

**Studying the Elasticity of Taxable Income and Its Functional Form from the
Taxpayer Compliance Perspective**

Binh Thanh Nguyen

Dissertation submitted to the faculty of the Virginia Polytechnic Institute and State
University in partial fulfillment of the requirements for the degree of

Doctor of Philosophy
In
Economics

Nicolaus Tideman, Chair
Sheryl Ball
Suqin Ge
Amoz Kats

May 5th, 2010
Blacksburg, VA

Keywords: elasticity of taxable income, functional form

Studying the Elasticity of Taxable Income and Its Functional Form from the Taxpayer Compliance Perspective

Binh Thanh Nguyen

ABSTRACT

The dissertation identifies and responds to two gaps in the current literature on the elasticity of taxable income (ETI). Firstly, there is a lack of a deep understanding of the process underlying behavioral responses of taxable income to taxation. Secondly, there is a lack of inquiry into the functional form of the ETI. This dissertation seeks to fill these gaps in the ETI literature. It constructs a theoretical framework for behavioral responses of taxable income to taxation, based on a review of the literature on taxpayer compliance behavior. The dissertation also introduces a new approach to estimating the ETI.

This study is the first attempt to fill in the gap of the ETI for a lack of studying the functional form of the ETI and factors determining the ETI function. Using the functional form derived from the Allingham-Sandmo model and empirical data on the function's arguments in the years 1979, 1982, 1985, and 1988, the dissertation studies behavior of the declared income elasticity function.

Acknowledgements

I appreciate my family for their encouragement and support to me to follow this Ph.D program. I express my gratitude to my committee chair Nic Tideman for his valuable advice and mentoring. I also appreciate the support and discussion of my committee members during my research process. I would like to thank the Department of Economics' faculty and staff for their warmly support during the last four years.

Table of Content

| | |
|--------------------------------------------------------------------------------------------|-----------|
| ABSTRACT..... | II |
| ACKNOWLEDGEMENTS | III |
| TABLE OF CONTENT..... | IV |
| LIST OF TABLES..... | VI |
| LIST OF ABBREVIATIONS..... | VII |
| 1. INTRODUCTION | 1 |
| 1. THE ETI LITERATURE REVIEW..... | 3 |
| 2.1. WHAT IS ETI AND WHY IT IS IMPORTANT? | 3 |
| 2.2. WHAT ARE DIFFICULTIES IN MEASURING ETI? | 4 |
| 2.2.1. <i>Exogenous Income Shifts</i> | 5 |
| 2.2.2. <i>Mean Reversion of Individual Income</i> | 5 |
| 2.2.3. <i>Tax Rate Endogeneity</i> | 5 |
| 2.2.4. <i>Institutional Changes</i> | 6 |
| 2.2.5. <i>Definitions of Taxable Income</i> | 6 |
| 2.2.6. <i>Transitory vs. Permanent Responses</i> | 6 |
| 2.3. HOW TO ESTIMATE ETI? | 7 |
| 2.3.1. <i>Lindsey (1987)</i> | 7 |
| 2.3.2. <i>Feldstein (1995)</i> | 7 |
| 2.3.3. <i>Auten and Carroll (1997)</i> | 8 |
| 2.3.4. <i>Auten and Carroll (1999)</i> | 8 |
| 2.3.5. <i>Carroll (1998)</i> | 9 |
| 2.3.6. <i>Goolsbee (2000)</i> | 10 |
| 2.3.7. <i>Moffitt and Wilhelm (2000)</i> | 11 |
| 2.3.8. <i>Gruber and Saez (2002)</i> | 11 |
| 2.3.9. <i>Saez (2003)</i> | 12 |
| 2.3.10. <i>Kopczuk (2003)</i> | 13 |
| 2.3.11. <i>Saez (2004)</i> | 14 |
| 2.3.12. <i>Giertz (2007)</i> | 14 |
| 2.3.13. <i>Summary</i> | 15 |
| 2.4. WHAT DO WE KNOW ABOUT BEHAVIORAL RESPONSES OF TAXABLE INCOME? | 16 |
| 2.5. WHAT DO WE KNOW ABOUT THE ETI FUNCTION? WHAT FACTORS DETERMINE THE ETI FUNCTION?..... | 17 |
| 2.5.1. <i>ETI Changes across Income Distribution</i> | 18 |
| 2.5.2. <i>ETI Changes across Occupations</i> | 18 |
| 2.5.3. <i>ETI Changes along Marital and Itemization Status</i> | 19 |
| 2.5.4. <i>ETI is a Function of Tax Base</i> | 19 |
| 2.5.5. <i>ETI Changes across Tax Regimes</i> | 19 |
| 2.5.6. <i>Different Income Components Have Different Response to Income Taxation</i> | 20 |
| <i>Remark: What has not done yet?</i> | 20 |
| 2.6. CONCLUSION..... | 21 |
| 3. NATURE OF TAXPAYER COMPLIANCE BEHAVIOR – A THEORETICAL FRAMEWORK..... | 22 |

