and tax avoidance is the illegality of evasion. Tax avoidance is the process of exploiting loopholes in the tax system to reduce tax liability. Sandmo (2005) argues that there are moral imperatives to tax avoidance and evasion; that is, what is right or wrong does not necessarily coincide with what is legal or illegal. As such, when considering tax evasion, one must be mindful of the fact that the basic assumption of the model is that the taxpayer is hiding the evasion activities from tax collectors.

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[44] This quote appears in Slemrod and Yitzhaki (2002) and others..

The A-S Model

Assuming that there is some cost to observe the true tax base of a given taxpayer, the taxpayer will make a decision under uncertainty as to how much income to evade.[45] *W* is the gross income of the taxpayer and *t* is a proportional income tax rate. Evaded income is given by *E*; thus, the amount of declared or reported income is (*W-E*), which we replace with *D* for simplicity.[46] There are two potential outcomes for the taxpayer: being caught and not being caught by the tax authority. Net income if the taxpayer is not apprehended is:

$$Y = W - t(W - E) = W - tD, \tag{3.1}$$

If apprehended, the taxpayer will pay a penalty rate f on evaded income (*W-D*), so that income *Z* becomes:

$$Z = W - tD - f(W - D) \tag{3.2}$$

where $f(W - D)$ is the penalty assessed on the amount of evaded income. The taxpayer maximizes expected utility by choosing *D* with the uncertainty ρ of being detected and punished.[47] Thus the individual chooses how much income to declare in order to maximize the following:

$$\max_{\{D\}} V = (1 - \rho)U(Y) + \rho U(Z) \tag{3.3}$$

[45] Sandmo (2005) notes that this is a simplifying assumption because in most cases earned income is reported to the tax authority by an individual's employer, so that the only way to evade this income is if the employer and the employee collude.
[46] *D* is the amount of declared income to the tax authority (Alm 1999).
[47] ρ is the taxpayer's subjective probability in that they do not know the true probability of detection as determined by the tax authority (Sandmo 2005).

Assuming that $U(\bullet)$ is increasing and concave implies that individuals are risk averse. Thus the first order condition for an interior solution is (primes denote derivatives):

$$(1-\rho)U'(Y)t - \rho U'(Z)(f-t) = 0 \tag{3.4}$$

This can be rewritten as a function of the probability of detection, tax rate, and penalty rate as follows:

$$\frac{U'(Z)}{U'(Y)} = \frac{(1-\rho)t}{\rho(f-t)} \tag{3.5}$$

Because the utility function is assumed to be concave, the second order condition, or

$$(1-\rho)U''(Y)t^2 - \rho U''(Z)(f-t)^2 < 0 \tag{3.6}$$

is satisfied. Using the first and second order conditions, comparative statics results can be derived. They show that an increase in the probability of detection ρ increases the amount of declared income, *D*. The same result holds for the penalty rate on undeclared income.[48] Interpreted in a different way, increasing the penalty rate or the probability of detection lowers the amount of evasion (Sandmo 2005). The assumptions of the utility function also imply that as individuals become more wealthy, they will be more inclined to engage in risky behavior, which implies that absolute relative risk aversion is decreasing in income, or $\left(-\frac{U''(\bullet)}{U'(\bullet)} \textit{ decreases as gross income increases}\right)$. Finally, the

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[48] Totally differentiate the first order condition and derive following :

$$dD/df = -\frac{(-1)\rho(f-t)U''(Z) + (1-\rho)U'(Z)}{(1-\rho)U''(Y)t^2 - \rho U''(Z)(f-t)^2} > 0 .$$

Given that the penalty rate is greater than 1, *f* >1, and given also the concavity of the utility function, this equation is unequivocally positive (Alm 1999).

A-S model shows that the effect of *t* on evasion is ambiguous due to income and substitution effects. If *t* increases, then the income effect is negative because individuals must pay more taxes and effectively become poorer, however the substitution effect is positive because the taxpayer can change the level of declared income (Alm 1999; Sandmo 2005).

Yitzhaki (1974) points out that the ambiguous result on the tax rate only occurs because of the assumption that the penalty is applied to evaded income and not the evaded tax, as is the case in the United States and Israeli tax law. Thus, changing *Z* to reflect the imposition of the penalty on evaded taxes (rather than evaded income) will eliminate the substitution effect present in the standard A-S model:

$$Z = W - tD - ft[W - D] \tag{3.7}$$

The first order condition now becomes:

$$\frac{U'(Z)}{U'(Y)} = \frac{(1-\rho)t}{\rho t(f-1)} = \frac{(1-\rho)}{\rho(f-1)} \tag{3.8}$$

Equation 3.8 shows that the relative price of income is no longer a function of the tax rate *t*, no matter what is the state of the world. There is no substitution effect because the penalty rate is fixed, and any changes in *t* have similar effects on income in the two states of the world (Sandmo 2005; Yitzhaki 1974). The paradox of Yitzhaki's (1974) result is that it goes against intuition about how people will react to high tax rates. The common belief is that higher marginal tax rates will encourage evasion because the individual faces a larger gain from underreporting income from the tax collector. The explanation for Yitzhaki's (1974) result is that as tax rates increase so does the penalty for evasion. The A-S model has "…a positive substitution effect on evasion because the net penalty—

the difference between the penalty rate and the regular tax rate—goes down when the tax rate increases" (Sandmo 2005).

Firm Level Evasion

Establishing that firms play a role in tax evasion incidence introduces as relevant considerations both different degrees of competition across sectors as it relates to factor mobility and also to firm entry across sectors. This is critical to understand how much benefit evaders may receive and how much is shifted away via price adjustments in the market (Martinez-Vazquez 1996).

There have been several papers introducing different types of tax evasion (i.e., indirect tax evasion), and, although they introduce uncertainty into the model, they are not general equilibrium analyses. Marrelli (1984) develops a model similar to the A-S model for a monopolistic firm's decision to evade indirect taxes. The firm must decide whether to shift the tax onto consumers; evade the tax by only declaring a portion α of the total revenue; or do a combination of shifting and evading. The income of the firm if it underreports and is not caught by the tax authority is:

$$Y = (1 - \alpha t)R(q) - C(q), \tag{3.9}$$

where $R(q)$ is the total revenue, $C(q)$ is the total cost of producing *q* units output, and *t* is a constant tax rate levied on a fraction of the gross sales price *p*. The firm faces a probability π of being caught, and, if apprehended by the tax authority, the firm will face a penalty on the evaded tax. Thus, income if caught is:

$$Z = (1 - \alpha t)R(q) - C(q) - \pi t(1 - \alpha)R(q) \tag{3.10}$$

The firm's problem is to maximize its expected utility by choosing the level of production q and the amount of evasion α to maximize expected utility. This can be written as:

$$\max_{\{q,\alpha\}} \varepsilon U = (1-\pi)U(Y) + \pi U(Z),\ s.t.\ q \geq 0,\ 0 \leq \alpha \leq 1 \tag{3.11}$$

Marrelli (1984) derives Kuhn-Tucker conditions, the solution for which is:

$$\begin{aligned} &\alpha = 1,\ for\ \frac{\pi(\tau-1)}{(1-\pi)} > \frac{U'_Y}{U'_Z} \\ &\alpha = 0,\ for\ \frac{\pi(\tau-1)}{(1-\pi)} < \frac{U'_Y}{U'_Z} \\ &\alpha = \alpha^*,\ which\ \ is\ the\ solution\ to\ \frac{\pi(\tau-1)}{(1-\pi)} = \frac{U'_Y}{U'_Z} \end{aligned} \tag{3.12}$$

To simplify these conditions, consider when the probability of detection is zero, or $\pi = 0$. Then $\alpha = 0$, and the firm evades all income and becomes a black market firm. At the other extreme, if the probability of detection is one, or $\pi = 1$, then $\alpha = 1$ and no evasion takes place, so that $Y = Z$. If $\pi\tau < 1$, we have $\alpha < 1$, and the taxpayer declares something less than true tax base. Further, if $\alpha = \alpha^*$, then the firm is able to pass the entire tax onto consumers just as if it was not evading any tax .[49] It is worth noting that the output of the firm is not dependent on the probability of detection and the penalty. Other similar papers include Marrelli and Martina (1988), Virmani (1989), and Gordon (1990). Again, all of these papers are only partial equilibrium models.

Firms may not only evade indirect taxes but may also evade income taxes, something that the A-S model cannot handle because of the contractual relationship of

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[49] For further analysis, see Marrelli (1984).

shareholders and managers of firms. The A-S model does not separate ownership from control of the firm, which is critical to corporate tax evasion analysis. Chen and Chu (2002) and Crocker and Slemrod (2003) are two recent papers that examine this issue, and they conclude that the evasion will depend on who is penalized for such activity.

Alm and Thorpe (1995) find that changes in the number of firms can cause discontinuities in the market equilibrium, which can lead to changes in market prices that are larger than the amount of the tax change, can impact income and welfare much differently, and can have a large impact on aggregate utility. Thus, different degrees of competition are necessary to understand the mobility of factors of production and entry, which will determine who benefits from tax evasion and for how long.

The hard-to-tax (HTT) literature also directly applies to this analysis, despite the fact that HTT groups include more than just tax evaders. HTT groups can be generally defined as "small and medium sized firms, professionals, and farmers" (Alm, Martinez-Vazquez, and Schneider 2004) . Taxpayers that fall into this group can function in the formal or informal sector of the economy, and the ability of the HTT to function in both the formal and informal sectors makes their tax information difficult, even impossible, to obtain. Thus, the economic analysis of the HTT is related to the shadow economy and the tax evasion literatures. Das-Gupta (1994) developed a theoretical model of the HTT based on the number of income generating transactions in one year. Individuals with many transactions, such as independent contractors, have income that is less risky because the tax authority does not have the ability to detect other transactions simply because it is able to see one single transaction. Alm, Martinez-Vazquez, and Schneider

(2004) point out that it is easy to find counterexamples of firms that have multiple transactions each year, and do not fall into the category of the hard-to-tax.[50]

Hard-to-tax groups may in fact exist in markets where engaging in some sort of evasion activities can lead to the aforementioned transfer of benefits (i.e., the taxi cab example). They are a source of significant revenue losses especially in developing countries, and their presence limits the sophistication and the complexity of the tax structure. The hard-to-tax may also cause resource allocation inefficiencies because they engage in cash, barter, or other means of carrying out transactions; they may lead to losses in economies of scale because small transactions are less likely to be detected; and they cause over-allocation of labor and other resources to the HTT sector because of differential burdens (Alm, Martinez-Vazquez, and Schneider 2004).[51]

The A-S model is inherently partial equilibrium, and a general equilibrium approach is necessary to complete the incidence of tax evasion. Martinez-Vazquez (1996) discusses how the benefit of tax evasion can be thought of as a tax advantage, and as such “we would expect replication and competition” until all advantages are competed away. For this reason, a general equilibrium approach is necessary for a complete analysis of evasion incidence, in order to capture the changes in relative prices of goods and factors of production.

There have been several papers that have adopted a general equilibrium approach adding to the study of evasion incidence, including Kesselman (1989, 1993), Alm (1985),

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[50] For further details on the hard-to-tax, see Alm, Martinez-Vazquez, and Schneider (2004).

[51] Over-allocation of labor and other resources to the HTT sector will only occur if resource decisions depend on tax evasion opportunities (Alm, Martinez-Vazquez, and Schneider 2004). Yaniv (1988, 1995) shows that the factor input decisions for production, under certain conditions, are separable from the evasion decision. Panteghini (2000) shows that separability fails to hold if firms fail to obtain an interior solution or if unfavorable events affect investment decisions (e.g., Bernanke’s “bad news principle." In these cases, a potential audit (e.g., “bad news”) affects investment decisions, which in turn affect production decisions.

Watson (1985), Hansson (1985), Thalmann (1992), and Sennoga (2006). Sennoga (2006) extends Thalmann's (1992) work by incorporating his model into a computable general equilibrium framework. Thalmann (1992) builds uncertainty into the individual's budgets constraint as an expected penalty on income of the informal sector. Sennoga (2006) extends this model to include market imperfections through the elasticity of substitution between consumption and leisure. In this chapter we also include uncertainty, like Thalmann (1992) and Sennoga (2006). However, our approach is different than in these other works, as we discuss later. Also, we incorporate differing degrees of competition by including a price mark-up, which is different from Sennoga's (2006) approach. Therefore, one goal of this chapter is to use a general equilibrium approach to include uncertainty, introduced by the A-S model, and differing degrees of competition in order to develop a more complete model of the incidence of tax evasion.

Tax Incidence Analysis

Tax incidence is concerned with identifying who bears the burden of a tax. The burden can be divided into statutory or economic incidence. "Statutory incidence" deals with who legally is obligated to pay the tax, while "economic incidence" deals with those who lose real income as a result of the tax. Further, a tax can be viewed as being passed forward to consumers or backwards on production inputs such as capital and labor. If a tax is passed forward to consumers, then the burden is considered to be on the *uses* of income side; if the tax is passed backwards, then the burden is on the *sources* of income side. Both the *uses* and *sources* side are used to measure the tax burden, especially whether the burden is progressive, regressive, or proportional (Fullerton and Metcalf 2002).

There are at least three measures of tax incidence. The first is statutory in nature in which the impact of the tax is calculated by income class and the burden of the tax is analyzed. A change in relative prices, or differential incidence, is a second measure of tax incidence. Harberger's (1962) work on the incidence of the corporate income tax was the first paper to address tax incidence in a general equilibrium framework, and has subsequently led to many extensions including dynamic tax incidence studies. The third approach to measuring incidence is to analyze changes in welfare using computational techniques, as introduced by Shoven and Whalley (1977) and as extended by many economists including Fullerton and Rogers (1993) and Auerbach and Kotlikoff (1987). At the end of the day, regardless of the way in which tax incidence is modeled, individuals must bear the burden of a tax (Tresch 2002).

Kotlikoff and Summers (1988) and Fullerton and Metcalf (2002) have comprehensive reviews of tax incidence modeling and the many directions in which incidence models have been extended. Both reviews begin with partial equilibrium analysis in which a tax is analyzed in a single sector, ceteris paribus. Consider an example in which an excise tax is introduced in a competitive market:

No Tax: $D(P) = S(P)$ (3.13)

Tax: $D(P) = S(P - T)$ (3.14)

In both cases demand is set equal to supply in the market. However, when the unit excise tax is applied, the price that suppliers receive is reduced by the amount of the tax. Totally differentiating the tax case gives:

$$D'dP = S'(dP - dT), \text{ where } S' = \frac{dS}{dP}, D' = \frac{dD}{dP} \tag{3.15}$$

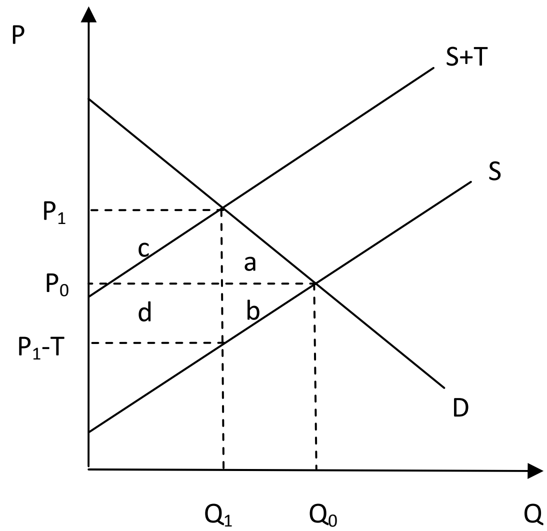
Solving for $\frac{dP}{dT}$ gives:

$$\frac{dP}{dT} = \frac{S'}{S' - D'} = \frac{\eta_S}{\eta_S - \eta_D} \tag{3.16}$$

This expression captures the partial equilibrium results for tax incidence. Some special cases in which consumers or producers bear the full burden of the tax are worth mentioning. If $\eta_S = 0$ or $\eta_D = \infty$, then $\frac{dP}{dT} = 0$ and producers will bear the full burden of the tax because the market price paid does not change given a change in the tax. On the other hand if $\eta_S = \infty$ or $\eta_D = 0$, then consumers will bear the full burden as the change in price is equal to the tax. The result is that those individuals with a more elastic demand or supply curve will bear more of the burden of the excise tax.

Figure 1 illustrates an excise tax that is collected and remitted to the tax authority by suppliers, hence the supply curve shifts up from S to S+T. In this case both demand and supply bear the burden of the tax. Consumer surplus that is lost is equal to areas c+a, and producer surplus loss is areas d+b. Tax revenues are equal to c+d, where c is part of the tax revenue that consumers pay and d is the portion of tax revenues that producers pay. P_1 is the gross of tax price paid in the market, and P_1-T is the net of tax price that producers receive. The deadweight welfare loss is equal to areas a+b.