| | | |
|-----------|----------------------------------------------------------------------------------------------------------------------------|-----------|
| 3.1. | TAX COMPLIANCE LITERATURE REVIEW: ECONOMIC MODELS OF TAXPAYER COMPLIANCE BEHAVIOR | 22 |
| 3.1.1. | <i>Static Random-audit Models</i> | 22 |
| 3.1.2. | <i>Models of Interactive Audit Strategies</i> | 23 |
| 3.1.3. | <i>Multiperiod Dynamic Models</i> | 25 |
| 3.2. | THEORETICAL FRAMEWORK: ANALYSIS OF BEHAVIORAL RESPONSES OF TAXABLE INCOME | 25 |
| 3.2.1. | <i>Substitution Responses: Labor Supply Analysis</i> | 26 |
| 3.2.2. | <i>Theoretical Models of Tax Evasion</i> | 28 |
| 3.2.3. | <i>Tax Evasion with Labor Supply</i> | 30 |
| 3.2.4. | <i>The Models of Tax Avoidance and Evasion</i> | 32 |
| 3.3. | SUMMARY | 43 |
| 4. | ESTIMATING THE ELASTICITY OF TAXABLE INCOME FROM THE TAXPAYER COMPLIANCE PERSPECTIVE..... | 45 |
| 4.1. | A REVIEW OF EMPIRICAL TAXPAYER COMPLIANCE STUDIES | 45 |
| 4.1.1. | <i>Clotfelter (1983)</i> | 45 |
| 4.1.2. | <i>Witte and Woodbury (1985)</i> | 45 |
| 4.1.3. | <i>Crane and Nouzard (1985)</i> | 46 |
| 4.1.4. | <i>Dubin and Wilde (1988)</i> | 47 |
| 4.1.5. | <i>Beron et al. (1988)</i> | 48 |
| 4.1.6. | <i>Dubin et al. (1990b)</i> | 49 |
| 4.1.7. | <i>Plumley (1996)</i> | 50 |
| 4.1.8. | <i>Summary</i> | 53 |
| 4.2. | ESTIMATING THE ETI FROM THE TAXPAYER COMPLIANCE PERSPECTIVE | 54 |
| 4.2.1. | <i>General Specification Model</i> | 54 |
| 4.2.2. | <i>Empirical Specification</i> | 55 |
| 4.2.3. | <i>Estimation Results</i> | 60 |
| 4.2.4. | <i>Findings</i> | 64 |
| 4.3. | CONCLUSION | 65 |
| 5. | STUDYING THE FUNCTIONAL FORM OF THE ELASTICITY OF TAX EVASION AND AVOIDANCE BEHAVIOR..... | 67 |
| 5.1. | THE FUNCTIONAL FORM OF THE ELASTICITY OF TAX EVASION AND AVOIDANCE BEHAVIOR..... | 67 |
| 5.1.1. | <i>AS Model</i> | 68 |
| 5.1.2. | <i>Alm Model</i> | 70 |
| 5.1.3. | <i>Summary</i> | 73 |
| 5.2. | STUDYING THE BEHAVIOR OF THE EDI FUNCTION | 73 |
| 5.2.1. | <i>The EDI Function for Calculation</i> | 74 |
| 5.2.2. | <i>Empirical Values for the EDI function's Arguments</i> | 74 |
| 5.2.3. | <i>Studying Behavior of the EDI function</i> | 77 |
| 5.3. | SUMMARY | 80 |
| 6. | CONCLUSIONS | 82 |
| | REFERENCES..... | 85 |
| | APPENDIX A: DEFINITIONS OF INCOME IN THE CURRENT ETI LITERATURE VERSUS DEFINITIONS OF INCOME IN PLUMLEY (1996)..... | 93 |
| | APPENDIX B: BASIC SPECIFICATION - EMPIRICAL RESULT | 96 |

List of Tables

| | |
|------------------------------------------------------------------------------------------|----|
| TABLE 2-1 <i>EMPIRICAL STUDIES ON THE ETI</i> | 15 |
| TABLE 3-1 <i>QUALITATIVE EFFECTS ON REPORTED INCOME</i> | 31 |
| TABLE 3-2 <i>COMPARATIVE STATIC RESULTS</i> | 38 |
| TABLE 3-3 <i>COMPARATIVE STATICS RESULTS OF ALM AND MCCALLIN (1990)</i> | 41 |
| TABLE 4-1 <i>ESTIMATION RESULTS</i> | 61 |
| TABLE 4-2 <i>PAIRWISE CORRELATION COEFFICIENTS AMONG EXPLANATORY VARIABLES</i> | 62 |
| TABLE 5-1 <i>AVERAGE MARGINAL TAX RATES, INDIVIDUAL PERSONAL INCOME, 1979-1990</i> | 74 |
| TABLE 5-2 <i>INDIVIDUAL AUDIT RATES, 1979-1992</i> | 75 |
| TABLE 5-3 <i>AVERAGE NET PENALTY RATES, INDIVIDUALS, 1979-1988</i> | 75 |
| TABLE 5-4 <i>VOLUNTARY REPORTING RATE (VRR) – INDIVIDUAL INCOME TAX RETURNS</i> | 77 |
| TABLE 5-5 <i>EMPIRICAL VALUES FOR THE EDI FUNCTION</i> | 77 |
| TABLE 5-6 <i>THE AS MODEL - CALCULATION RESULTS IN 1982</i> | 78 |
| TABLE 5-7 <i>THE EDI WITH VARIATION IN THE VOLUNTARY INCOME REPORTING RATE (S)</i> | 78 |
| TABLE 5-8 <i>THE EDI WITH VARIATION IN THE MARGINAL TAX RATE (T)</i> | 79 |
| TABLE 5-9 <i>THE EDI WITH VARIATION IN THE AUDIT RATE (P)</i> | 79 |
| TABLE 5-10 <i>THE EDI WITH VARIATION IN THE FINE RATE (II)</i> | 79 |