Figure 1. Basic Tax Incidence Model



The limitation of partial equilibrium analysis is that it does not consider other markets that may be affected from a tax in a single market, via changes in factor inputs, complements, or substitute goods due to a tax. Thus, a general equilibrium approach is necessary (Kotlikoff and Summers 1988).

General equilibrium models can be divided into two broad categories, static and dynamic. Static general equilibrium models are simplified because it is assumed that savings and investment do not affect the analysis. Harberger (1962) is a classic example of a static general equilibrium model with two goods and two factor inputs to model the incidence of the corporate income tax.[52] There have been many extensions to this classic model over the years. McLure (1975) reviews the many early extensions and applications of the Harberger model. One such extension that is of importance to this

[52] This model also assumes perfect mobility of fixed factors, constant returns to scale, full employment, and perfect competition (Harberger 1962).

analysis is weakening the assumption of perfect mobility and assuming that one factor input is immobile due to evasion activities (McLure 1971). He finds that factor mobility has an effect on tax incidence. Mieszkowski (1967) finds that there are two other effects of some taxes, which he calls the output or factor-intensity effect and the factor-substitution effect and which sum to the total effect on tax incidence.[53]

Harberger (2008) discusses how there is no all-encompassing model of tax incidence and that certain assumptions are necessary given the specific distortions and questions that a researcher wishes to answer. One such assumption that is often made is that of *demand neutrality*, in which it is assumed that the government will spend tax revenues in exactly the same way as individuals would had they not been taxed. This enables the researcher to use one set of demand functions rather than complicating the analysis with a government demand function. He argues that the key to "good" incidence analysis is to keep it simple enough to capture economic behavior and realistic economic structure while still allowing one to understand how the model is working. Too many complications can lead to results that we either have to accept as truth or that remain unclear about the process that produces them. Harberger (2008) defines the *known* as the economic behavior that can best be represented by demand, production functions, and the like, which are the basic elements of general equilibrium modeling. The *knowable* are the parameters of the known functions in terms of their orders of magnitudes (and not specific point estimates). This leads to the logical conclusion that general equilibrium modeling allows us to broadly paint a picture of the economy and the incidence of a specific tax (Harberger 2008).

[53] Factor immobility can occur regardless of whether or not tax evasion is taking place.

Depending on the scenario one may wish to analyze, it may be better to model an open economy rather than the classic closed economy model. Developing an open economy extends the classic model in which there are two sectors (corporate and non-corporate), to four sectors (corporate, non-corporate, tradable, and non-tradable). The traditional Harberger model leads to the conclusion that owners of capital bear the burden of the corporate income tax; extending the model to an open economy with four sectors leads to labor bearing more than the full burden of the corporate income tax (Harberger 2008).[54]

The second category of general equilibrium models is dynamic in nature in that taxes affect savings and investment decisions and thus have an effect on capital formation and subsequent factor and product prices. The importance of these models is that through time capital formation, intergenerational distribution of welfare, and prices will be affected by tax policy decisions. Life-cycle or overlapping generation models distinguish between members of different generations.

The model that is developed here extends Harberger's (1962) work using a static general equilibrium model assuming that savings and investment decisions remain constant. The model we build differs from Harberger's (1962) model in that it is a non-linear computable general equilibrium model and it includes differing degrees of competition, uncertainty, and tax evasion.

Recall that the basic tax evasion models at both the individual and firm level are partial equilibrium and do not consider general equilibrium effects. Recall also that there have been some attempts at a general equilibrium analysis of tax evasion; however, these models lack either uncertainty or differing degrees of competition. Sennoga (2006) uses

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[54] See Harberger (1995) for the complete analysis of the corporate income tax in an open economy.

Thalmann's (1992) general equilibrium model to build a computable general equilibrium model to analyze the tax incidence with evasion; however, he builds a model based on individual level evasion while we focus on firm level evasion. We believe that a better way of modeling competition is through the ability of firms to include a price mark-up above the competitive price level. We also believe that building evasion into the market through the firm is a better approach for analyzing the incidence of tax evasion than Thalmann's (1992) model. Thus, we will be able to identify how tax evasion affects output and output prices, factor input prices, and welfare of individuals in the economy. Section three of this chapter extends previous work on tax evasion incidence to build tax evasion, uncertainty, and differing degrees of competition into a non-linear computable general equilibrium model.

A Non-linear Computable General Equilibrium Model

Testing the non-linear computable general equilibrium model developed here involves simulations of an economy with realistic parameter values utilizing general equilibrium conditions formalized by Arrow and Debreu. A static CGE model emphasizes the interaction among different industries and sectors, and allows for product and factor mobility in response to changes in returns, the main purpose of which is to analyze the distributional aspects of various tax policies in a general equilibrium environment. Specifically, how do the distributional aspects of factor input or sales taxes change in the presence of a sector that evades each tax? The microeconomic foundations of CGE modeling are based on Walrasian equilibrium. The main actors in this circular flow are households and firms where households supply factor inputs and consume final products, while firms rent factor inputs from households in order to produce goods and services. Equilibrium in this setting must follow the concept of conservation of product and value. Conservation of product means that factor inputs owned by households must be fully absorbed by firms to produce output, which in turn must be fully absorbed by household consumption. Conservation of value is an accounting principle, such that the value of expenditures must be met with an equal value of income. These characteristics of the circular flow lead to three conditions that define Walrasian equilibrium: market clearance, zero profit, and income balance. These conditions enable the CGE model to solve for market equilibrium prices, goods, and factor inputs simultaneously. Another aspect of the model is that we are also able to examine the welfare effects of policies (Wing 2006).

McDougall (1995) points out that CGE modeling is useful when both the economy-wide constraints and sector specific effects are important for welfare analysis of a second-best nature, and for questions that relate to general equilibrium rather than partial equilibrium elasticities. In the case of tax evasion incidence, we want to explore the general equilibrium distributional impact of evasion in the presence of a pre-existing factor input or sales tax both in a perfectly competitive environment and in a monopoly environment. A second issue is the effects on welfare. How does a partial factor or sales tax with evasion occurring affect distribution and welfare in both a perfectly competitive and monopoly environment? Answering these questions allows us to examine how the benefits of evasion may be transferred from evaders to consumers in the form of lower prices of final goods.

Walrasian General Equilibrium and the Social Accounting Matrix

This section derives the equilibrium expressions necessary to maintain the circular flow of the economy, which are also used to calibrate the CGE model. First, assume a closed economy with N-industries producing commodities, an unspecified number of households acting as one representative agent with an endowment of F different primary factor inputs for rent. Further assume that there are no taxes or other distortions in the economy and that households use their income to purchase N commodities to satisfy D types of demand. Each firm hires F primary factor inputs and N commodities as intermediate inputs to produce a quantity of output, Q. The following indices hold true for the remainder of this section; $i = \{1,...,N\}$ represents the set of commodities, $j = \{1,...,N\}$ is the set of industries, $f = \{1,...,F\}$ represents the set of primary factor inputs to production, and $d = \{1,\ldots,D\}$ is the set of consumer final demands for commodities. See Shoven and Whalley (1992) and Wing (2006) for a detailed discussion. Our approach follows their analyses.

The circular flow of the economy can be described as a set of input-output matrices describing the aforementioned economy. First, there is an N x N matrix of commodities used as intermediate inputs to industry output $\overline{Z}$, an F x N matrix of primary factors of production used in each industry $\overline{V}$, and an N x D matrix of commodities to satisfy consumer demands $\overline{G}$.

A computable general equilibrium model begins with various equilibrium conditions that can be interpreted in terms of the circular flow of the economy:

- *Commodity Market Clearance*
- *Zero Profits*

- *Income Balance*

The matrices can be arranged to satisfy these three necessary conditions. Commodity market clearance requires that the value of gross output of industry *i* ($\overline{q}_i$) equals the sum of intermediate uses ($\overline{z}_{i,j}$) and the sum of final consumer demand ($\overline{g}_{i,d}$), or:

$$\overline{q}_i = \sum_{i=1}^{N} \overline{z}_{i,j} + \sum_{d=1}^{D} \overline{g}_{i,d} \tag{3.17}$$

Likewise, factor market clearance requires that the value of all individual uses of primary factor inputs ($\overline{v}_{f,j}$) equals the endowment of each agent in the economy:

$$\overline{V}_f = \sum_{j=1}^{N} \overline{v}_{f,j} \tag{3.18}$$

Zero profits requires that the value of gross output of sector *j* ($\overline{q}_j$) equals the sum of all inputs, whether they be intermediate ($\overline{z}_{i,j}$) or primary factor ($\overline{v}_{f,j}$):

$$\overline{q}_j = \sum_{i=1}^{N} \overline{z}_{i,j} + \sum_{f=1}^{F} \overline{v}_{f,j} \tag{3.19}$$

Finally, income balance is required to maintain consistency in the circular flow of the economy, and contains the total gross payment for rental of primary factor inputs. The gross income ($\overline{M}$) received for rental of primary factor inputs $\left(\sum_{f=1}^{F} \overline{V}_f \right)$ must equal the representative agent's expenditure on final demand commodities:

$$\overline{M} = \sum_{f=1}^{F} \overline{V}_f = \sum_{i=1}^{N} \sum_{d=1}^{D} \overline{g}_{i,d} \tag{3.20}$$

Together, market clearance, zero profit, and income balance require that the matrices $\overline{Z}$, $\overline{G}$, and $\overline{V}$ be arranged so that the rows and columns are equal in the benchmark period; see Figure 2. The values of income receipts for a sale of a commodity appear along the rows, while the values of inputs to demand or production appear along the column. To maintain internal consistency of the economy, some social accounting matrices will be square where supplies equal demands and therefore each row and column will sum to zero (Rutherford 1999).

Figure 2: Social Accounting Matrix

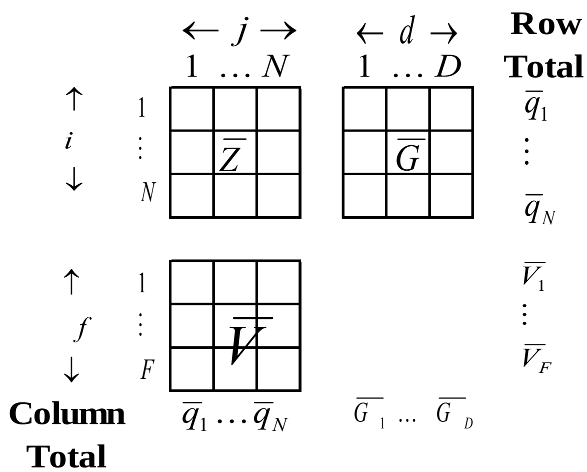

Figure 2 demonstrates that each of equations (3.17) through (3.19) holds, thereby maintaining the benchmark equilibrium absent any distortions. Summing across the top row, we see that commodity market clearance holds, or equation (3.17). Similarly, summing across the bottom row maintains primary factor input market clearance, or equation (3.18). Vertically adding down column one, we find the zero profits condition holding, equation (3.19). Finally, income balance requires that the value of income earned from endowments of primary factors equal the value of final goods consumed by households, which is represented by the bottom-right quadrant of the social accounting matrix, equation (3.20).

The analysis and equilibrium are altered from the benchmark, first, by adding labor or sales taxes to the model (which requires the addition of government), and second, by adding evasion of each tax to the model, which alters not only the amount of revenue for the government but also payments to factors and prices for consumer goods used in final demands.

Non-linear General Equilibrium Equations

Basic Assumptions

The model begins with some simple general assumptions, using the earlier framework:

- There are two consumers; i =1, 2
- There are two goods: X_j , j =1,2; j = 2 is the evading sector
- There are two producers: Non-evader and Evader, j = 1, 2
- Individuals have an endowment of factors used in production V_f ; $f = K^{i,E}, L^{i,E}$
- Individuals/households maximize utility subject to a budget constraint:

$$\max_{\{X_1, X_2\}} U^i = (X_j) \text{subject to } M^i \leq \sum_{j=1}^{J} P_j^i X_j^i \qquad (3.21)$$

where $M^i = wL^{i,E} + rK^{i,E}$; i =1,2

Individual i earns income from endowments of labor and capital. Consumers allocate endowments where they earn their highest returns. Therefore, when taxes (labor or sales) are applied to each sector equally, the evading firm will be able to pay a higher net return for factor endowments.

- The individual utility function has a CES form:

$$U^i = \left(\alpha_1^{1/\sigma} X_1^{i\,\sigma-1/\sigma} + \alpha_2^{1/\sigma} X_2^{i\,\sigma-1/\sigma} \right)^{\sigma/\sigma-1}$$

where $M^i = wL^{i,E} + rK^{i,E}$; i =1,2 and individual i earns income from his/her endowment of labor and capital. The share parameters for X_1 and X_2 are α_1 and α_2, respectively, and σ is the elasticity of substitution.

- Producers maximize profits:

$$\max_{Q_j, v_{f,j}, z_{i,j}} P_j Q_j - \sum_{j=1}^{N} p_i z_{i,j} - \sum_{f=1}^{F} w_f v_{f,j} \text{ ; } N = 2,\ F = 2 = \text{K,L} \tag{3.22}$$

Q_j – Production Good

$z_{i,j}$ – Intermediate good i used in production of Q_j

$v_{f,j}$ – Factor good f used in production of Q_j

- The only inputs to production are primary factor inputs, so that the profit maximization problem can be rewritten as:

$$\max_{Q_j, v_f} P_j Q_j - \sum_{f=1}^{F} w_f v_{f,j} \tag{3.22′}$$

- Given the producer assumptions and factor inputs, sector X_1 and sector X_2 maximization problems become:

Sector X_2:

$$\max_{K_2, L_2} P_2 Q_2 (L_2, K_2) - wL_2 - rK_2 \tag{3.22′a}$$

Sector X_1:

$$\max_{K_1, L_1} P_1 Q_1 (L_1, K_1) - wL_1 - rK_1 \tag{3.22′b}$$

Given the basic assumptions of the model, we begin by applying taxes on labor inputs and then a sales tax in both sectors. Sector 2 firms are non-compliant and evade some portion of the labor or sales tax based on their perceived probability of detection and fine rate. Therefore, we model firm level tax evasion. Two tax cases are implemented; an ad-valorem labor and sales tax are applied to factor inputs in both production sectors. Absent evasion, when implementing the ad-valorem labor tax (3.22′a) and (3.22′b) become:

Sector X_2:

$$\max_{K_2, L_2} P_2 Q_2 (L_2, K_2) - (1 + t_w) w L_2 - r K_2 \tag{3.22′′a}$$

Sector X_1:

$$\max_{K_1, L_1} P_1 Q_1 (L_1, K_1) - (1 + t_w) w L_1 - r K_1 \tag{3.22′′b}$$

The sales tax is implemented in the CGE model by applying an equal ad-valorem tax on both capital and labor inputs resulting in a model that is logically equivalent to the following equations: (3.22′a and 3.22′b change as follows):

Sector X_2:

$$\max_{K_2, L_2} (1 + t_s) P_2 Q_2 (L_2, K_2) - w L_2 - r K_2 \tag{3.22′′′a}$$

Sector X_1:

$$\max_{K_1, L_1} (1 + t_s) P_1 Q_1 (L_1, K_1) - w L_1 - r K_1 \tag{3.22′′′b}$$

The MPSGE solver used is limited with respect to the complexity of the model developed however; it can be altered to equivalently represent the desired model. Therefore, implementing an identical factor tax in both sectors is equivalent to an ad-valorem sales tax in each sector.

Consumption taxes cannot be levied on final demands in the GAMS software and must be implemented upstream in production activities.

We want to model two market cases: perfect competition and monopoly. The purpose of each case is to demonstrate the effects of tax evasion and the change in the benefits of evasion when the level of competition increases in each market. The computable general equilibrium model is static, and therefore calculates the market equilibrium at one point in time rather than over time as in a dynamic model. We increase the level of competition in each market in order to illustrate how the benefits of evasion are transferred away through market competition. For example, when the labor tax is evaded and competition increases, we show that labor more readily enters the evading sector and competes away the benefits of evasion. Increasing competition is carried out by increasing the elasticity of substitution between factor inputs, thereby allowing factor inputs to flow more easily between sectors. The monopoly market case incorporates a price mark-up in order to illustrate that the evading firm may retain the benefits of evasion. A barrier to entry allows the evading firm to maintain the price mark-up even in the presence of tax evasion of either sales or labor taxes.

In what follows we incorporate the necessary components of firm level evasion of a sales or labor taxes in the profit maximization problem, followed by the consumer's utility maximization problem.