List of Abbreviations

| | |
|-----------|-------------------------------------------|
| AGI | Adjusted Gross Income |
| AS model | Allingham and Sandmo model |
| ASY model | Allingham-Sandmo-Yitzhaki model |
| CID | Criminal Investigation Division |
| CPI | Consumer Price Index |
| CPS | Current Population Survey |
| CWHS | Continuous Work History Survey |
| EDI | Elasticity of Declared Income |
| ERTA | Economic Recovery Tax Act of 1981 |
| ETI | Elasticity of Taxable Income |
| IRP | Information Returns Program |
| IRS | Internal Revenue Service |
| IV | Instrument Variables |
| LSDV | Least Squares Dummy Variable |
| NIPA | National Income and Product Account |
| NRP | National Research Program |
| OBRA90 | Omnibus Budget Reconciliation Act of 1990 |
| OBRA93 | Omnibus Budget Reconciliation Act of 1993 |
| SCF | Survey of Consumer Finances |
| SOI | Statistics of Income |
| TCMP | Taxpayer Compliance Measurement Program |
| TPS | Taxpayer Service |
| TRA86 | Tax Reform Act of 1986 |
| VCL | Voluntary Compliance Level |
| VRR | Voluntary Reporting Rate |
| 2SLS | Two-Stage Least Squares |

1. Introduction

Over last two decades, the elasticity of taxable income with respect to the net-of-tax rate (ETI) has become a central parameter in the welfare analysis. The ETI literature has greatly improved the understanding of the relationship between taxable income and taxation. The current understanding of ETI has permitted economists to estimate taxpayers' responses to income taxation.

The ETI literature has provided evidence of factors affecting ETI such as income, occupation, tax base, marital and itemization status. However, there has been no research adequately investigating functional form of the ETI as well as factors determining the ETI function.

Reviewing the current ETI literature, Giertz (2004) argues that it is difficult to estimate the ETI accurately. One of the reasons is that “the process underlying (or sources driving) the taxable income response is not fully understood.”¹ This suggests that there is a lack of understanding of the process or mechanism underlying behavioral responses of taxable income and the factors determining responses of taxable income. This is an important weakness of the current ETI literature. This understanding is necessary because it provides essential knowledge to quantify effects of the tax rate and non-tax factors on taxable income responses.

Actually, there are at least two papers suggesting a theory of behavioral response of taxable income. Slemrod (1995) suggests that it is necessary to construct a theory of behavioral response of taxpayer to taxation that recognizes varieties of behavioral response and the interrelationship among those responses. Slemrod and Yitzhaki (2000) provide the first attempt to construct a common framework that integrates all types of behavioral responses of taxpayers to the taxation system. These behavioral responses include a substitution response, tax avoidance, and tax evasion. However, these papers only give some general ideas of a theoretical framework for behavioral responses of taxable income. They do not provide a theoretical framework that explains in detail the mechanism underlying the behavioral responses of taxable income and factors determining those responses.

The purpose of my study is to fill in these gaps in the ETI literature. There has been a rich literature on the income reporting behavior of taxpayers that started in the early 1970s with the seminal paper by Allingham and Sandmo (1972). It is surprising me that empirical ETI studies have not drawn upon the taxpayer compliance literature before now.

Drawing on the taxpayer compliance literature, this dissertation seeks to construct a theoretical framework for behavioral responses of taxable income. The main purpose of this theoretical framework is (i) to give an explanation about the underlying mechanism of behavioral responses of taxable income, and (ii) to identify factors that determine responses of the taxable income.

¹ Giertz (2004), p.13.

Relying on this theoretical framework, the dissertation seeks to quantify the effects of tax rate and other factors on taxable income. As a result, this study introduces a new approach to estimating the ETI from the taxpayer compliance perspective.

It is notable that this dissertation is the first effort to merge the empirical ETI literature into the taxpayer compliance literature. To achieve this purpose, the study uses a panel data set for the period 1982-1991. This data set has been used by Plumley (1996). This new estimation approach is more general and yields an empirical result that is very close to the empirical results of the current ETI literature. The most favored specification yields an estimated ETI of 0.33 for the period 1982-1991; the most reliable longer-run ETI estimates in the current ETI literature are in the range of 0.12 to 0.4.² However, the estimates of ETI in this framework have large standard errors, implying a substantial lack of precision in estimates of ETI. This may come from a collinear problem between year dummies and the net-of-tax rate.