Producer's Problem

Firms evade some portion of either the labor or sales tax, and declare only β to the tax authority; therefore, 1-μ is the amount of tax evasion.[55] The government's tax revenue becomes (1- μ)τΦ, where τ is the tax rate on Φ and Φ is a composite good to represent either factors or commodities that could face a tax in which evasion may take place. Firms choose how much tax to declare/evade based on their perceived probability of detection $0 \leq \rho \leq 1$, where the government/tax authority may investigate to discover if

[55] Again, firms will evade either the labor or sales tax and depends on the tax case we are analyzing.

firms are evading. If the firm is caught evading, then it faces a fine $f > 1$ on evaded income.[56]

Sector X_2 is the evading sector, and maximizes expected net profits:

$$\begin{aligned}\max_{K_2, L_2, \mu_2} E\left[\pi_2^{Net}\right] = \rho\left[\left(1-\left(1-\mu_2\right)\tau_2\right)P_2Q_2\left(L_2, K_2\right) + \Psi_2 - f\mu_2\tau_2P_2Q_2\right] \\ + \left(1-\rho\right)\left[\left(1+\left(1-\mu_2\right)\tau_2\right)P_2Q_2\left(L_2, K_2\right) + \Psi_2\right]\end{aligned} \tag{3.23}$$

where $\Psi_2 = -wL_2 - rK_2$. This equation may be rewritten as profits less the declared sales taxes plus the expected penalty of being caught:

$$\max_{K_2, L_2, \mu_2}, E\left[\pi_2^{Net}\right] = P_2Q_2\left(L_2, K_2\right) - w_2L_2 - r_2K_2 - \left[\left(1-\mu_2\right) + \rho f\mu_2\right]\tau_2P_2Q_2\left(L_2, K_2\right) \tag{3.23'}$$

where $\left[\left(1-\mu_2\right) + \rho f\mu_2\right]\tau_2$ is the expected tax an evading firm will face. This term includes the declared sales tax $\left(1-\mu_2\right)\tau_2$, and the expected penalty of being caught evading the sales tax, $\rho f\mu_2\tau_2$. Firms will maximize profits by selecting capital, labor, and the amount of the sales tax to evade. The first order condition with respect to μ_2 is as follows:

$$\frac{\partial E\left[\pi_2^{Net}\right]}{\partial \mu_2} = -\left[\left(-1\right) + \rho f\right]\tau_2P_2Q_2\left(L_2, K_2\right) = 0 \tag{3.24}$$

$$1 - \rho f = 0$$

Firms will evade up to the point where their expected fine is equal to one and the evaded sales tax equals the penalty if caught. Therefore, we set $\mu_2 = 1 - \rho f$ and, when a firm believes that any evaded taxes will be detection by the tax authority, ($\rho = 1$), they will

[56] Ideal policy would be designed such that individuals or firms caught evading will face large enough fines to result in negative or zero profit so as to provide the incentive to not engage in non-compliance. However, this is not necessarily the case in actual applied policy. Therefore, the use of a fine will not necessarily result in zero or negative profits.

fully comply. If a firm perceives that the probability of detection is zero, then it will fully evade the sales tax. Firms will know the fine rate for purposely evading sales taxes, and will estimate the probability of detection by the tax authority (e.g., if the fine rate is 1.1 and the perceived probability of detection is 0.1, then μ_2 = 1-0.11 = 0.89). Thus, tax evasion is endogenous and built into computable general equilibrium model.

Partial factor taxes such as a tax on capital and on labor result in a similar solution as (3.23′):

$$\max_{K_2, L_2, \mu_{l,2}} E\left[\pi_2^{Net}\right] = \rho\left[P_2Q_2(L_2,K_2) - (1+(1-\mu_2)\tau_{L,2})wL_2 - rK_2 - f\mu_2\tau_{L,2}wL_2\right] + (1-\rho)\left[P_2Q_2(L_2,K_2) - (1+(1-\mu_2)\tau_{L,2})wL_2 - rK_2\right] \tag{3.25}$$

$$\max_{K_2, L_2, \mu_{L,2}} E\left[\pi_2^{Net}\right] = P_2Q_2(L_2,K_2) - rK_2 - wL_2 - \left[(1-\mu_{L,2}) + \rho f\mu_{L,2}\right]\tau_{L,2}wL_{2L,2}wL_2 \tag{3.26}$$

Regardless of whether a firm is caught evading the sales or the partial factor tax, each retains tax savings (e.g., evaded revenues in the sales tax case, (3.23′), or partial factor taxes (3.26)), and sustains some expected penalty consisting of the amount of evasion, the probability of detection, the tax rate, and the fine rate, or $((1-\mu_2) + \rho f\mu_2)\tau$.

Household's Problem

The consumer maximizes utility by consuming goods, and is limited by the budget constraint. When firms evade labor taxes, the individual's income is increased by the amount of income their employer evades, including the cost the firm faces if caught evading. The consumer's income is equal to the sum of value of factor endowments plus the evaded income from the payroll tax. The consumer solves the following problem:

$$\max_{\{X_1,X_2\}} U^i = (X_j) \text{subject to } M^i + E[M^i] \leq \sum_{j=1}^{J} P_j^i X_j^i \ = wL^{i,E} + rK^{i,E} \text{; } i = 1,2 \quad (3.28)$$

$L^{i,E}$ - consumer *i*'s endowment of labor

$K^{i,E}$ - consumer *i*'s endowment of capital

When the payroll tax or partial factor tax is evaded, the budget constraint changes to reflect the reduction due to the tax while evasion increases the amount of income the individual earns from the firm and used for consumption. The individuals in sector X_2 have the following budget constraint:

$$M^i = \sum_{j=1}^{J} P_j X_j = wL_2^{i,E} + rK_2^{i,E} - (1-\mu_2)\tau_w wL_2^{i,E} \quad (3.29)$$

Sector 2 firms face the probability of apprehension and fines when engaging in evasion and incorporate this into the net wage paid to labor. The budget constraint including the probability of detection and fine faced by the firm as follows:

$$M^i = \sum_{j=1}^{J} P_j X_j = wL_2^{i,E} + rK_2^{i,E} - (1-\mu_2)\tau_w wL_2^{i,E} - \rho f \mu_2 \tau_w wL_2^{i,E} \quad (3.30)$$

$$= wL_2^{i,E} + rK_2^{i,E} - [(1-\mu_2) + \rho f \mu_2]\tau_w wL_2^{i,E}$$

Therefore, the consumer faces the same potential additional cost component as the evading firm in the budget constraint, which represents the expected cost of evasion and which is dependent on the probability of detection, the fine rate, the tax rate, and the proportion of evaded income. Note that the level of evasion is selected by the firm and not the individual. The general equilibrium model used here focuses on firm level evasion, and, when partial factor taxes are applied, the model maintains income balance by giving the taxes to the government. Assuming the government uses the tax revenue in the same manner as individuals, we are able to distribute the tax revenues equally between each individual in the economy. This is a standard assumption in computable general equilibrium models.

When the firm evades the sales tax, equation (3.28) becomes:

$$\max_{\{X_1,X_2\}} U^i = (X_j) \text{subject to } M^i = \sum_{j=1}^{J} (1+\tau_{j,s}) P_j^i X_j^i = wL^{i,E} + rK^{i,E} ;\ i = 1,2 \qquad (3.28')$$

When sector 2 firms evade the sales tax and face the expected penalty of evasion (3.30) is written as follows:

$$M^i = (1+\tau_{1,s}) P_1 X_1 + (1+\tau_{2,s}[(1-\mu_{2,s}) + \rho f \mu_{2,s}]) P_2 X_2 = wL_2^{i,E} + rK_2^{i,E} \qquad (3.30')$$

Absent evasion, the gross price of each good the consumer purchases increases by equal amounts as a result of the sales tax in each sector. When firms in sector 2 evade part of the sales tax we find that the evading firm declares less in sales taxes, $(1-\mu_{2,s})$, and faces an expected penalty on the evaded sales tax if caught, $(\rho f \mu_{2,s})$. The presence of evasion will alter the relative prices and cause individuals to reallocate resources towards the cheaper good and increase utility. We continue to assume the government would use the sales tax revenue in the same manner as the consumer and we distribute the sales tax revenues equally between each consumer in the economy.

Choosing Functional Forms of Utility and Production

A constant elasticity of substitution (CES) model is selected for both consumer utility and firm production technology because it allows for more plausible results than a Cobb-Douglas function (Shoven and Whalley 1992). Further, CES functions are easily transformed into Cobb-Douglas or Leontief function in the GAMS software. We begin with a no-tax, no-evasion model to illustrate the basic steps for CGE model building. We then add distortions such as the labor and sales tax (separately) along with evasion to finish the model.

The baseline model assumes an ad-valorem tax rate of $t = 1$ on labor, in the case of a partial factor tax on labor, or on both capital and labor, in the case of the sales tax.[57] Individuals make consumption decisions on the margin and any change in relative prices of goods will alter the utility maximizing decision. An ad-valorem tax rate equal to 1 signifies a doubling of prices when either the labor or sales tax is applied. There is no specific rational for setting $t = 1$and doubling prices when implementing the labor and sales ad-valorem tax. A doubling of prices does not change the signs of the non-evasion general equilibrium compared to a labor or sales tax rate that is something less than one. We want to show a robust change in the general equilibrium when evasion takes place and therefore; we wanted a large change in prices through the implementation of a labor and sales tax equal to one. Fine rates need to be greater than one in order to collect more than what was simply evaded. The baseline fine rate is set at $f = 1.1$, implying a 10 percent fine on top of evaded taxes. Finally, the probability of detection is a subjective measure because the tax authority does not publicly publish the formula for determining audit selection. Given the limited resources of a tax authority to audit every taxpayer

[57] The application of an equal tax on both capital and labor represents a sales tax in GAMS.

annually, it is assumed that the probability of detection is small, or $\rho = 0.1$. Given the fine rate and the perceived probability of detection, firms are evading 89 percent ($1-\rho f = 1-(0.1*1.1) = 0.89$) of the labor and sales tax in the baseline model estimates.

Producers

Producers maximize the profit function subject to current production technologies however; it is simpler and more representative of what GAMS computes to represent the firm's problem as minimizing costs subject to the production technology.[58] Assuming CES production technologies and no taxes, we have the following minimization problem:

$$\min_{\{L_j,K_j\}} wL_j + rK_j \text{ subject to } Q_j = \left[\delta_j L_j^{(\sigma_j-1)/\sigma_j} + (1-\delta_j)K_j^{(\sigma_j-1)/\sigma_j}\right]^{\sigma_j/(1-\sigma_j)}, j = 1,2 \quad (3.31)$$

where Q_j is output in industry j, δ is the technical coefficient of the CES production function, and σ is the elasticity of substitution between capital and labor. Factor demands for capital and labor are as follows:

$$L_j = Q_j\left[\delta_j + (1-\delta_j)\left[\frac{\delta_j r}{(1-\delta_j)w}\right]^{(1-\sigma_j)}\right]^{\sigma_j/\sigma_j - 1} \quad (3.32)$$

$$K_j = Q_j\left[\delta_j\left[\frac{\delta_j w}{(1-\delta_j)r}\right]^{(1-\sigma_j)} + (1-\delta_j)\right]^{\sigma_j/\sigma_j - 1} \quad (3.33)$$

[58] This is possible because of duality between cost functions and production technologies.

where w and r are the per unit factor costs for labor and capital, respectively, and include any applicable taxes or evasion. When the labor tax and evasion are implemented, (3.31) becomes:

$$\min_{\{L_j, K_j, \mu_{j,L}\}} \left(1+\tau_w\left(\left(1-\mu_{j,L}\right)+\rho f \mu_{j,L}\right)\right) w L_j + r K_j \text{ subject to} \tag{3.31$'$}$$

$$Q_j = \left[\delta_j L_j^{(\sigma_j - 1)/\sigma_j} + \left(1-\delta_j\right) K_j^{(\sigma_j - 1)/\sigma_j}\right]^{\sigma_j/(1-\sigma_j)}, j = 1,2$$

The unit cost and factor demands change as follows:

$$L_j = Q_j\left[\delta_j + \left(1-\delta_j\right)\left[\frac{\delta_j r}{\left(1-\delta_j\right)\left[\left(1-\mu_{j,L}\right)\tau_w w + \rho f \mu_{j,L}\tau_w w\right]}\right]^{(1-\sigma_j)}\right]^{\sigma_j/\sigma_j - 1} \tag{3.32$'$}$$

$$K_j = Q_j\left[\delta_j\left[\frac{\delta_j\left[\left(1-\mu_{j,L}\right)\tau_w w + \rho f \mu_{j,L}\tau_w w\right]}{\left(1-\delta_j\right) r}\right]^{(1-\sigma_j)} + \left(1-\delta_j\right)\right]^{\sigma_j/\sigma_j - 1} \tag{3.33$'$}$$

where $\mu_{j,L}$ is the portion of labor taxes τ_w evaded, ρ is the perceived probability of detection, and f is the fine rate on evaded labor taxes. Therefore, when a firm declares something less than the full amount of the tax on labor, or (1- $\mu_{j,L}$), the relative price of labor decreases, changing the distribution of capital and labor and causing a shift of labor from the non-evading sector to the evading sector. Evading firms also face the expected penalty of evasion ($\rho f \mu_{j,L} \tau_w L$) if caught, increasing the relative price of labor, changing the distribution of capital and labor, and causing a shift of labor back from the evading sector to the non-evading sector.

Households

A representative agent maximizes utility by consuming goods subject to a budget constraint that is defined by prevailing market prices and income earned from each agent's endowments of labor and capital. With savings and investment assumed to equal zero, each agent has a vector of final demands equal to those consumption goods that maximize utility, $d = \{X_j\}$, where j = 1,2. The representative agent's problem is thus:

$$\max_{\{X_1, X_2\}} U^i = \left(\alpha_1^{1/\sigma} X_1^{i\,\sigma-1/\sigma} + \alpha_2^{1/\sigma} X_2^{i\,\sigma-1/\sigma} \right)^{\sigma/\sigma-1} \text{subject to } M^i \le P_1 X_1 + P_2 X_2 \tag{3.34}$$

where $M^i = wL^{i,E} + rK^{i,E}$; i =1,2 and individual i earns income from his/her endowment of labor and capital. Final demand for good i with no taxes or firm-level evasion is thus:

$$X_j = \frac{\sigma_j^i M^i}{P_j^{\sigma^i} \left(\sum_{h=1}^{J} \alpha_h^i P_i^{(1-\sigma_i)} \right)} \tag{3.35}$$

If the individual works in the evading sector (sector 2), then he or she receives some additional income as a result of the firm evading a portion of the labor input taxes. The net return to labor increases, and consumers will have more income to use in the purchase of goods and utility maximization. This does not change their decision process; however, it changes their income and demand for goods in the market to:

$$X_j = \frac{\sigma_j^i \left[M^i = wL_2^{i,E} - [(1-\mu_2) + \rho f \mu_2] \tau_w w L_2^{i,E} + rK_2^{i,E} \right]}{P_j^{\sigma^i} \left(\sum_{h=1}^{J} \alpha_h^i P_i^{(1-\sigma_i)} \right)} \tag{3.35′}$$

Demand for good j will increase as a result of tax evasion on labor inputs occurring in sector 2. If firms evade a sales tax and pass on part of the tax savings to consumers, the price of good *j* will decrease, and reduce the denominator of (3.35). The demand for good *j* will increase as a result of lower prices, and individuals will allocate more income toward the cheaper good, assuming some substitutability between the two goods in the economy. The difference between this scenario and equation (3.35) is that the evasion and uncertainty cost are in the denominator as follows:

$$X_j = \frac{\sigma_j^i M^i}{\left(\left[\left(1+\left(1-\mu_j\right)\tau_j\right)+\rho f\mu_j\tau_j\right]P_j\right)^{\sigma^i}\left(\sum_{h=1}^{J}\alpha_h^i P_i^{(1-\sigma_i)}\right)} \tag{3.35''}$$

Parameters

Parameter value specification is an integral component to computable general equilibrium methods, and changing values for exogenous parameters can alter the equilibrium. Most modelers specify parameter values based on previous literature values, and these values can change the model's equilibrium. In the model developed here, there are four production function parameters affecting the supply of two products, or δ_j, σ_j for *j* = 1,2, where δ_j are the technology coefficients of the production function. In both the monopoly and competitive social accounting matrices (Tables A10), we have set $\delta_1 = 0.6$ and $\delta_2 = 0.4$. Thus, to produce 1 unit of output in sector 1 requires 0.6 units of capital and 0.4 ($1-\delta_1$) units of labor. Sector 2 uses 0.4 units of capital and 0.6 ($1-\delta_2$) units of labor to product 1 unit of X_2. Thus, sector 1 is capital intensive and sector 2 is labor intensive. This parameterization was chosen because sector 2 firms evade the labor and sales tax and more labor intensive firms will find it easier to evade. Firms that produce services with only labor input will have a low cost of evasion due to intangible output.[59] Service industries such as housekeeping or landscaping do not have a tangible output as that of a production industry like a DVD manufacturer, and therefore they may have a lower cost of evasion using a larger amount of labor than capital inputs and having no physical output that may be difficult to hide from the tax authority. Without specifying sector 2 output as intangible, we are able to illustrate that labor intensive firms are able to evade, alter the relative price of labor to capital, and cause resource allocation towards sector 2 goods. Production in sector 2 is altered in the monopoly model by building profit into the social accounting matrix (Table A11) and altering the total production in sector 2 to a value of 80 versus 100. This is done in the computable general equilibrium model in order to create a price mark-up for the sector 2 monopolist. The mark-up is set by the monopolist to equal the inverse of the Marshallian elasticity of demand and using the data in the social accounting matrix we are able to calculate the monopolist mark-up and back out the elasticity of substitution of demand for the monopolist good.

The top level elasticity of substitution (σ_j =ELAS) in production is set at 0.5 for both sector 1 and sector 2 output functions. The elasticity of substitution (ELAS) between capital and labor initially equals 0.5, in order to model some level of trade-off between capital and labor and to ensure production technology is of CES form. It is common in most CGE work to model intermediate inputs with primary facts as Leontief (top ELAS = 0) production functions and to nest the primary factors in a CES function in a value added format selecting a second elasticity of substitution to nest within the Leontief technology. We do not select this format here as we do not select any output as

[59] One may also say that consumer 2 is poor relative to consumer 1 because consumer 2 has relatively more labor and less capital.

an intermediate input. Increasing ELAS to 9 illustrates an increase in competition when evasion of the labor or sales tax is occurring and the resulting equilibrium after a reallocation of factor inputs. When the elasticity of substitution between factor inputs is increased (ELAS), labor and capital become more substitutable with each other. When tax evasion is present, the lower cost factor input will be substituted for the higher cost factor input. The CES production function is versatile because it allows us to alter the elasticity of substitution between capital and labor. As the elasticity of substitution increases, capital and labor become more substitutable with each other allowing reallocation of capital and labor when relative prices change.

There are four utility function parameters that affect final consumer demands: $\alpha_1^i, \alpha_2^i, \sigma_1, \sigma_2$. We assume consumers in the evading sector (X_2) consume more of the evading good and demand 70 units of X_2 and 30 units of X_1 to maximize utility. Therefore, consumer 2's share of X_2 is set at $\alpha^2 = 0.7$, and the share of X_1 is equal to $\alpha^1 = 0.3$. Consumer 1 consumes 30 X_2 and 70 X_1 to maximize utility.[60] Consumer 1's share of X_2 and X_1 is opposite; the share of X_2 is set at $\alpha^2 = 0.3$ and the share of X_1 is equal to $\alpha^1 = 0.7$. Consumer elasticity of substitution between goods 1 and 2 is set equal to 2. This elasticity was chosen because we wanted some substitutability between goods 1 and 2 in the individual's consumption decisions. Therefore, a change in the price of either goods will result in a change in consumer final demands for each good.

Capital and labor endowments are given exogenously for each consumer in the economy:

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[60] Note these consumption units are the value of price times quantity, and in the benchmark equilibrium prices are equal to one.

$L^{i,E}, K^{i,E}$ for $i = 1, 2$. Consumer 1 is endowed with 60 capital and 40 labor and works in sector 1 while consumer 2 works in sector 2 and is endowed with 40 capital and 60 labor. The endowments are selected in order to analyze how the allocation of capital and labor changes after the labor or sales tax and evasion are implemented. If evasion is easily replicated (e.g., consumers in sector 1 can see how evasion is taking place in sector 2), then we should find a change in the relative price of labor to capital, causing a reallocation of labor to the evading sector until a new equilibrium is reached.

Government Revenues and Closing the CGE Model

To close the model we need to make some assumption about the tax revenues that the government collects. In the absence of evasion, total factor and sales tax revenues collected by the government equal

$$\hat{T} = \tau_j\left(\hat{w}\overline{L} + \hat{r}\overline{K}\right) + \sum_{j=1}^{N} \hat{P}\hat{Q}_j\tau_j \tag{3.36}$$

Where total tax revenue, $\hat{T}$, equals the taxes that may be applied to factor inputs in sector j, $\tau_j\left(\hat{w}\overline{L} + \hat{r}\overline{K}\right)$, plus the sales tax revenues collected, $\sum_{j=1}^{N} \hat{P}\hat{Q}_j$, in the j sector. In the model we are building here, excluding any tax evasion, the government's total tax revenue (3.36) becomes:

$$\hat{T} = \tau_w\hat{w}L_1 + \tau_w\hat{w}L_2 + \tau_s\hat{P}\hat{Q}_1 + \tau_s\hat{P}\hat{Q}_2 \tag{3.36′}$$

When evasion takes place, the government will collect something less than the total labor and sales tax revenues in, $\hat{T}_e < \hat{T}$ and (3.36') becomes:

$$\hat{T}_e = \tau_w \hat{w} L_1 + \tau_w \left[\left(1 - \mu_{2,L}\right) + \rho f \mu_{2,L}\right] \hat{w} L_2 + \tau_s \hat{P} \hat{Q}_1 + \tau_s \left[\left(1 - \mu_2\right) + \rho f \mu_2\right] \hat{P} \hat{Q}_2 \qquad (3.36'')$$

The government collects labor and sales tax revenues and will only receive the declared labor and sales taxes from the evading sector 2 plus any penalty that may be assessed on evaded taxes (labor and sales) from sector 2 firms the government apprehends. Note that (3.36″) has both labor and sales taxation along with evasion and expected penalties however; in the CGE model we run we consider the labor and sales tax with evasion separately. Further, the government will recognize that it has a tax gap as in actual practice, but it will not have the resources to search out all individuals or firms engaging evasion activities. This does not mean that the government is incapable of identifying tax evaders; however, in reality, the government is bound by limited resources and time to audit every taxpayer and firm year after year to determine tax evaders. To keep the model simple, we assume that the government uses tax revenues (labor or sales) in the same way as consumers, so that revenues can be modeled as a lump-sum transfer to consumers.

Complementary Slackness and Computable General Equilibrium

The general equilibrium equations may be written in complementarity format by inserting the appropriate variables from the household and production optimization problems (Rutherford 1995). Optimal variables are represented with a "^." The system of non-linear equations represents the benchmark computable general equilibrium, and can be written in general format as follows:

$$\Omega(\mathrm{b}) \geq 0, \quad \mathrm{b} \geq 0, \quad \mathrm{b}'\Omega(\mathrm{b}) = 0 \qquad (3.37)$$

where Ω is a stacked vector of non-linear equations and $\mathbf{b}$ is the vector of unknowns the model is to estimate. This equation can be rewritten in shorthand using "⊥" to represent the complementary slackness condition,

$$\Omega(\mathbf{b}) \geq 0, \quad \perp \quad \mathbf{b} \tag{3.37′}$$

Expanding (3.37′) into each non-linear equation is illustrated in (3.37a) through (3.37d):

Zero Profit

$$p_j \leq \left(\sum_{i=1}^{N} p_i \hat{z}_{i,j} + \sum_{f=1}^{F} w_f \hat{v}_{f,j} \right), \quad Q_j \geq 0, \tag{3.37 a}$$

$$q_j \left[p_j - \left(\sum_{i=1}^{N} p_i \hat{z}_{i,j} + \sum_{f=1}^{F} w_f \hat{v}_{f,j} \right) \right] = 0 \quad \forall j \;\Rightarrow p_j \leq \left(\sum_{i=1}^{N} p_i \hat{z}_{i,j} + \sum_{f=1}^{F} w_f \hat{v}_{f,j} \right) \quad \perp \quad Q_j$$

The intuition of (3.37 a) is that, if the zero profit condition (LHS of 3.37 a) holds as a strict inequality, then profits are negative and the good in sector *j* will not be produced. Therefore, the complementary variable to (3.37 a) is output, Q_j. In the two-good, two-consumer model developed earlier, (3.37 a) becomes

$$\Rightarrow p_j \leq \left(w \; \hat{L}_j + r \hat{K}_j \right) \quad \perp \quad Q_j$$

where $\hat{L}_j$ and $\hat{K}_j$ are the factor demands from (3.32) and (3.33), respectively.

Market Clearance

$$Q_i \geq \left(\sum_{j=1}^{N} \hat{z}_{i,j} + \hat{c}_i \right), \quad p_i \geq 0, \quad p_i \left[Q_i - \left(\sum_{j=1}^{N} \hat{z}_{i,j} + \hat{c}_i \right) \right] = 0 \quad \forall i \qquad (3.37 \text{ b})$$

$$\Rightarrow Q_i \geq \left(\sum_{j=1}^{N} \hat{z}_{i,j} + \hat{c}_i \right) \quad \perp \quad p_i$$

If (3.37b) holds as a strict inequality, supply of good *i* will exceed the demand and the subsequent market price will be zero. Thus, the price of good *i* is the complementary variable for the market clearing condition.

With the model developed thus far, (3.37) becomes

$$\Rightarrow Q_j \geq \left(\sum_{j=1}^{J} \hat{X}_j \right) \quad \perp \quad p_j$$

where $\hat{X}_j$ is final consumer demand from (3.35).

Factor Market Clearance

$$V_f \geq \sum_{j=1}^{N} \hat{v}_{f,j}, \quad w_f \geq 0, \quad w_f \left[V_f - \sum_{j=1}^{N} \hat{v}_{f,j} \right] = 0 \quad \forall f \qquad (3.37 \text{ c})$$

$$\Rightarrow V_f \geq \sum_{j=1}^{N} \hat{v}_{f,j} \quad \perp \quad w_f$$

As in market clearance for final goods in equation (3.37 b), when the supply of factors exceeds the demand for factors, the factor price will be zero. The complementary variable is the factor price for each factor market.

In this model (3.37 c) becomes

$$\Rightarrow \overline{L} \geq \sum_{j=1}^{J} \hat{L}_j \left(w_j, r_j, Q_j \right) \quad \perp \quad w_j \text{ and}$$

$$\Rightarrow \overline{K} \geq \sum_{j=1}^{J} \hat{K}_j\left(w_j, r_j, Q_j\right) \quad \perp \quad r_j$$

where the choice of capital and labor are demanded based on equations (3.32) and (3.33), respectively.

Income Balance

$$M = \sum_{f=1}^{F} w_f V_f\ , \quad M \geq 0\ , \quad M\left[M - \sum_{f=1}^{F} w_f V_f\right] = 0 \qquad (3.37\ d)$$

$\Rightarrow M = \sum_{f=1}^{F} w_f V_f \quad \perp \quad M$ and in the model developed here becomes

$$\Rightarrow M^i = wL^{i,E} + rK^{i,E} \quad \perp \quad M^i$$

The complementary variable for income balance is income itself for each agent in the economy. If income does not equal the value of factor endowments for each consumer in the economy, then no income is earned.

Introducing ad valorem taxes, labor or sales, and evasion will distort prices, and a new equilibrium will result. This new equilibrium can be compared to the non-evasion equilibrium in which there are taxes (labor or sales) but no evasion, therefore; the effects of labor or sales tax evasion may be discussed in a general equilibrium framework. We begin with the zero profit, factor and output market clearance, and income balance general equilibrium equations when there is a labor tax followed by the sales tax case. In the general equilibrium equations below, an ad valorem tax is added to labor ($\tau_{j,L}$) in the evading sector 2.

Zero Profit

$$p_j \leq \left(w\hat{L}_j + r\hat{K}_j \right) \quad \perp \quad Q_j \tag{3.37 a'}$$

where $\hat{L}_j = Q_j\left[\delta_j + \left(1-\delta_j\right)\left[\frac{\delta_j r}{\left(1-\delta_j\right)\left[\left(1-\mu_{j,L}\right)\tau_w w + \rho f \mu_{j,L}\tau_w w\right]}\right]^{\left(1-\sigma_j\right)}\right]^{\sigma_j / \sigma_j - 1}$ and

$$\hat{K}_j = Q_j\left[\delta_j\left[\frac{\delta_j\left[\left(1-\mu_{j,L}\right)\tau_w w + \rho f \mu_{j,L}\tau_w w\right]}{\left(1-\delta_j\right)r}\right]^{\left(1-\sigma_j\right)} + \left(1-\delta_j\right)\right]^{\sigma_j / \sigma_j - 1}$$

Market Clearance

$$\Rightarrow Q_j \geq \left(\sum_{j=1}^{J}\hat{X}_j\right) \quad \perp \quad p_j \text{ where} \tag{3.37 b'}$$

$$\hat{X}_j = \frac{\sigma_j^i\left[M^i = wL_2^{i,E} - \left(1-\mu_2\right)\tau_w wL_2^{i,E} - \rho f \mu_2 \tau_w wL_2^{i,E} + rK_2^{i,E}\right]}{P_j^{\sigma^i}\left(\sum_{h=1}^{J}\alpha_h^i P_i^{\left(1-\sigma_i\right)}\right)}$$

Factor Market Clearance

$$\Rightarrow \overline{L} \geq \sum_{j=1}^{J}\hat{L}_j\left(w_j, \tau_j, \mu\ , \rho, f, r_j, Q_j\right) \quad \perp \quad w_j \text{ and} \tag{3.37 c'}$$

$$\Rightarrow \overline{K} \geq \sum_{j=1}^{J}\hat{K}_j\left(w_j, r_j, Q_j\right) \quad \perp \quad r_j$$

Income Balance

$$\Rightarrow M^i = wL_2^{i,E} - \left(1-\mu_2\right)\tau_w wL_2^{i,E} - \rho f \mu_2 \tau_w wL_2^{i,E} + rK^{i,E} \quad \perp \quad M^i \tag{3.37 d'}$$

The addition of the ad-valorem labor tax, evasion, the probability of detection, and the fine distorts prices, resulting in a change in relative prices and demands for final goods and primary factor inputs. The new demands calculated as a result of changes in relative prices from labor taxes and evasion activities will still require zero value of excess demands in equilibrium in order to maintain Walras Law and a new general equilibrium in the economy.

The sales tax is applied as an ad-valorem to both factor inputs thereby, raising the cost of production, and output prices. In the general equilibrium equations below, an ad valorem tax is added to both labor and capital ($\tau_{j,K}$ and $\tau_{j,L}$) in the evading sector.

Zero Profit

$$p_j \leq \left(w\hat{L}_j + r\hat{K}_j \right) \quad \perp \quad Q_j \tag{3.37 a''}$$

where $\hat{L}_j = Q_j \left[\delta_j + (1-\delta_j) \left[\frac{\delta_j \left[(1-\mu_{j,K})\tau_r r + \rho f \mu_{j,K} \tau_r r \right]}{(1-\delta_j)\left[(1-\mu_{j,L})\tau_w w + \rho f \mu_{j,L} \tau_w w \right]} \right]^{(1-\sigma_j)} \right]^{\sigma_j / \sigma_j - 1}$ and

$$\hat{K}_j = Q_j \left[\delta_j \left[\frac{\delta_j \left[(1-\mu_{j,L})\tau_w w + \rho f \mu_{j,L} \tau_w w \right]}{(1-\delta_j)\left[(1-\mu_{j,K})\tau_r r + \rho f \mu_{j,K} \tau_r r \right]} \right]^{(1-\sigma_j)} + (1-\delta_j) \right]^{\sigma_j / \sigma_j - 1}$$

Market Clearance

$$\Rightarrow Q_j \geq \left(\sum_{j=1}^{J} \hat{X}_j \right) \quad \perp \quad p_j \text{ where} \qquad (3.37\text{ b}'')$$

$$\hat{X}_j = \frac{\sigma_j^i \left[M^i = wL_2^{i,E} - (1-\mu_2)\tau_w wL_2^{i,E} - \rho f \mu_2 \tau_w wL_2^{i,E} + rK_2^{i,E} - (1-\mu_2)\tau_r rK_2^{i,E} - \rho f \mu_2 \tau_r rK_2^{i,E} \right]}{P_j^{\sigma^i} \left(\sum_{h=1}^{J} \alpha_h^i P_i^{(1-\sigma_i)} \right)}$$

Factor Market Clearance

$$\Rightarrow \overline{L} \geq \sum_{j=1}^{J} \hat{L}_j \left(w_j, \tau_j, \mu\ , \rho, f, r_j, Q_j \right) \quad \perp \quad w_j \text{ and} \qquad (3.37\text{ c}'')$$

$$\Rightarrow \overline{K} \geq \sum_{j=1}^{J} \hat{L}_j \left(w_j, \tau_j, \mu\ , \rho, f, r_j, Q_j \right) \quad \perp \quad r_j$$

Income Balance

$$\Rightarrow M^i = wL_2^{i,E} - (1-\mu_2)\tau_w wL_2^{i,E} - \rho f \mu_2 \tau_w wL_2^{i,E} + rK^{i,E} \qquad (3.37\text{ d}'')$$

$$-(1-\mu_2)\tau_r rK_2^{i,E} - \rho f \mu_2 \tau_r rK_2^{i,E} \quad \perp \quad M^i$$

This new general equilibrium with sales tax evasion can be compared to the non-evasion equilibrium in which there is a sales tax but no evasion. The presence of evasion will alter both factor input prices and the factor used more intensively will benefit from evasion.