The advantage of this new approach is that it yields a more meaningful explanation of factors determining response of the taxable income. The ETI can be estimated in a simple regression model with a more complete set of explanatory variables.

The theoretical framework for behavioral responses of taxable income also provides a foundation for studying the functional form of the elasticity of tax evasion and avoidance - two components of the taxable income response. The theoretical models developed by Allingham and Sandmo (1972) and Alm (1988a) provide valuable elements for deriving specific functional forms of the declared income elasticity function and the taxable income elasticity function. This dissertation studies behavior of the declared income elasticity function derived from the Allingham and Sandmo model.

The rest of the dissertation includes five chapters. Chapter 2 reviews the ETI literature. This chapter summarizes what already know about the ETI and suggests possible gaps in the current ETI literature. Chapter 3 reviews the taxpayer compliance literature and constructs a theoretical framework for behavioral responses of taxable income. Basing on the theoretical framework developed in the previous chapter, Chapter 4 is an attempt to estimate ETI and quantify effects of tax rate and other non-tax factors on taxable income. Chapter 5 studies the functional forms of the elasticity of tax evasion and avoidance behavior. It uses the empirical data regarding the arguments of the elasticity function to study the function's behavior. Chapter 6 summarizes findings and contributions of the dissertation and suggests directions for further research.

² Saez et. al. (2009).

1. The ETI Literature Review

This chapter reviews the ETI literature. The purpose of this chapter is to answer the two sets of questions about the ETI literature:

- (1) What is already known about the ETI? Why it is important to measure the ETI? What are problems in measuring ETI? How do researchers measure the ETI and what are limitations in their estimation methods?
- (2) What has been on the agenda of ETI researchers but not accomplished yet? What has the literature not revealed about the ETI?

Until now there have been three papers reviewing the ETI literature in detail. Slemrod (1998a) summarizes evidence about ETIs and reviews critically the methodological issues in measuring ETI. Giertz (2004) focusses on empirical studies that examined the U.S. tax changes of 1981 (ERTA), 1986 (TRA86), 1990 and 1993 (OBRA90 and OBRA93), and the bracket creep of the late 1970s and early 1980s.³ He also discusses major methodological issues in measuring ETIs. Saez et. al. (2009) review critically the most of the ETI studies to date, both in the U.S. and abroad.

The rest of this chapter consists of six sections. The first three sections seek answers for the first set of questions. Section 2.1 presents the concept of the ETI and explains implication of the ETI for welfare analysis. Section 2.2 discusses difficulties in estimating the ETI. Section 2.3 reviews empirical ETI studies to see how the researchers measure the ETI and identify limitations in their estimation methods.

The next two sections explore what the ETI literature still needs to investigate. Section 2.4 discusses the behavioral responses of taxable income to taxation. Section 2.5 discusses the ETI function and factors that affect the ETI. These two sections answer the question of what more we need to know about the ETI.

Section 6 concludes this chapter by explaining why this research is relevant and providing a roadmap for the rest of the paper.

2.1. What is ETI and Why It is Important?

The ETI measures the relationship between taxable income and income taxes. The ETI is defined the percentage change in reported taxable income associated with a one-percent increase in the “net-of-tax rate”, which is the share of the next dollar of reported taxable income that is not collected in taxes, that is one minus the tax rate.⁴

³ ERTA stands for the Economic Recovery Tax Act of 1981, TRA86 stands for the Tax Reform Act of 1986, OBRA90 and OBRA93 stand for the Omnibus Budget Reconciliation Acts of 1990 and 1993.

⁴ Giertz (2004), p.1.

$$(2.1) \text{ETI} = \frac{\partial(\text{Taxable Income})}{\partial(1-t)} \frac{1-t}{\text{Taxable Income}}.$$

It is important to measure the ETI because it is a key parameter for projecting income tax revenue and evaluating the efficiency implications of a tax change.

Feldstein (1999) asserts that, under certain assumptions, all behavioral responses to income tax rate changes are symptoms of inefficiency, and all such responses are captured by the ETI.⁵ Therefore, the ETI can be used to calculate both the change in efficiency cost (i.e., dead-weight loss) and the change in income-tax revenue resulting from a change in tax rates. Feldstein shows that:

$$(2.2) \text{Dead weight loss} = -0.5 \times \text{ETI} \times \text{Taxable Income} \times \frac{t^2}{1-t}.$$

The change in income tax revenue can be derived as following:

$$(2.3) \text{ETI} = \frac{\partial(\text{Taxable Income})}{\partial(1-t)} \frac{1-t}{\text{Taxable Income}} = \frac{\partial(t \times \text{Taxable Income})}{t \times \text{Taxable Income}} \frac{1-t}{\partial(1-t)} = \frac{\partial(\text{Tax Revenue})}{\text{Tax Revenue}} \frac{1-t}{\partial(1-t)}.$$

Then,

$$(2.4) \frac{\partial(\text{Tax Revenue})}{\partial(1-t)} = \text{ETI} \times \left(\frac{\text{Tax Revenue}}{1-t} \right) = \text{ETI} \times \text{Taxable Income} \times \left(\frac{t}{1-t} \right).$$

Assuming a constant ETI over the tax change, the change in revenues for a change in the tax rate (Δt) can be expressed such that

$$(2.5) \Delta t \frac{\partial(\text{Tax Revenue})}{\partial(1-t)} = \text{ETI} \times \text{Taxable Income} \times \Delta t \times \left(\frac{t}{1-t} \right).$$

The ETI is not always a sufficient statistic for the welfare analysis. Saez et. al (2009) points out that if some of the responses of taxpayers involve changes in activities with externalities, then the ETI is not a sufficient statistic for welfare analysis.