Social Accounting Matrices and Model Calibration

The social accounting matrices are designed to maintain internal consistency through income balance, zero profits, and market clearance. Two social accounting matrices are built to represent two cases: monopoly and perfect competition. See Table A10 and A11. The matrices represent a two-consumer, two-good, two-factor economy in which consumer 2 (CONS2) is endowed with more labor than consumer 1 and works for the evading producer of good 2 (X_2). Consumers sell endowments of labor and capital to producers of X_1 and X_2 and maximize utility through consumption of each good. The monopoly case builds profit into the market and returns it to consumer 2 to maintain a balanced matrix. Using this matrix, we can design an optimal monopoly markup on marginal cost and substitution elasticity in order to calibrate the model (Rutherford 1995). The markup is equal to the inverse of the standard Marshallian elasticity calculated using the share of X_2 in the economy and assuming prices in are 1. The optimal markup is equal to 0.2, and the calibrated elasticity of substitution is equal to 9. The monopolist is the sector 2 producer, and has a reduced output of 80 units with a price of 1.25 versus an output of 100 units with a price of 1 in the competitive case.

In each case the models are calibrated without any ad-valorem labor or sales tax in order to successfully replicate the economy and to check that the model is specified correctly. When the economy is successfully replicated, we begin by applying a labor tax in both the competitive and monopoly cases, followed by a sales tax in both the competitive and monopoly market cases. For example, an ad-valorem labor tax is applied to labor inputs on producers in both X_1 and X_2 markets with no evasion taking place. This output is the comparison group before either evasion or increased competition is introduced as counterfactuals, and is called Non-Evasion in Tables A13-A28. Each case collects total labor or sales tax revenues from each market and distributes them equally to each consumer. When evasion takes place in the production market of X_2, there may be a reduction of the labor or sales tax revenues from the non-evasion situation; however, the declared labor or sales tax revenues are divided between each consumer.

Sensitivity Analysis

The sensitivity analysis tests the robustness of the model's results. There are two social accounting matrices: a perfectly competitive scenario and a monopoly markup scenario, where sales and labor taxes are implemented independently of each other. In each matrix and for each tax, the elasticity of substitution between the primary factor inputs of production is increased to represent an increase in competitiveness in the production market. This will allow for a long-run situation in which capital and labor are freer to move between industries. Further, the probability of detection, the labor or sales tax rate, and the fine rate are altered independently in order to see the effects of potential changes in fiscal and enforcement policies. The importance of each output is not the level but the comparison of the changes when exogenous variables are altered. Of particular importance are the changes in the output and primary factor prices and consumer welfare for each individual presented in tables A13-A28. The welfare measure is Hicksian's equivalent variation, which is the amount of money the individual would be willing to pay to return to pre-tax or pre-evasion prices. This can be used as a measure of the gains or loss of each consumer between a situation with a labor or sales tax (non-evasion) and when evasion takes place.

Counterfactuals and Simulations

For each counterfactual we compare two different simulations. The first comparison is between a general equilibrium with a labor or sales tax (Non-Evasion) and with evasion (Evasion_1). The second compares the evasion equilibrium (Evasion_1) with one in which the elasticity of substitution between production inputs is increased causing capital and labor to flow more easily between producers in sectors X_1 and X_2 (Evasion_2). The counterfactuals first consider the perfectly competitive market with labor taxes, followed by the sales tax. In both tax cases, the probability of detection (Simulation 1), the fine rate (Simulation 2), and labor or sales tax rate (Simulation 3) are increased independently in order to test the robustness of the computable general equilibrium (Table A13). The second set of counterfactuals considers a monopoly market where the sector 2 producer is a monopolist and is able to apply a price mark-up. Taxes are applied first on labor followed by a general sales tax. As in the perfect competition case, we consider the general equilibrium changes when the probability of detection, the fine rate, and the labor or sales tax rate increases separately.

In both the perfectly competitive and monopolist markets, we calculate and compare the percent change when evasion occurs (Evasion_1) to the case when no evasion (Non-Evasion) takes place, or %ΔPre. Increasing competition results in a new equilibrium ($Evasion_2$) in which we compare it to $Evasion_1$ by calculating the percent change between the two equilibriums, or %ΔPost.

Perfect Competition

For both the labor and sales tax, we calibrate the non-linear equations and replicate the social accounting matrix with prices equal to one. The next step is implementing the labor tax and sales tax, each of which generates the Non-Evasion equilibrium in Table A13 and A17, respectively.[61]

Labor Tax

As shown in Table A13, the ad valorem tax (t =1) on labor without any evasion lowers the price of labor by 44 percent.[62] Consumer 2's welfare decreases relative to consumer 1 due to consumer 2's relatively large labor endowment. When evasion occurs ($Evasion_1$) in sector 2 with a low probability of detection (0.1) and a fine rate of 1.1 on evaded labor taxes, the price of labor increases almost 68 percent (%Δ Pre). The price of capital decreases 20 percent, and thus the relative price of labor to capital increases and labor flows from sector 1 to sector 2. This increases sector 2 output, which leads to a decrease in the price of sector 2 output. The welfare of consumer 2 increases (7.5 percent) as they consume a larger share of the sector 2 good. The reallocation of capital and labor also reduces output in sector 1 by 31.5 percent; increasing the price of X_1 by 11

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[61] The Non-Evasion equilibrium is the same for each situation until the tax rates are doubled for the labor and sales tax, respectively.

[62] Recall, we want to show a robust change in the general equilibrium when evasion takes place and therefore; we want a large change in prices through the implementation of a labor and sales tax equal to one.

percent. The welfare of consumer 1 decreases (12.9 percent) because they consumer a larger share of X_1 to maximize utility.

When the elasticity of substitution between capital and labor is increased ($Evasion_2$), labor flows into sector 2 and reduces the price of labor 10.4 percent; replication and competition has reduced some of the benefits of evasion. The price of capital increases 3.4 percent, and the relative price of labor to capital decreases, causing a reallocation of capital and labor towards sector 1. Sector 1 output increases 15.8, and its price decreases 20.1 percent as capital flows to where it receives its highest return. Consumer 1's welfare increases 3.4 percent as a result of the increase in X_1 output and the large share of X_1 they use to maximize utility. Output in sector 2 decreases 12.8 percent and prices decrease 7.4 percent. The increase in the substitutability of labor and capital between sector 1 and 2 leads to greater replication and competition among labor and capital, and transfers the benefits of evasion (increased net wage of labor) away from labor in sector 2 to consumers in the form of lower prices of sector 2 output. Labor entering sector 2 will compete with each other and bid down the net wage with evasion, thus transferring the benefits of evasion to sector 2 producers. Sector 2 firm's cost of production decreases as a result of the decrease in the price of labor, resulting in the transfer of benefits to consumers in the form of lower prices (price of X_2 decreases 7.4 percent).

As a robustness check, the probability of detection, the fine rate, and the labor tax rate are increased independently of each other to analyze the change in equilibrium with evasion and increases in competition (Tables A14-A16). The robustness checks are important to note any sign changes in the calculations of the percent change between the

$Evasion_1$ and Non-Evasion scenarios and the percentage change between $Evasion_2$ and $Evasion_1$. There is only one case in which welfare for both individuals decreases rather than increases. When the probability of detection increases, welfare decreases slightly for both individuals when competition increases. Recall that consumer 1 is endowed with relatively more capital and uses a larger share of capital in maximizing utility, thus the decrease in the price of capital leads to a decrease in welfare of consumer 1.

For each robustness check, we find that the benefits of evasion remain with the evading sector and benefit the factor used more intensely, in this case labor. When the elasticity of substitution is increased to make factor inputs more like perfect substitutes, we find the benefits of evasion are competed away through replication and competition (Tables A14-A16). The only real difference between each labor tax scenario is in the magnitudes of the percent change calculations.

Sales Tax

Sales taxes are applied as an ad-valorem on both inputs of each sector and without any evasion (Table A17). The benchmark social accounting matrix is successfully replicated with a resulting increase in prices from 1 to 3 with sales tax revenues being distributed equally between each consumer. When firms in sector 2 begin evading the sales tax, the prices of capital and labor both increase.[63] Sector 2 firms use relatively more labor than capital, and when they evade the net price of labor increases more than capital (58.7 percent). The relative price of labor to capital increases causing labor to flow into sector 2 from sector 1. Output in sector 2 increases 53.2 percent and the price

[63] This still assumes a base fine rate of 1.1, a tax rate of 1 (100 percent), and a 0.1 probability of detection evading in each of the baseline cases.

of goods in sector 2 decreases by almost 37 percent as a result. Sector 1 output decreases 55.6 percent, leading to an increase in price of 22.3 percent (Table A17). Consumer 1's welfare decreases almost 23 percent because they consume a larger share of X_1, which has increased in price. The welfare of consumer 2 increases almost 5 percent in the presence of sales tax evasion due to the large share of X_2 they consume and to the increase in output and the decrease in price of sector 2.

Increasing competition again allows replication of the evasion activity in sector 2, lowering consumer 2's welfare by 1.6 percent. The welfare of consumer 1 increases; however, this increase is so small that it is not economically significant. The net wage of labor decreases about 20 percent while the price of capital increases 23.4 percent. Again, the relative price of labor to capital has decreased due to the increase in the substitutability between capital and labor. Output in sector 2 increases (4.2 percent) and prices decrease slightly (5.7 percent). Overall, then, the benefits of evasion have been transferred to sector 2 producers in the form of lower input prices for labor. Sector 2 output increases 4.2 percent and price decreases 5.7 percent. Therefore, consumers also benefit from lower X_2 prices. Consumer 2's welfare decreases because of the reduction in net wage they earn as a result of competition and replication of evasion in sector 2.

These results are robust to increasing the probability of detection ($\rho = 0.5$) and the fine rate ($f = 2$); the only changes between the estimates are magnitudes of the percent change pre- and post-competition (Table A18, A19, and A20).[64]

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[64] There are some changes in the signs of the welfare of consumer 1 when increasing the probability of detection, the fine rate, and the tax rate. However, in each case the change is nearly equal to zero, and is due to the opposite and equal change in the price of capital and labor. For example, in Table A18, when competition is increased, the price of capital increases 4.5 percent and the price of labor decreases 4.5 percent.

In both the labor and sales tax simulations, we find the input that is used more intensely may receive a larger share of sales tax evasion until competition increases and the benefits of evasion are replicated and competed away, as asserted by Martinez-Vazquez (1996). We also find that individuals who consume a larger share of the evaded good will experience increases in welfare when evasion occurs and a loss in welfare when competition and replication reduce the benefits of evasion to labor.

Monopoly

The monopoly case begins with calibrating the substitution elasticity of demand with an optimal monopoly markup on prices. Using the characteristics of the monopoly social accounting matrix, we are able to calculate the share of X_2 in the market, determine the marginal cost and price of the calibrated market, and determine the optimal markup. Using this information, the benchmark equilibrium is successfully replicated and a labor and sales tax are applied separately to create the Non-Evasion benchmark for comparison with $Evasion_1$ and $Evasion_2$.

Labor Tax

Labor taxes with a monopoly markup lead to an equilibrium with a reduction in net labor wages of 86.1 percent and a decrease in the price of capital of 24.4 percent ($Evasion_1$ in Table A21). The reduction in the relative price of labor to capital reallocates labor from sector 1 to sector 2 where it earns a higher return. As labor flows into sector 2, X_2 output increases by 48.5 percent as it is labor intensive. The increase in X_2 output causes a 9 percent decrease in output prices. The reduction in X_2 (monopolist) output prices is not as large as in the competitive case (20.5 percent reduction); the barrier to entry allows the monopolist to retain the benefits of evasion due to the monopoly mark-up. Absent labor taxes and evasion, price of X_2 would be equal to $1.25; with evasion and labor taxes, price of X_2 equals $1.87, which is 50 percent above the monopolist benchmark price and lower than the non-evasion price of $2.06. The reallocation of capital and labor causes X_1 output to decline 40.3 percent, increasing price of X_1 13.7 percent. Similar to the competitive market case in Table A13, we also find that the welfare of consumer 2 increases 21.8 percent as a direct result of the increase in X_2 output and the reduction in price. The reduction in X_1 output decreases the welfare of consumer 1 by 17.3 percent. Consumer 2 is benefiting from evasion while consumer 1 is losing.

When competition increases, we find that the net price of labor decreases 7.4 percent as labor becomes more substitutable with capital and flows into sector 2. The returns to capital increase and capital flows to sector 1 (the capital intensive sector), increasing X_1 output by 21.2 percent and reducing the price of X_1 by 11 percent. Reallocating capital and labor causes X_2 output to decline. Intuition expects the price of X_2 to increase, yet we find its price decreasing by 2.8 percent. As labor flows into sector 2, earning a greater net wage with evasion ($Evasion_1$) than with the Non-Evasion equilibrium, labor will compete and replicate the evasion behavior and reduce the price of X_2 caused by the reduction in the price of labor. The monopoly mark-up results in a reduction of only 2.8 percent; the monopolist is still able to maintain prices at $1.82, which is 45 percent above the benchmark equilibrium price of $1.25. The monopolist is able to maintain some of the benefits of evasion with the price mark-up, and reduced input costs reduce X_2 output prices. Therefore, consumers of X_2 benefit through evasion in the form of lower prices. Welfare of consumer 1 increases 8.7 percent in $Evasion_2$ through the increase in X_1 output and its lower price. The welfare of consumer 2 decreases by 11.2 percent in $Evasion_2$ as a result of X_2 output decreasing 14 percent.

The results are robust to an increase in the fine and labor tax rates. The magnitudes of each comparison change, but the sign of each variable does not change (Tables A23 and A24). When we increase the probability of detection, the baseline evasion simulation ($Evasion_1$) is robust; however, when competition is increased, the welfare of consumer 1 and X_1 output both decrease. The relative price of labor to capital decreases slightly from 0.38 to 0.36 between $Evasion_1$ and $Evasion_2$, respectively. There is a decrease in the net wage of labor as some labor enters sector 2 in exchange for capital. We further find that the price of capital decreases between $Evasion_1$ and $Evasion_2$. The increase in the probability of detection increases the cost of evasion to producers of X_2 and does not induce a large change in the equilibrium values when we allow evasion to take place as we find in $Evasion_1$, Table A21. Therefore, when we increase the elasticity of substitution we do not find large a significantly large shift in capital for labor leading to an increase in X_1 output. We find a reduction of X_1 output and lower welfare (-0.2 percent) for consumers who require a large share of X_1 goods when maximizing utility. Despite this issue, the new equilibrium still indicates that the markup with an increase in the probability of detection allows the evading firm to retain the benefits of evasion in the form of higher prices, and, when competition increases, the net wage of labor and price of X_2 output decreases transferring the benefits of evasion to producers. Further, the decrease in cost of production allows for a small increase in X_2 output and a reduction in output prices. The benefits of evasion are transferred away to consumers in the form of lower prices. The net result of the decrease in net wages and X_2 output prices is a decrease in welfare for consumer 2. Based on this simple model we have shown that increasing the probability of detection results can reduce the increase in net wages (the benefits of evasion in $Evasion_1$ listed in Table A22).

Sales Tax

As with the perfectly competitive case, we implement a sales tax with the same monopoly markup and analyze the equilibrium with Non-Evasion, $Evasion_1$, and $Evasion_2$. The monopoly model is again calibrated, and the sales tax is applied in both production sectors. Sector 2 has monopoly power, and, in the Non-Evasion case when the sales tax is applied, X_1 and X_2 prices increase where the price of X_2 increases from 1.25 to 3.75 when sales taxes are administered (Table A25). When firms in sector 2 evade ($Evasion_1$), we find that the price of labor increases 33.5 percent and the price of capital decreases 29 percent. Production technology in sector 2 is labor intensive, and as a result the price of labor increases as evasion occurs. The relative price of labor to capital increases, and labor flows into sector 2 in exchange for capital. As a result, X_2 output increases 71.1 percent and price decreases 39.6 percent. The increase in X_2 output and its resulting lower price increase the welfare of consumer 2 who consumes a relatively larger share of X_2. X_1 output decreases by 61.5 percent; because the decrease in the price of capital is so large (29 percent), the cost of X_1 output decreases. Even with a large decrease in X_1 output, firms are able to reduce the price of X_1 by 6.3 percent. On net, the price of X_1 relative to the price of X_2 has increased as a result of sales tax evasion. Consumer 1 uses a larger share of X_1 output relative to X_2 to maximize utility; as a result of the decrease in the price of capital and X_1 output, the welfare of consumer 1 decreases by 28.9 percent. Evasion by firms in sector 2 leads to a reduction in its price and an increase in output. Despite the reduction in price of X_2 output, firms in sector 2 are able to retain some of the benefits of evasion in that they are able to increase output and the price is still about 82 percent larger than the benchmark equilibrium price of $1.25. Consumer 2 also receives some benefit of evasion in the form of a higher net wage and increased welfare.