2.2. What Are Difficulties in Measuring ETI?

Giertz (2004) points out that measuring accurately ETI is difficult. He mentions three main causes for this difficulty: (i) responses to taxation are complex and never occur in isolation; (ii) the underlying economic conditions are complex and impact reported taxable income in ways that are not fully understood; and (iii) the tax code provides opportunities to shift income between different tax bases (or to alter the timing of taxation), but reporting requirements do not allow researchers to observe the full spectrum of behavior. For these reasons it is difficult to measure the ETI accurately.

⁵ Slemrod (1998a) mentions these assumptions. They require that there be no externalities or other market failures and no income effects.

Technical problems in measuring ETI are discussed by Slemrod (1998a) and Giertz (2004). The primary technical problem is to devise a method for separating the response of taxable income to changes in taxes from the many other factors that also affect taxable income. It is commonly agreed that adequately controlling for non-tax-induced trends in taxable income poses a major challenge for estimating the elasticities. In addition, several other issues create obstacles for elasticity estimation. Those issues include mean reversion, tax rate endogeneity, institutional changes, and the distinction between transitory and permanent responses.

2.2.1. Exogenous Income Shifts

Slemrod (1998a) points out that one methodological problem is to separate the influence of tax changes from non-tax factors affecting the steadily increasing dispersion of taxable income. There two non-tax explanations for the increase in income inequality in the U.S since the 1970s. The first one is technological change, which increased the relative return to skilled labor. The other is increased globalization of the U.S. economy, which increased the supply of unskilled labor and thereby lowered its relative return.

Giertz (2004) suggests that exogenous changes in the income distribution are not well understood. The fact that the exogenous income trend has persisted through periods of both increases and decreases in the level and progressivity of tax rates suggests that it is, in large part, not a direct response to tax changes. In addition, because the trend has been irregular, distributional changes in years without tax changes may not provide useful measures of exogenous shifts that occur during period with tax changes.

2.2.2. Mean Reversion of Individual Income

Mean reversion complicates ETI estimations using individual tax return data.⁶ Not accounting for mean reversion at the tails of the distribution can substantially bias estimated elasticities. More specifically, not fully controlling for mean reversion will erroneously count non-tax related increases by those below their lifetime path and non-tax-related decreases by those above their lifetime path as responses to changes in tax rates. Those factors will bias ETI estimates in opposite directions, depending on whether tax rates are raised or lowered. For that reason, many studies exclude observations with very low earnings.

2.2.3. Tax Rate Endogeneity

Slemrod (1998a) points out that the endogeneity of the marginal tax in a progressive income tax system is a generic problem that plagues all empirical work on the behavioral response to taxation. The empirical ETI literature has adopted a number of different approaches to this problem. Feldstein (1995) groups taxpayers by their pre-TRA 86 marginal tax rates. Auten and

⁶ Giertz (2004) explains the mean reversion phenomenon. Over a person's life time, income often follows a path with many fluctuations. After a period when income is particularly high or low it will often revert to a more normal path. This phenomenon is especially pronounced at the tails of the distribution.

Carroll (1999) instrument for the difference in logged net-of-tax rates by constructing a taxpayer's 1989 tax rate using 1989 tax law applied to 1985 taxable income inflated to 1989 levels. Carroll (1998) uses as an instrument the constant tax law last-dollar marginal tax rate evaluated at the average taxable income over the seven-year period examined. Moffitt and Wilhelm (2000) investigate several different instruments, including education and occupation.

2.2.4. Institutional Changes

Sometimes the tax rate schedule changes without other major changes in the tax law (e.g., ERTA, OBRA90 and OBRA93). In other cases, tax rate changes are accompanied by many changes in the tax base (e.g., TRA86). Giertz (2004) argues that institutional changes in the tax system, taking effect concurrently with tax rate changes, could affect reported taxable income, biasing estimated elasticities or at least complicating estimation. For example, most elasticity measures assume policies toward tax evasion and avoidance are given, when in fact those policies can change.

2.2.5. Definitions of Taxable Income

Definitions of taxable income may cause problem in estimating ETI.⁷ Using a concurrent definition of taxable income will confuse tax-induced changes in behavior with definitional changes. Researchers can overcome this problem by consistently using either a pre- or post-tax change definition of taxable income. Even if a consistent measure of taxable income could be constructed, the choice of which constant-law definition of taxable income to use is a problem. For example, in the case of TRA86, using the post-reform definition produces lower estimates of the ETI.

2.2.6. Transitory vs. Permanent Responses

Giertz (2004) suggests that separating transitory from permanent responses is often difficult. Measuring changes in taxable income in the year prior to and the years succeeding a tax change will likely yield a combination of permanent and transitory responses.