When the level of competition is increased ($Evasion_2$), the net wage decreases by 26 percent (Table A25). Labor flows into the X_2 market, and competes away the benefits of evasion. The price of X_2 decreases 8.5 percent and X_2 output increases. The return to capital increases by 34.3 percent, causing capital to flow into sector 1 where it is used more intensively. This increases the cost of production X_1 and we find a decrease in output of 10.7 percent. This leads in turn to an increase in price of 3.1 percent. The changes in output levels and prices decrease consumer 1's welfare by 0.9 percent, and increase consumer 2's welfare by 2.9 percent.

Changing the probability of detection or the fine rate has no impact on $Evasion_1$ in Tables A26 and A27. In every robustness check, the net wage first increases as a result of evasion and subsequently decreases after competition is increased. At the same time the price of good X_2 decreases with evasion and again when competition is increased. We find, when increasing the probability of detection and the fine rate in the case of increased competition ($Evasion_2$), that the price of X_1 output slightly decreases. Like the other robustness checks, we find that increasing the probability of detection mitigates the changes in equilibrium in the presence of sales tax evasion and increased competition. This result is consistent with increasing costs to evaders as their perceived probability of detection increases.

When the sales tax rate is doubled, there is a significant drop in consumer 1 welfare while consumer 2's welfare increases ($Evasion_1$ in Table A28). Production of X_1 nearly shuts down (output reduction of almost 72 percent), while X_2 picks up the slack with lower prices and higher output. Net wages increase by 54 percent, while the rental rate of capital decreases by 25.8 percent.

When competition is increased (Table A28), labor enters the evading sector (X_2) and competition reduces net wages by 31.2 percent. The rental rate of capital increases by 37.8 percent, which increases the cost of production for sector 1 (the capital intensive sector) and reduces output by 13.2 percent. Consumer 1's welfare decreases by 2.0 percent due to the decrease in X_1 output and the increase in X_1 prices.

Again, as in other robustness checks, the model behaves fairly well, and there is a general theme: in markets where there is some monopoly power, the benefits of evasion remain with the intensive factor and evading firm, and there is an increase in welfare for those working in the evading sector.

Summary and Future Extensions

This simple computable general equilibrium model provides evidence of the importance of tax evasion, specifically labor and sales tax evasion, and market structure introduced by Martinez-Vazquez (1996). Depending on the relative competitiveness of the market, the benefits of evasion may be replicated and competed away through entrants or reallocation of factor inputs. Further, industries in which one factor input is used more intensively than any others or in which there is market power will be able to retain these benefits.

It is also clear that government may enact policies to change the probability of evasion or the fine rate, thus reclaiming the benefits of evasion through apprehensions or deterrence. It is not clear in our model that this would be cost effective given that we do not model the cost of increasing the probability of detection. Even so, our work uncovers potential enforcement policies in which the tax agency may focus attention: markets where the benefits of evasion remain with the individual evaders and where these benefits are not replicated away through market forces. We have found that the perceived probability of detection is the most robust variable the government may influence to reduce the benefits of evasion, as evidenced in the sensitivity analysis when the probability of detection is increased. In each simulation we found that the price of X_2 decreased as a result of evasion and subsequently decreased again when competition was increased. Thus, the benefits of evasion appear to be transferred to consumers. We also found that the factor input used more intensively in the evading sector benefits from evasion and transfers this benefit to producers when competition is increased. Our model assumes that the evading sector is relatively labor intensive, so that industries that deliver output such as services (which are highly labor intensive) where evasion may be relatively easy may transfer the benefits of evasion to consumers in the form of price reductions.

The policy recommendation from this research is not simply to allow evasion to occur unchecked in sectors in which replication and competition may reduce the benefits of evasion. Policy makers need to recognize, first, that labor and sales taxes distort prices and cause a reallocation of resources and second, that the presence of tax evasion of labor and sales taxes causes further distortions. Depending on the markets in which evasion occurs, we see a reduction in the price distortions induced by the labor and sales taxes. Enforcement policy should be designed to recognize industries that pose a high risk of evasion and competitiveness, which may eliminate the benefits of evasion. Failure to recognize this dynamic relationship may result in labor and sales tax policy that increases price distortions in order to meet expenditure needs.

Future research should focus on opening up the model to multiple countries and multiple time periods in order to investigate international and dynamic elements. It would also be interesting to investigate potential functional forms of the probability of detection and build this into a general equilibrium framework.

Dissertation Concluding Remarks

This body of research has explored two related topics. First, we present in Chapter one some evidence of the impact of law enforcement expenditures on both violent and property crime. When appropriate estimation methods are used, increasing police expenditures lowers crime rates for both violent and property crime. This finding is contrary to much previous work with alternative estimation methods, which found that increasing expenditures leads to more "identification" of crime. We also find that the main role of police officers seems to be one of "labeling" individuals as criminal, rather than one of deterring violent crime. This result implies that police are reactive rather than proactive to incidents of violent crime, meaning that they respond to rather than prevent crime.[65] Further, we find that arresting more individuals for violent crimes serves society mainly by weakly deterring individuals from committing further acts of crime. Property crime arrests have a negative effect on crime, although in none of the GMM specifications are these effects significant. Finally, we find differences between the Arellano and Bond (1991, 1998) dynamic GMM estimator, which controls for the endogeneity in the crime equations, and the results of other estimation methods.

This work suggests that a useful policy recommendation is not simply to increase law enforcement expenditures, but to change how state budgets are allocated. This work also suggests that dynamic GMM can be used to handle endogeneity problems where there does not seem to be a suitable instrument, even while recognizing that the GMM model has many critics who wonder especially about the "black box" aspects of the estimator.

[65] Note that our police employment variable does not capture any level of police productivity.

The second and larger research topic provides evidence that market conditions and industries matter as it pertains to firm level tax evasion. Our estimation results in Chapter two provide evidence of the importance in firm evasion decisions of both traditional tax evasion variables and also market structure and industry in which tax evasion may take place. The benefits of evasion may be replicated and competed away, thus transferring the benefits to consumers in the form of lower prices. This implies that there is a short-run/long-run dynamic to the problem: in the short-run replication causes more competitive markets to have higher rates of tax evasion, while in the long-run the benefits of evasion will be competed away and firms in competitive markets will not benefit from further evasion activities. This chapter finds evidence of a long-run situation in which the benefits of evasion have been replicated and competed away. Further, we find evidence that a firm with more monopoly power a firm will evade more (in terms of the percentage of sales the firm evades). This is expected because firms with monopoly power are protected from replication and competition by barriers to entry. Finally, and consistent with previous work, the results in Chapter two indicate that enforcement and corruption are critical to the firm's tax evasion decision. In countries where corruption is rampant, it seems likely that businesses will enter the underground economy to avoid the added costs that comes with dealing with corrupt government officials.

Finally, the last essay builds a general equilibrium model with labor and sales tax evasion, an expected penalty, and differing degrees of competition (e.g., perfect competition and monopoly). Computable general equilibrium models are constructed to represent different taxes and market competition. Numerical solution of these CGE models provides evidence of the transfer of the benefits of evasion through market forces to consumers in the form of lower prices. Further, factor inputs used more intensively than others benefit from evasion, but lose that benefit when competition increases; thereby causing a reallocation of goods and factors in the market. This is particularly important since the motivation of tax evasion incidence comes from markets where labor is a major factor input and the output of the market may be a service, making it easy to remain underground. The model also suggests to policy makers that labor and sales tax evasion can change the distribution of income and affect welfare, and so must be considered when making tax or tax enforcement policy decisions.

Appendix

Table A1. Crime Variable Definitions and Sources

Variable	Definition	Source
Law Enforcement Expenditures	Expenditures on current operations for police protection; current operations includes salaries and wages, fees and commissions, purchase of supplies, materials, and contractual services	U.S. Dept. of Justice, Bureau of Justice Statistics. EXPENDITURE AND EMPLOYMENT DATA FOR THE CRIMINAL JUSTICE SYSTEM [UNITED STATES]: CJEE EXTRACTS FILE, 2003 [Computer file]. Conducted by U.S. Dept. of Commerce, Bureau of the Census. ICPSR04366-v1. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [producer and distributor], 2005-12-19. http://www.icpsr.umich.edu/NACJD/ (accessed December 19, 2005)
Police Employment	Total number of police officers; includes both part-time and full-time officers	U.S. Dept. of Justice, Bureau of Justice Statistics. EXPENDITURE AND EMPLOYMENT DATA FOR THE CRIMINAL JUSTICE SYSTEM [UNITED STATES]: CJEE EXTRACTS FILE, 2003 [Computer file]. Conducted by U.S. Dept. of Commerce, Bureau of the Census. ICPSR04366-v1. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [producer and distributor], 2005-12-19. http://www.icpsr.umich.edu/NACJD/ (accessed December 19, 2005)
Arrests	The total number of arrests for the crime in question (e.g., violent crime arrests and property crime arrests)	http://www.fbi.gov/ucr/ucr.htm (accessed December 19, 2005).
Population	Total state population	U.S. Dept. of Justice, Bureau of Justice Statistics. EXPENDITURE AND EMPLOYMENT DATA FOR THE CRIMINAL JUSTICE SYSTEM [UNITED STATES]: CJEE EXTRACTS FILE, 2003 [Computer file]. Conducted by U.S. Dept. of Commerce, Bureau of the Census. ICPSR04366-v1. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [producer and distributor], 2005-12-19. http://www.icpsr.umich.edu/NACJD/ (accessed December 19, 2005)
Density	Population per square mile	http://www.50states.com/; http://www.infoplease.com/ipa/A0108620.html

		http://www.infoplease.com/ipa/A0108620.html (accessed December 19, 2005)
Black	Total number of individuals in the population whose race is defined as black	http://www.census.gov/popest/archives/ http://www.census.gov/popest/archives/2000s/vintage_2002/ST-EST2002-ASRO-05.html (accessed December 19, 2005)
Poverty	Total number of individuals in the population defined as living in poverty, according to the official definition	U.S. Bureau of the Census, Current Population Survey, Annual Social and Economic Supplements, Poverty and Health Statistics Branch/HHES Division, U. S. Bureau of the Census, U. S. Department of Commerce, Washington, DC. http://www.census.gov/hhes/www/poverty/histpov/hstpov21.html. (accessed December 19, 2005)
High School	Total number of individuals in the population greater than 25 years of age who have completed 4 or more years of high school	http://www.census.gov/population/www/socdemo/past-educ.html (accessed December 19, 2005)
College	Total number of individuals in the population greater than 25 of age who have completed 4 or more years of college	http://www.census.gov/population/www/socdemo/past-educ.html (accessed December 19, 2005)
Young Males	Total number of males who are between ages 10 and 39	Population Estimates Program, Population Division, U.S. Census Bureau, Washington, DC, Statistical Information Staff, Population Division, U.S. Census Bureau, U. S. Department of Commerce, Washington, DC. (accessed December 19, 2005)
Violent Crime	Total number of violent crimes, including murder, non-negligent manslaughter, forcible rape, and aggravated assault	Bureau of Justice Statistics - Data Online (from UCR Data) (accessed December 19, 2005)
Property Crime	Total number of property crimes; including burglary, larceny-theft, and motor vehicle theft	Bureau of Justice Statistics - Data Online (from UCR Data) (accessed December 19, 2005)
Inflation Adjustment	Price index	http://inflationdata.com/inflation/Consumer_Price_Index/HistoricalCPI.aspx?rsCPI_currentPage=1. (accessed December 19, 2005).

Table A2. Summary Statistics

Variable	Mean	Standard Deviation	Minimum	Maximum
VC	31,812	46,899	424	345,624
VC Arrests	11,296	21,733	63	150,531
PC	220,486	257,232	13,364	1,716,137
PC Arrests	30,430	39,165	77	289,402
LE Expenditures	831,081	982,795	16,181	6,579,202
Police Employment	2,739	2,924	0	21,104
Young	1,187,716	1,359,447	105,799	8,203,619
Poverty	696,150	902,338	42,000	5,803,000
High School	2,797,769	3,042,124	244,245	17,800,000
College	831,964	1,012,084	47,880	8,257,600
Black	672,126	807,979	2,260	3,366,193
Density	354	1,279	1	9,949

Table A3. Per Capita Violent Crime Results

Dependent Variable: Per Capita Violent Crime	**GMM**			**FGLS**	**RE**	**FE**	**POLS**
	1	**2**	**3**	**4**	**5**	**6**	**7**
L1 VC	0.87051***	0.75461***	0.80872***				
	[0.03869]	[0.05790]	[0.04322]				
L2 VC		0.10628***	0.11810***				
		[0.03562]	[0.02121]				
L3 VC			-0.0309				
			[0.01932]				
LE Expenditures	-0.00154***	-0.00189***	-0.00125***	0.00312***	-0.00224***	-0.00266***	0.00312**
	[0.00028]	[0.00029]	[0.00038]	[0.00093]	[0.00067]	[0.00074]	[0.00144]
Police Employment	0.40463***	0.52078***	0.48722***	-0.06101	0.64024**	0.04119	-0.06101
	[0.15098]	[0.16527]	[0.12148]	[0.30201]	[0.29023]	[0.33594]	[0.42079]
VC Arrests	-0.14622*	-0.19827***	0.0526	1.05882***	0.48647***	0.40872***	1.05882***
	[0.08023]	[0.05979]	[0.05240]	[0.06678]	[0.04294]	[0.04385]	[0.19725]
Poverty	0.00216	0.00269***	0.00194**	0.01399***	0.00704***	0.00596***	0.01399***
	[0.00129]	[0.00077]	[0.00075]	[0.00199]	[0.00174]	[0.00174]	[0.00093]
Black	0.00168**	0.00140*	0.00097**	0.00889***	0.01355***	0.03683***	0.00889***
	[0.00079]	[0.00074]	[0.00040]	[0.00077]	[0.00213]	[0.00678]	[0.00093]
Young	0.01207	0.01289***	0.00927***	0.01132	-0.03022***	-0.04342***	0.01132***
	[0.00739]	[0.00359]	[0.00216]	[0.00726]	[0.00939]	[0.01001]	[0.00338]
High School	0.00419**	0.00447***	0.00469**	0.00023	-0.00003	-0.00006	0.00023*

			*				
	[0.00180]	[0.00122]	[0.00096]	[0.00036]	[0.00016]	[0.00016]	[0.00013]
College	-0.00236	-0.00253**	-0.00212***	0.00175*	0.0003	0.00018	0.00175**
	[0.00216]	[0.00122]	[0.00060]	[0.00100]	[0.00048]	[0.00047]	[0.00074]
Observations	526	480	431	577	577	577	577
Instruments	41	43	44				
AR(1)	-2.93***	-2.53**	-3.53***				
AR(2)	1.53	-0.63	-2.41**				
Sargan Test P-Value	0.091*	0.092*	0.107				
Hansen Test P-Value	0.507	0.557	0.449				

Standard errors are in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%. Note that the Sargan test is not robust but is not weakened by many instruments; the Hansen test is robust but is weakened by many instruments.