Phase-in periods and taxpayer expectations about future tax legislation also matter. For example, if rate cuts phase in, people not only divert income to the future, but also substitute leisure in the short term for work in the future. In that instance, intertemporal substitution could result in a short-term understatement and a long-term overstatement of the ETI.

In addition, tax policy can affect investment in both human and physical capital, which over time could influence taxable income. That long-run response is the best indicator of the true response to tax changes, but it may not be fully observed for many years following a tax change, leading to an understatement of the ETI.

⁷ Slemrod (1998a), Saez et. al. (2009).

2.3. How to Estimate ETI?

This section reviews the empirical ETI studies to answer following questions: How do researchers measure ETI? What are their estimation methods? How do they handle the technical issues? What are limitations in their methods? What are estimated values of ETI?

2.3.1. Lindsey (1987)

Lindsey studies the Economic Recovery Tax Act of 1981 (ERTA) using repeated cross-sectional data.

He uses IRS tax return data from 1979 to make projections of the income distribution for years after ERTA, based on pre-ERTA law and the macroeconomic conditions existing in the intervening years. Then he compares the counterfactual projections against the actual post-ERTA income distribution to measure responses of taxable income to the tax cuts.

Lindsey considers three logarithmic regression specifications to estimate the ETI. From the data analysis, Lindsey realizes the ETI may change with the taxpayer's income. So he considers different regression specifications with constant elasticity and income-variant elasticities.

Constant elasticity model of taxpayer behavior⁸:

$$(2.6) \log\left(\frac{Y_i}{Y_i^*}\right) = \alpha + \beta \ln\left[\frac{1-t_i}{1-t_i^*}\right] + \varepsilon_i$$

Income-variant elasticity model 1 (elasticity rises with natural log of income):

$$(2.7) \log\left(\frac{Y_i}{Y_i^*}\right) = \alpha + \beta \ln\left[\frac{1-t_i}{1-t_i^*}\right] + \gamma \ln Y^* \ln\left[\frac{1-t_i}{1-t_i^*}\right] + \varepsilon_i$$

Income-variant elasticity model 2 (elasticity rises in direct proportion to income):

$$(2.8) \log\left(\frac{Y_i}{Y_i^*}\right) = \alpha + \beta \ln\left[\frac{1-t_i}{1-t_i^*}\right] + \gamma Y^* \ln\left[\frac{1-t_i}{1-t_i^*}\right] + \varepsilon_i.$$

The central estimates of the ETI lie between 1.60 and 1.80. The main problem with Lindsey's method is that he does not control for exogenous changes in the income distribution and thus attributes those changes to ERTA. As a result, he obtains upwardly biased estimates of the ETI.

2.3.2. Feldstein (1995)

Feldstein (1995) uses tax return panel data to study the Tax Reform Act of 1986 (TRA86). He uses data from the Statistics of Income's (SOI) Continuous Work History Survey (CWHS) for years from 1985 and 1988.

Feldstein uses the differences-in-differences method to estimate the ETI. He groups taxpayers by their 1985 marginal tax rates. For the first difference he calculates both the percentage change in

⁸ Lindsey denotes the actual taxable income by Y_i , the baseline level of taxable income by Y_i^* , the post-ERTA tax rate by t_i , and the pre-ERTA tax rate on which the base line is based by t_i^* .

mean taxable income and the percentage change in the net-of-tax rate from 1985 to 1988. The results show the relationship between change in tax rate and change in taxable income in each group. To remove effects of other non-tax factors that would affect taxable income, Feldstein conducts a second difference. He subtracts the percentage changes of the taxable income and the net-of-tax rate for one of the two lower-income groups from the respective changes for one of the two higher groups. Then he calculates the elasticities by dividing the second difference for taxable income by the second difference for the net-of-tax rate.

He obtains estimated ETIs for the two highest income groups ranging from 1.1 to 3.05 for Adjusted Gross Income (AGI). There are two major limitations with Feldstein's estimation method. First, the differences-in-differences method assumes that unobserved factors that may influence the change in taxable income over the period under study have a proportional impact across the income distribution. In fact, this assumption does not hold. The secular uptrend in taxable income is much more pronounced at the upper end of the distribution. As a result, the differences-in-differences method leads to overestimates of the ETI.

The other drawback of Feldstein's study is that his data set contained only a very small number of high-income observations, and there is some attrition in the sample over time. Those problems may lead to underrepresentation in the sample and endogenous sample selection, which bias the estimation of ETI.

2.3.3. Auten and Carroll (1997)

Auten and Carroll replicate Feldstein's methodology but use a much larger panel data set available within the U.S. Treasury. They compare CWSHS data for 1985 and 1989 and obtain high estimated elasticities (from 0.46 to 3.04), which are consistent with Feldstein's results.

Auten and Carroll test the sensitivity of their results. They explore several specifications, adding variables such as age, age squared, and wealth to the model. They also expand the panel with a large number of high-income filers and add state tax rates to the model. They find that estimated ETIs are quite sensitive to both income definition and regression weights. They are most confident in an ETI estimate of 0.74, which is based on a constant-law definition of taxable income and employs regression weights to control for the SOI's random sampling.