Table A4. Per Capita Property Crime Results

Dependent Variable: Per Capita Property Crime	**GMM**			**FGLS**	**RE**	**FE**	**POLS**
	1	**2**	**3**	**4**	**5**	**6**	**7**
L1PC	0.71682***	0.80593***	0.77434***				
	[0.07927]	[0.07754]	[0.07823]				
L2 PC		0.07633*	0.11267***				
		[0.04166]	[0.03402]				
L3 PC			-0.06017				
			[0.03759]				
LE Expenditures	-0.02255***	-0.02367***	-0.01698***	0.00076	-0.00636**	-0.00750**	0.00076
	[0.00252]	[0.00222]	[0.00360]	[0.00461]	[0.00296]	[0.00333]	[0.00295]
Police Employment	-3.04400*	-3.14405*	1.18174	-0.37816	5.47117***	3.83329**	-0.37816
	[1.75061]	[1.66142]	[1.40720]	[1.50153]	[1.34710]	[1.54390]	[0.93918]
PC Arrests	-0.08739	-0.31937	-0.30197	1.55743***	0.33321***	0.24776***	1.55743***
	[0.16614]	[0.19565]	[0.23359]	[0.12270]	[0.07184]	[0.07171]	[0.34833]
Poverty	0.01906**	0.01401	0.0125	0.06819***	0.01534*	0.00951	0.06819***
	[0.00840]	[0.00874]	[0.00844]	[0.00990]	[0.00806]	[0.00803]	[0.00801]
Black	0.00291	-0.00188	0.00441	0.02292***	0.03906***	0.11715***	0.02292***
	[0.00626]	[0.00470]	[0.00406]	[0.00373]	[0.01039]	[0.03052]	[0.00212]
Young	0.22558***	0.20134***	0.14895***	0.21765***	0.04426	0.00599	0.21765***
	[0.03880]	[0.03248]	[0.03023]	[0.03678]	[0.04370]	[0.04602]	[0.03540]
High School	0.05159***	0.05380***	0.03140***	0.00157	-0.00008	-0.00025	0.00157*
	[0.01093]	[0.01001]	[0.00966]	[0.00178]	[0.00076]	[0.00073]	[0.00081]
College	-0.08553***	-0.09136***	-0.04290***	0.01115**	0.00056	-0.00023	0.01115***
	[0.01465]	[0.01288]	[0.01473]	[0.00497]	[0.00223]	[0.00216]	[0.00286]
Observations	526	480	431	577	577	577	577
Instruments	42	43	44				
AR(1)	-3.49***	-3.05***	-3.57***				

AR(2)	-0.06	-0.52	-0.88				
Sargan Test P-Value	0.344	0.442	0.536				
Hansen Test P-Value	0.449	0.446	0.261				

Standard errors are in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%. Note that the Sargan test is not robust but is not weakened by many instruments; the Hansen test is robust but is weakened by many instruments.

Table A5. Violent Crime GMM Lag Structure

Dependent Variable: Per Capita Violent Crime	**1**		**2**		**3**	
	a	**b**	**a**	**b**	**a**	**B**
L1 VC	2	.	1	.	1	.
L2 VC			1	.	1	.
L3 VC					1	.
L4 VC						
LE Expenditures Per Capita	6	.	6	.	6	.
Police Employment Per Capita	3	.	3	.	3	.
VC Arrests Per Capita	5	.	5	.	5	.

Property Crime GMM Lag Structure

Dependent Variable: Per Capita Property Crime	**1**		**2**		**3**	
	a	**b**	**a**	**b**	**a**	**b**
L1 PC	1	.	1	.	1	.
L2 PC			1	.	1	.
L3 PC					1	.
L4 PC						
LE Expenditures	6	.	6	.	6	.
Police Employment	3	.	3	.	3	.
PC Arrests	5	.	5	.	5	.

Note: *a* and *b* specify the lag limits of the model specified as instruments in both the level equation (1) and the first-difference equation (2). The first-difference equation uses lagged levels t-a through t-b as instruments while for the level equation t-a+1 of the first-differences are used as instruments Leaving *b*=."” specifies that *b* be allowed to go to infinity.

Table A6. Tax Evasion and Market Structure Variables and Description

Variables	**Proxies**	**Description**	**Measurement**
y_i Tax Evasion (dependent variable)	Q58	BEEPS 2002: "Recognizing the difficulties that many firms face in fully complying with taxes and regulations, what per cent of total annual sales would you estimate the typical firm in your area of business reports for tax purposes?"	0% to 100%
h_i Probit dep. variable	Q56g	BEEPS 2002: Developed from Q56g: "Thinking now of unofficial payments/gifts that a firm like yours would make in a given year, could you please tell me how often would they make payments/gifts for the following purposes: g.) To deal with taxes and tax collection"	A dummy variable with 0 for "never" and 1 otherwise.
SST *VAT* *CIT* Tax Rates	SST VAT CIT	Global Reform of Personal Income Taxation, 1981-2005: Evidence from 189 Countries.	%
Complex Complexity of Tax System/compliance cost	Q50	BEEPS 2002: "What per cent of senior management's time in 2001 was spent in dealing with public officials about the application and interpretation of laws and regulations and to get or to maintain access to public services?"	%
CorrTax *CorrGen* Corruption	Q56g Q55	BEEPS 2002: Q56g:"Thinking now of unofficial payments/gifts that a firm like yours would make in a given year, could you please tell me how often would they make payments/gifts for the following purposes: g.) To deal with taxes and tax collection" Q55 "On average, what percent of total annual sales do firm's like yours typically pay in unofficial payments/gifts to public officials?"	Q56g ranges from 1 ("never") to 6 ("always") Q55: 0% to 100%
CRI Reform Progress	CRI	Cumulative Tax Reform Index (Martinez-Vazquez and McNab 1997)	CRI ranges from 3 (most reformed) to 17 (least

			reformed).
Enforce Enforcement	Q74	BEEPS 2002: "Does your establishment have its annual financial statement reviewed by an external auditor?"	A dummy variable with 1 recorded for "yes" and 0 otherwise
TaxAdmin Tax Administration	Q80h	BEEPS 2002: "Can you tell me how problematic are these different factors for the operation and growth of your business – h.) tax administration"	A dummy with a 0 for "minor obstacle" or less and 1 for "moderate obstacle" or more
Size Firm Size	S4a2	BEEPS 2002: Screening question for the size of the firm based on the number of full-time employees 1 = 2 to 49 2 = 50 to 249 3 = 250 to 9,999	A dummy variable with 1 for less than 50 full time employees and 0 otherwise
Fair Perceived fairness & trust in government	Q41a	BEEPS 2002: "How often do you associate the following descriptions with the court system in resolving business disputes? a) Fair and impartial"	Q41a ranges from 1 ("Never") to 6 ("Always").
Owner Ownership	S2b	BEEPS 2002: screening question on the legal organization of the company.	A dummy with 1 if the firm is privately-owned and 0 otherwise.
Excl Exclusion restriction	Q53a	BEEPS 2002: How much influence do you think the following groups actually had on recently enacted national laws and regulations that have a substantial impact on your business? a) your firm."	Q53a ranges from 1 ("no impact") to 5 ("decisive influence").
Competition Competition variable 2	Q21	BEEPS 2002: "Now I would like to ask you a hypothetical question. If you were to raise your prices of your main product line or main line of services 10% above their current level in the domestic market (after allowing for any inflation) which of the following would best describe the result assuming that your competitors maintained their current prices?"	Ranges from 1 "Our customers would continue to buy from us in the same quantities as now" to 4 "Many of our customers would buy from our competitors instead"

Monopoly Monopoly Power variable	Q23	BEEPS 2002: "Considering your main product line or main line of services in the domestic market, by what margin does your sales price exceed your operating costs (i.e., the cost material inputs plus wage costs but not overheads and depreciation)"	%
Ind Industry	Q2a to Q2h	BEEPS 2002: "What percentage of your sales comes from the following sectors in which your establishment operates?"	%

Mining and Quarrying	Q2a
Construction	Q2b
Manufacturing	Q2c
Transport Storage and Communication	Q2d
Wholesale, Retail, Repairs	Q2e
Real Estate, Renting and Business Services	Q2f
Hotels and Restaurants	Q2g
Other	Q2h

Table A7. Heckman Two-Step Regression Results

Dependent Variable y_i: Percent Annual Sales Evaded	**Heckman**	**Standard Error**
SST	-0.318	[0.089]***
VAT	-0.969	[0.454]**
CIT	-0.217	[0.112]*
Complex	0.147	[0.047]***
Corrtax	2.275	[0.453]***
Corrgen	0.476	[0.335]
CRI	0.273	[0.219]
Enforce	-1.053	[1.136]
TaxAdmin	-1.004	[0.898]
Size	5.848	[1.307]***
Fair	-0.733	[0.602]
Owner	-0.391	[2.288]
Monopoly	0.07	[0.049]
Competition	-1.08	[0.520]**
Construction	0.062	[0.056]
Manufacturing	0.042	[0.054]
Transport	0.051	[0.058]
Wholesale and Retail	0.051	[0.053]
Real Estate	0.043	[0.057]
Other	0.09	[0.058]
Hotel and Restaurant	0.13	[0.057]**
Constant	46.827	[14.268]***
Selection Probit Equation Dependent Variable h_i		
SST	-0.002	[0.003]
VAT	-0.014	[0.014]
CIT	0.005	[0.004]

CRI	0.034	[0.006]***
Complex	0.000	[0.002]
Corrgen	0.127	[0.008]***
Enforce	0.028	[0.042]
TaxAdmin	0.204	[0.018]***
Owner	0.293	[0.062]***
Size	-0.007	[0.047]
Fair	-0.109	[0.015]***
Monopoly	0.004	[0.001]***
Competition	0.046	[0.018]***
Construction	-0.004	[0.002]*
Manufacturing	-0.002	[0.002]
Transport	-0.004	[0.002]**
Wholesale and Retail	-0.001	[0.002]
Real Estate	-0.003	[0.002]
Other	-0.004	[0.002]*
Hotel and Restaurant	-0.002	[0.002]
Excl	0.075	[0.024]***
Constant	-0.876	[0.371]**
Inverse Mills Ratio	-6.801	[5.930]
Observations	4691	
Censored Observations	2507	
Uncensored Observations	2184	
Wald Statistic (41)	868.90***	

Standard errors in brackets

* significant at 10%; ** significant at 5%; *** significant at 1%

Table A8. Tax Evasion and Market Structure OLS Results

Dependent Variable y_i: Percent Annual Sales Evaded	**OLS**	**Standard Error**
SST	-0.102	[0.043]**
VAT	-0.173	[0.197]
CIT	-0.125	[0.049]**
Complex	0.105	[0.032]***
Corrtax	3.577	[0.284]***
Corrgen	0.846	[0.129]***
CRI	0.117	[0.084]
Enforce	-2.179	[0.697]***
TaxAdmin	0.307	[0.290]
Size	3.544	[0.746]***
Fair	-1.453	[0.240]***
Owner	2.867	[0.888]***
Monopoly	0.056	[0.029]*
Competition	-0.733	[0.292]**
Construction	0.027	[0.033]
Manufacturing	0.028	[0.032]
Transport	0.032	[0.033]
Wholesale and Retail	0.036	[0.032]
Real Estate	0.024	[0.032]
Other	0.044	[0.034]
Hotel and Restaurant	0.076	[0.034]**
Constant	11.294	[5.296]**
Observations	4907	
R-squared	0.13	
F-Statistic	33.92	

(21 , 4885)

Heteroskedastic-consistent robust standard errors in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%

Table A9. Tax Evasion and Market Structure OLS Results (Significant at 5% or better)

Dependent Variable y_i: Percent Annual Sales Evaded		
Variable	**OLS**	**Standard Error**
SST	-0.102	[0.043]**
CIT	-0.125	[0.049]**
Complex	0.105	[0.032]***
Corrtax	3.577	[0.284]***
Corrgen	0.846	[0.129]***
Enforce	-2.179	[0.697]***
Size	3.544	[0.746]***
Fair	-1.453	[0.240]***
Owner	2.867	[0.888]***
Competition	-0.733	[0.292]**
Hotel and Restaurant	0.076	[0.034]**
Constant	11.294	[5.296]**

Heteroskedastic robust standard errors in brackets
** significant at 5%; *** significant at 1%

Table A10. Social Accounting Matrix - Competitive Case

	PRODUCTION SECTORS				CONSUMER ENDOWMENTS	
MARKETS	X_1	X_2	W_1	W_2	$CONS_1$	$CONS_2$
PX_1	100		-70	-30		
PX_2		100	-30	-70		
PL	-40	-60			40	60
PK	-60	-40			60	40
PW_1			100		-50	-50
PW_2				100	-50	-50

Table A11. Social Accounting Matrix - Monopoly Case

	PRODUCTION SECTORS				CONSUMER ENDOWMENTS	
MARKETS	X_1	X_2	W_1	W_2	$CONS_1$	$CONS_2$
PX_1	100		-70	-30		
PX_2		100	-30	-70		
PL	-40	-50			40	50
PK	-60	-30			60	30
PW_1			100		-100	
PW_2				100		-100
PROFIT		-20				20

Table A12. Counterfactual Simulation Parameters for Sensitivity Analysis

	Non-Evasion	Evasion$_1$			
		Baseline	**Simulation**		
			1	**2**	**3**
$\boldsymbol{\rho}$	0	0.1	0.5	0.1	0.1
$\boldsymbol{f}$	0	1.1	1.1	2	1.1
$\boldsymbol{t}$	1	1	1	1	2

Evasion$_1$	**Evasion$_2$**
ELAS	**ELAS´**
0.5	9

Table A13. Computable General Equilibrium Results - Partial Factor Tax on Labor

	Competition			Increased Competition	
	Non-Evasion	$Evasion_1$	% Δ Pre	$Evasion_2$	% Δ Post
Welfare 1	1.07	0.93	-12.9%	0.96	3.4%
Welfare 2	0.93	1.00	7.5%	0.95	-5.3%
X_1 Output	1.02	0.70	-31.5%	0.81	15.8%
X_2 Output	0.98	1.28	30.8%	1.11	-12.8%
Price X_1	1.69	1.87	11.0%	1.50	-20.1%
Price X_2	1.68	1.34	-20.5%	1.24	-7.4%
Capital Price	1.70	1.36	-20.1%	1.40	3.4%
Labor Price (Net)	0.56	0.93	67.9%	0.84	-10.4%
Consumer 1 Income	179.71	155.08	-13.7%	135.20	-12.8%
Consumer 2 Income	156.84	146.56	-6.6%	123.82	-15.5%

% Δ Pre refers to the percent change of evasion over non-evasion before increasing competition
% Δ Post refers to the percent change of evasion over evasion after increasing competition (e.g. When evasion is occurring and we increase competition the net price of labor decreases 10.4 percent; the relative price of labor to capital has increased, labor enters the evading sector and competes away the benefits of evasion.)

Increase in competition is adjusted by increasing the elasticity of substitution production inputs.

Table A14. Computable General Equilibrium Results - Partial Factor Tax on Labor; Increase in Penalty through Increased Probability of Detection (ρ = 0.1 to ρ = 0.5)

	Competition			Increased Competition	
	Non-Evasion	$Evasion_1$	% Δ Pre	$Evasion_2$	% Δ Post
Welfare 1	1.07	1.05	-1.8%	1.05	-0.3%
Welfare 2	0.93	0.95	1.8%	0.94	-0.7%
X_1 Output	1.02	0.96	-6.0%	0.96	-0.6%
X_2 Output	0.98	1.04	6.1%	1.03	-0.3%
Price X_1	1.69	1.69	0.5%	1.64	-3.4%
Price X_2	1.68	1.59	-5.6%	1.53	-3.7%
Capital Price	1.70	1.62	-4.5%	1.60	-1.7%
Labor Price (Net)	0.56	0.60	8.3%	0.58	-4.3%
Consumer 1 Income	179.71	173.89	-3.2%	167.33	-3.8%
Consumer 2 Income	156.84	153.45	-2.2%	146.92	-4.3%

% Δ Pre refers to the percent change of evasion over non-evasion before increasing competition.
% Δ Post refers to the percent change of evasion over evasion after increasing competition.
Increase in competition is adjusted by increasing the elasticity of substitution production inputs.

Table A15. Computable General Equilibrium Results - Partial Factor Tax on Labor; Increase in Penalty by Increasing Fine (f = 1.1 to f = 2)

	Competition			Increased Competition	
	Non-Evasion	$Evasion_1$	% Δ Pre	$Evasion_2$	% Δ Post
Welfare 1	1.07	0.97	-8.7%	0.98	0.4%
Welfare 2	0.93	0.99	6.0%	0.94	-4.7%
X_1 Output	1.02	0.79	-23.1%	0.83	5.1%
X_2 Output	0.98	1.20	23.1%	1.11	-7.7%
Price X_1	1.69	1.79	5.9%	1.54	-13.5%
Price X_2	1.68	1.39	-17.0%	1.29	-7.7%
Capital Price	1.70	1.44	-15.5%	1.45	1.3%
Labor Price (Net)	0.56	0.80	43.2%	0.72	-9.9%
Consumer 1 Income	179.71	160.32	-10.8%	142.40	-11.2%
Consumer 2 Income	156.84	147.52	-5.9%	127.65	-13.5%

% Δ Pre refers to the percent change of evasion over non-evasion before increasing competition.
% Δ Post refers to the percent change of evasion over evasion after increasing competition.
Increase in competition is adjusted by increasing the elasticity of substitution production inputs.

Table A16. Computable General Equilibrium Results - Partial Factor Tax on Labor; Increase in Penalty by Doubling of Tax (t = 1 to t = 2)

	Competition			Increased Competition	
	Non-Evasion	$Evasion_1$	% Δ Pre	$Evasion_2$	% Δ Post
Welfare 1	1.08	0.97	-9.8%	0.98	0.5%
Welfare 2	0.92	0.98	7.0%	0.93	-5.8%
X_1 Output	1.03	0.84	-18.8%	0.87	3.6%
X_2 Output	0.97	1.15	18.2%	1.05	-8.4%
Price X_1	2.29	2.46	7.6%	2.13	-13.7%
Price X_2	2.28	1.76	-22.8%	1.68	-4.2%
Capital Price	2.31	1.95	-15.8%	2.00	2.6%
Labor Price (Net)	0.45	0.67	48.6%	0.66	-2.1%
Consumer 1 Income	246.93	216.47	-12.3%	193.90	-10.4%
Consumer 2 Income	209.72	190.94	-9.0%	167.06	-12.5%

% Δ Pre refers to the percent change of evasion over non-evasion before increasing competition.
% Δ Post refers to the percent change of evasion over evasion after increasing competition.
Increase in competition is adjusted by increasing the elasticity of substitution production inputs.

Table A17. Computable General Equilibrium Results - Sales Tax

	Competition			Increased Competition	
	Non-Evasion	$Evasion_1$	% Δ Pre	$Evasion_2$	% Δ Post
Welfare 1	1.00	0.77	-22.9%	0.77	0.0%
Welfare 2	1.00	1.05	4.8%	1.03	-1.6%
X_1 Output	1.00	0.44	-55.6%	0.40	-9.5%
X_2 Output	1.00	1.53	53.2%	1.60	4.2%
Price X_1	3.00	3.67	22.3%	3.77	2.7%
Price X_2	3.00	1.90	-36.8%	1.79	-5.7%
Capital Price	1.00	1.01	0.7%	1.24	23.4%
Labor Price (Net)	1.00	1.59	58.7%	1.28	-19.5%
Consumer 1 Income	300.00	220.79	-26.4%	218.08	-1.2%
Consumer 2 Income	300.00	232.39	-22.5%	218.77	-5.9%

% Δ Pre refers to the percent change of evasion over non-evasion before increasing competition.
% Δ Post refers to the percent change of evasion over evasion after increasing competition.
Increase in competition is adjusted by increasing the elasticity of substitution production inputs.

Table A18. Computable General Equilibrium Results - Sales Tax; Increase in Penalty through Increased Probability of Detection (ρ = 0.1 to ρ = 0.5)

	Competition			Increased Competition	
	Non-Evasion	$Evasion_1$	% Δ Pre	$Evasion_2$	% Δ Post
Welfare 1	1.00	0.97	-3.2%	0.97	-0.1%
Welfare 2	1.00	1.03	2.5%	1.02	-0.1%
X_1 Output	1.00	0.88	-11.7%	0.87	-1.7%
X_2 Output	1.00	1.12	11.6%	1.13	1.4%
Price X_1	3.00	3.01	0.2%	3.03	0.7%
Price X_2	3.00	2.65	-11.6%	2.62	-1.1%
Capital Price	1.00	0.96	-3.6%	1.01	4.5%
Labor Price (Net)	1.00	1.06	6.2%	1.01	-4.5%
Consumer 1 Income	300.00	279.75	-6.8%	279.91	0.1%
Consumer 2 Income	300.00	281.71	-6.1%	280.03	-0.6%

% Δ Pre refers to the percent change of evasion over non-evasion before increasing competition.
% Δ Post refers to the percent change of evasion over evasion after increasing competition.
Increase in competition is adjusted by increasing the elasticity of substitution production inputs.

Table A19. Computable General Equilibrium Results - Sales Tax; Increase in Penalty by Increasing Fine (f = 1.1 to f = 2)

	Competition			Increased Competition	
	Non-Evasion	$Evasion_1$	% Δ Pre	$Evasion_2$	% Δ Post
Welfare 1	1.00	0.84	-15.9%	0.84	-0.2%
Welfare 2	1.00	1.05	5.3%	1.04	-0.9%
X_1 Output	1.00	0.57	-43.0%	0.53	-7.0%
X_2 Output	1.00	1.42	41.5%	1.47	3.8%
Price X_1	3.00	3.33	11.1%	3.37	1.1%
Price X_2	3.00	2.05	-31.7%	1.94	-5.4%
Capital Price	1.00	0.96	-4.3%	1.11	16.4%
Labor Price (Net)	1.00	1.36	36.2%	1.14	-16.4%
Consumer 1 Income	300.00	236.00	-21.3%	231.58	-1.9%
Consumer 2 Income	300.00	244.10	-18.6%	232.06	-4.9%

% Δ Pre refers to the percent change of evasion over non-evasion before increasing competition.
% Δ Post refers to the percent change of evasion over evasion after increasing competition.
Increase in competition is adjusted by increasing the elasticity of substitution production inputs.

Table A20. Computable General Equilibrium Results -Sales Tax; Increase in Penalty by Increasing Tax (t = 1 to t = 2)

	Competition			Increased Competition	
	Non-Evasion	$Evasion_1$	% Δ Pre	$Evasion_2$	% Δ Post
Welfare 1	1.00	0.69	-31.0%	0.69	-0.6%
Welfare 2	1.00	1.02	1.6%	1.00	-1.6%
X_1 Output	1.00	0.31	-68.9%	0.27	-12.5%
X_2 Output	1.00	1.65	65.2%	1.73	4.4%
Price X_1	5.00	7.09	41.8%	7.08	-0.2%
Price X_2	5.00	2.90	-41.9%	2.61	-10.0%
Capital Price	1.00	1.11	11.1%	1.40	25.7%
Labor Price (Net)	1.00	1.95	94.8%	1.45	-25.6%
Consumer 1 Income	500.00	341.58	-31.7%	321.00	-6.0%
Consumer 2 Income	500.00	358.33	-28.3%	322.07	-10.1%

% Δ Pre refers to the percent change of evasion over non-evasion before increasing competition.
% Δ Post refers to the percent change of evasion over evasion after increasing competition.
Increase in competition is adjusted by increasing the elasticity of substitution production inputs.

Table A21. Computable General Equilibrium Results - Monopoly Markup; Partial Factor Tax on Labor

	Monopoly Markup			Increased Competition	
	Non-Evasion	$Evasion_1$	% Δ Pre	$Evasion_2$	% Δ Post
Welfare 1	1.09	0.90	-17.3%	0.98	8.7%
Welfare 2	0.91	1.11	21.8%	0.99	-11.2%
X_1 Output	1.02	0.61	-40.3%	0.74	21.2%
X_2 Output	0.98	1.45	48.5%	1.25	-14.0%
Price X_1	1.66	1.89	13.7%	1.68	-11.0%
Price X_2	2.06	1.87	-9.0%	1.82	-2.8%
Capital Price	1.67	1.26	-24.4%	1.58	24.8%
Labor Price (Net)	0.55	1.02	86.1%	0.94	-7.4%
Consumer 1 Income	171.35	151.07	-11.8%	150.16	-0.6%
Consumer 2 Income	158.19	181.02	14.4%	155.04	-14.4%

% Δ Pre refers to the percent change of evasion over non-evasion before increasing competition
% Δ Post refers to the percent change of evasion over evasion after increasing competition.
Increase in competition is adjusted by increasing the elasticity of substitution production inputs.

Table A22. Computable General Equilibrium Results - Monopoly Markup; Partial Factor Tax on Labor; Increase in Penalty through Increased Probability of Detection (ρ = 0.1 to ρ = 0.5)

	Monopoly Markup			Increased Competition	
	Non-Evasion	$Evasion_1$	% Δ Pre	$Evasion_2$	% Δ Post
Welfare 1	1.09	1.06	-2.4%	1.06	-0.2%
Welfare 2	0.91	0.96	4.5%	0.95	-0.4%
X_1 Output	1.02	0.93	-8.5%	0.91	-2.1%
X_2 Output	0.98	1.09	10.9%	1.10	1.4%
Price X_1	1.66	1.67	0.6%	1.55	-7.0%
Price X_2	2.06	1.99	-3.4%	1.83	-7.9%
Capital Price	1.67	1.58	-5.7%	1.51	-3.9%
Labor Price (Net)	0.55	0.61	10.6%	0.54	-10.1%
Consumer 1 Income	171.35	166.53	-2.8%	154.24	-7.4%
Consumer 2 Income	158.19	161.29	2.0%	148.22	-8.1%

% Δ Pre refers to the percent change of evasion over non-evasion before increasing competition.
% Δ Post refers to the percent change of evasion over evasion after increasing competition.
Increase in competition is adjusted by increasing the elasticity of substitution production inputs.

Table A23. Computable General Equilibrium Results - Monopoly Markup; Partial Factor Tax on Labor; Increase in Penalty by Increasing Fine (f = 1.1 to f = 2)

	Monopoly Markup			Increased Competition	
	Non-Evasion	$Evasion_1$	% Δ Pre	$Evasion_2$	% Δ Post
Welfare 1	1.09	0.96	-11.8%	0.99	3.2%
Welfare 2	0.91	1.06	16.4%	0.98	-7.6%
X_1 Output	1.02	0.70	-30.9%	0.75	6.7%
X_2 Output	0.98	1.35	37.9%	1.24	-8.1%
Price X_1	1.66	1.79	7.6%	1.61	-10.0%
Price X_2	2.06	1.89	-8.3%	1.75	-7.3%
Capital Price	1.67	1.35	-19.2%	1.51	12.0%
Labor Price (Net)	0.55	0.85	55.4%	0.75	-11.9%
Consumer 1 Income	171.35	155.35	-9.3%	145.66	-6.2%
Consumer 2 Income	158.19	173.53	9.7%	148.27	-14.6%

% Δ Pre refers to the percent change of evasion over non-evasion before increasing competition.
% Δ Post refers to the percent change of evasion over evasion after increasing competition.
Increase in competition is adjusted by increasing the elasticity of substitution production inputs.

Table A24. Computable General Equilibrium Results - Monopoly Markup; Partial Factor Tax on Labor; Increase in Penalty by Doubling of Tax (t = 1 to t = 2)

	Monopoly Markup			Increased Competition	
	Non-Evasion	$Evasion_1$	% Δ Pre	$Evasion_2$	% Δ Post
Welfare 1	1.10	0.83	-24.0%	0.99	18.1%
Welfare 2	0.91	1.16	27.6%	0.98	-15.3%
X_1 Output	1.02	0.51	-50.3%	0.74	45.3%
X_2 Output	0.98	1.56	59.7%	1.25	-20.1%
Price X_1	2.23	2.78	24.6%	2.21	-20.5%
Price X_2	2.76	2.50	-9.4%	2.38	-4.7%
Capital Price	2.25	1.58	-29.9%	2.07	31.4%
Labor Price (Net)	0.44	1.04	137.0%	0.95	-8.5%
Consumer 1 Income	231.58	199.64	-13.8%	198.12	-0.8%
Consumer 2 Income	210.75	252.10	19.6%	201.43	-20.1%

% Δ Pre refers to the percent change of evasion over non-evasion before increasing competition.
% Δ Post refers to the percent change of evasion over evasion after increasing competition.
Increase in competition is adjusted by increasing the elasticity of substitution production inputs.

Table A25. Computable General Equilibrium Results - Monopoly Markup; Sales Tax

	Monopoly Markup			Increased Competition	
	Non-Evasion	$Evasion_1$	% Δ Pre	$Evasion_2$	% Δ Post
Welfare 1	0.98	0.70	-28.9%	0.69	-0.9%
Welfare 2	1.02	1.29	27.2%	1.33	2.9%
X_1 Output	1.00	0.38	-61.5%	0.34	-10.7%
X_2 Output	1.00	1.72	71.1%	1.82	5.8%
Price X_1	3.00	2.81	-6.3%	2.90	3.1%
Price X_2	3.75	2.27	-39.6%	2.08	-8.5%
Capital Price	1.00	0.71	-29.0%	0.95	34.3%
Labor Price (Net)	1.00	1.34	33.5%	0.99	-26.0%
Consumer 1 Income	279.80	162.75	-41.8%	159.24	-2.2%
Consumer 2 Income	320.41	256.78	-19.9%	241.92	-5.8%

% Δ Pre refers to the percent change of evasion over non-evasion before increasing competition.
% Δ Post refers to the percent change of evasion over evasion after increasing competition.
Increase in competition is adjusted by increasing the elasticity of substitution production inputs.

Table A26. Computable General Equilibrium Results - Monopoly Markup; Sales Tax; Increase in Penalty through Increased Probability of Detection (ρ = 0.1 to ρ = 0.5)

	Monopoly Markup			Increased Competition	
	Non-Evasion	$Evasion_1$	% Δ Pre	$Evasion_2$	% Δ Post
Welfare 1	0.98	0.94	-4.1%	0.94	-0.6%
Welfare 2	1.02	1.08	6.5%	1.10	1.6%
X_1 Output	1.00	0.83	-16.4%	0.79	-5.5%
X_2 Output	1.00	1.21	20.0%	1.27	5.1%
Price X_1	3.00	2.83	-5.7%	2.80	-0.8%
Price X_2	3.75	3.29	-12.4%	3.18	-3.4%
Capital Price	1.00	0.88	-12.1%	0.93	5.9%
Labor Price (Net)	1.00	1.04	4.3%	0.94	-9.9%
Consumer 1 Income	279.80	248.10	-11.3%	242.55	-2.2%
Consumer 2 Income	320.41	304.14	-5.1%	299.72	-1.5%

% Δ Pre refers to the percent change of evasion over non-evasion before increasing competition.
% Δ Post refers to the percent change of evasion over evasion after increasing competition.
Increase in competition is adjusted by increasing the elasticity of substitution production inputs.

Table A27. Computable General Equilibrium Results - Monopoly Markup; Sales Tax; Increase in Penalty by Increasing Fine (f = 1.1 to f = 2)

	Monopoly Markup			Increased Competition	
	Non-Evasion	$Evasion_1$	% Δ Pre	$Evasion_2$	% Δ Post
Welfare 1	0.98	0.78	-20.9%	0.77	-1.5%
Welfare 2	1.02	1.24	21.7%	1.28	3.0%
X_1 Output	1.00	0.49	-51.1%	0.44	-10.9%
X_2 Output	1.00	1.60	59.8%	1.70	6.2%
Price X_1	3.00	2.71	-9.7%	2.70	-0.1%
Price X_2	3.75	2.49	-33.6%	2.27	-9.0%
Capital Price	1.00	0.72	-28.1%	0.89	24.0%
Labor Price (Net)	1.00	1.22	21.6%	0.92	-24.5%
Consumer 1 Income	279.80	182.63	-34.7%	173.88	-4.8%
Consumer 2 Income	320.41	269.00	-16.0%	252.80	-6.0%

% Δ Pre refers to the percent change of evasion over non-evasion before increasing competition.
% Δ Post refers to the percent change of evasion over evasion after increasing competition.
Increase in competition is adjusted by increasing the elasticity of substitution production inputs.

Table A28. Computable General Equilibrium Results - Monopoly Markup; Sales Tax; Increase in Penalty by Increasing Tax (t = 1 to t = 2

	Monopoly Markup			Increased Competition	
	Non-Evasion	$Evasion_1$	% Δ Pre	$Evasion_2$	% Δ Post
Welfare 1	0.97	0.60	-38.4%	0.58	-2.0%
Welfare 2	1.03	1.36	32.3%	1.42	3.8%
X_1 Output	0.99	0.28	-71.7%	0.24	-13.2%
X_2 Output	1.01	1.83	81.6%	1.94	6.1%
Price X_1	4.99	5.13	2.8%	5.17	0.7%
Price X_2	6.26	3.47	-44.7%	3.05	-12.1%
Capital Price	1.00	0.74	-25.8%	1.02	37.8%
Labor Price (Net)	1.00	1.55	54.3%	1.06	-31.2%
Consumer 1 Income	459.60	237.38	-48.4%	221.57	-6.7%
Consumer 2 Income	541.33	413.64	-23.6%	377.50	-8.7%

% Δ Pre refers to the percent change of evasion over non-evasion before increasing competition.
% Δ Post refers to the percent change of evasion over evasion after increasing competition.
Increase in competition is adjusted by increasing the elasticity of substitution production inputs.

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Curriculum Vitae

Sean Christopher Turner was born in 1978 in New Jersey, and grew up in Milford, Pennsylvania. He received Bachelors of Science degrees in Economics and Criminal Justice from Shippensburg University in 2004. He was accepted into the doctoral program at Georgia State University in the fall of 2004. In 2007, he earned a Master of Arts degree in Economics and completed all the requirements for the Doctor of Philosophy in Economics degree at the Andrew Young School of Policy Studies of Georgia State University in August, 2010.

While attending Georgia State University, he worked as a graduate research assistant for Felix Rioja, Douglas Krupka, and Mark Rider. In 2007, he was hired as a research associate in the Fiscal Research Center where he conducted research for Kenneth Heaghney, State Fiscal Economist. He also worked as an adjunct professor at Georgia Perimeter College since July, 2009.

He is currently a Transfer Pricing Associate at PricewaterhouseCoopers, LLP in Atlanta, Georgia. His primary research interests are in the field of public finance, particularly in the areas of domestic and international tax policy.