2.3.4. Auten and Carroll (1999)

In this study, Auten and Carroll address issues such as mean reversion, tax rate endogeneity, and exogenous changes in the income distribution, which plagued the earlier studies. They use a larger panel data set for 1985 and 1989 to study TRA86.

Auten and Carroll use control variables for region and occupation to address mean reversion and control for divergence in the income distribution. They adopt a two-stage least-squares (2SLS) regression approach, regressing the change in the log of the constant-law AGI between 1985 and

1989 against the change in the log of the net-of-tax rate and a set of other exogenous variables.⁹ To address tax rate endogeneity, they instrument for the change in the net-of-tax rate by inflating adjusted 1985 incomes by the CPI to 1989 levels and then applying 1989 law to these incomes.

Auten and Carroll obtain their most confident result in a weighted least-squares model that includes both tax and non-tax factors (including occupational dummies), which yields an estimate of ETI of 0.55. Excluding occupation information reduces the elasticity to 0.51. Excluding all non-tax factors raises the elasticity to 0.75.

The limitation of their estimation method is that their method does not address tax rate endogeneity effectively. Auten and Carroll use only one year of income data to construct the instrumental variable. Carroll (1998) suggests that, due to mean reversion, the use of a single year of income on which to calculate the synthetic tax price results in substantial bias in the estimated elasticity. Saez et. al. (2009) points out the evidence of mean reversion by employing the inverted panel approach. The resulting estimate of ETI rises to 1.13, which is consistent with mean reversion.

In addition, Auten and Carroll do not control effectively for mean reversion and exogenous changes in the income distribution. Gruber and Saez (2002) suggest that controlling by lagged income is not appropriate because the two effects (mean reversion and exogenous changes in the income distribution) do not necessarily operate linearly.

Saez et. al (2009) conclude that no convincing estimates of the ETI can be obtained with panel data for only two years. With only two years of data, adding necessary base-year income controls destroys the possibility of identification.

2.3.5. Carroll (1998)

Carroll uses a method similar to Auten and Carroll's (1999) to study the tax increases in the early 1990s, OBRA90 and OBRA93. He uses the SOI data set for a group of taxpayers from 1989 to 1995.

Carroll uses the log of year-to-year income changes as his dependent variable. To control for tax rate endogeneity and mean reversion, he uses average income over the seven years to construct an instrumented tax rate that varies only with exogenous tax law changes. To control for non-tax factors, he includes year dummies, age, age-squared, occupation, region, financial wealth, and the number of dependent children.

Carroll obtains estimated elasticities of 0.38 for adjusted taxable income and 0.32 for gross income, with his most confident specification.

⁹ The key exogenous variables include a proxy for financial wealth; age and age-squared are used to control for life-cycle effects; a taxpayer's 1985 income is included to control for mean reversion; dummy variables for census regions based on state of residence in 1985 are included to capture the different opportunities for income growth; occupational variables are added to consider the effect of human capital on income growth.

There are two limitations of Carroll's estimation. First, Carroll uses permanent income to control for mean reversion. While it may help with mean reversion, it does not address the concern with omitted variable bias through exogenous changes of the income distribution.¹⁰ Second, Carroll uses annual data from 1989-1995 to measure the permanent overall ETI. This measure may not remove transitory influences from the elasticity estimates, so it may overestimate the overall ETI.¹¹

2.3.6. Goolsbee (2000)

Goolsbee uses a panel dataset of the top five executives from 1991-1995 at corporations in the Standard and Poor's S&P 500, S&P Mid Cap 400 and S&P Small Cap 600, to examine high-income responses to OBRA93.

He runs regression of income against both the current year net-of-tax rate and the future year net-of-tax rate, along with year dummies and firm-specific information. The regression model takes the following form:

$$(2.9) \quad \ln(\text{income}_i) = \alpha_i + \beta \ln(1 - \text{Tax}_{it+1}) + \delta \ln(1 - \text{Tax}_{it}) + X'_{it} \Gamma + \varepsilon_{it},$$

where the *Tax* terms represent the marginal tax rates at the next and current periods, the *X*'s are other controls, which can vary by executive-year (such as firm performance) or just by year (such as year dummies). If short-run timing changes and anticipation are important, future tax increases should increase current taxable income and current taxes should reduce current taxable income (i.e., $\beta < 0$ and $\delta > 0$).

Because sources of executive income vary greatly from year to year, it complicates elasticity estimation. So Goolsbee explores various approaches, including regressions with linear fixed effects, first differencing, and split samples.

The income variable Goolsbee uses is earned income, instead of taxable income. Earned income makes up just one component of taxable income. Actually, Goolsbee measures the elasticity of earned income, not the elasticity of taxable income. Goolsbee's estimated elasticities are often above one, but much of that response is transitory. Longer-term elasticities are much smaller, often close to zero, but as high as 0.40.

One limitation of Goolsbee's method is that his data sample may not be representative of other high-income taxpayers. The data set lacks both demographic information and information on deductions, exemptions, and income received from outside the firm. The other limitation is that Goolsbee uses few controls for exogenous changes in the income distribution, which could bias responses downward.

¹⁰ Gruber and Saez (2002).

¹¹ Giertz (2007). To take out the influence of the transitory component of income, Giertz re-estimates the ETIs after excluding all years just after and before tax the reforms in the 1980s and the 1990s. He estimates that the ETI for the 1990s is 0.15, a little smaller than the corresponding estimate that does not exclude any years.

2.3.7. Moffitt and Wilhelm (2000)

Moffitt and Wilhelm use panel data from the 1983 and 1989 Survey of Consumer Finances (SCF) to study responses of reported income to TRA86. Due to data limitations, they use an income concept close to AGI rather than taxable income.

Using Feldstein's (1995) approach, they obtain estimated elasticities for AGI from 1.76 to 1.99. Then they apply a 2SLS regression approach, using different instruments for the change in net-of-tax rate (including education and measures of illiquid assets). This method yields estimated elasticities ranging between 0.35 and 0.97.

As in the case of Auten and Carroll (1999), the limitation of this study is that the estimates of elasticity based on only two years of data are subject to mean reversion.

2.3.8. Gruber and Saez (2002)

Gruber and Saez use the CWS panel for the years 1979 to 1990 to study responses of taxable income to both ERTA and TRA86. They consider two income concepts, broad income and taxable income.¹² They measure behavioral changes over three-year intervals. This yields variation in tax rates across time for all income levels. They incorporate state and federal income tax changes, so they have cross-sectional variations in tax rate changes within income groups.

Gruber and Saez construct instruments to control for tax rate endogeneity. First, they inflate beginning-year income by the growth in broad income over the three-year interval. Then they calculate counterfactual tax rates by applying the future tax law to the inflated beginning-year income. The instrumented tax rates are estimated via a 2SLS regression, where the actual change in tax rates is regressed against the counterfactual change in rates, along with other independent variables. Gruber and Saez also construct a similar instrument for the income effect.

To control for mean reversion and exogenous changes in the income distribution, Gruber and Saez add a ten-piece spline in log of the first period income, in addition to log of the first period income. They also control for time (by including year dummies) and marital status.

Their regression specification takes following form:

¹² Broad income equals AGI plus "adjustments" such as IRA contributions, but it does not include capital gains. Taxable income includes itemized deductions and adjustments that are reported for all years from 1979 to 1990, but it does not include capital gains.

$$\begin{aligned}
(2.10) \quad \log\left(\frac{z_2}{z_1}\right) &= \alpha_0 + \zeta \log\left[\frac{1 - T_2'}{1 - T_1'}\right] + \eta \log\left[\frac{z_2 - T_2(z_2)}{z_1 - T_1(z_1)}\right] + \alpha_1 \log(z_1) \\
&+ \sum_k \alpha_{2k} mars_k + \sum_j \alpha_{3j} YEAR_j + \sum_{i=1}^{10} \alpha_{4i} SPLINE_i(z_1) + \varepsilon,
\end{aligned}$$

where $YEAR_j$ denote base year dummies, and $mars_k$ dummies for marital status in base year.

The equation is estimated by 2SLS using $\log\left[\frac{1 - T_p'}{1 - T_1'}\right]$ and $\log\left[\frac{z_2 - T_p}{z_1 - T_1(z_1)}\right]$ as instruments.

Gruber and Saez are most confident in the estimated taxable income elasticity of 0.40 from the model including a 10-piece spline based on the natural log of the first period income. The estimated elasticity for broad income is 0.12, which is much smaller than the estimated value of taxable income elasticity.

Kopczuk (2003) uses the same CWS data and varies Gruber and Saez's specification with different sample selections. He shows that the Gruber and Saez's estimation results are very sensitive to sample selection. This suggests the Gruber and Saez's specification may suffer from mis-specification error.

Another possible limitation of Gruber and Saez's study is that they use the base year income as the single variable to control for both mean reversion and changes in the income distribution. Kopczuk (2003) argues that one cannot control for these two issues by using a single control variable. These two issues should be controlled for by two separate control variables.

2.3.9. Saez (2003)

Saez uses a publicly available SOI-based dataset (the University of Michigan Panel) to study responses to tax increases resulting from bracket creep between 1979 and 1981. Saez compares taxpayers with similar incomes (and the same tax rate) in the initial year, but whose predicted incomes put them into different brackets in a subsequent year.

Saez runs regression of the one-year change in the log of income against the instrumented log change in the net-of-tax rate, along with base year income controls and dummies for filing and itemization status. The discontinuities created by bracket creeps create an effective control for mean reversion and exogenous trends in income. Saez obtains a statistically insignificant overall ETI estimate of 0.31. The overall elasticity for AGI is 0.18.

There are some limitations to Saez's estimation method. First, the ETI estimates capture only short-run responses to tax changes because Saez only works with year-to-year changes. Second, the ETI estimates are not very precise because changes in tax rates due to "bracket creep" are relatively small compared to the changes induced by the tax reforms of the 1980s. Third, the

‘bracket creep’ cannot be satisfactorily used to estimate the elasticities because it appears that taxpayers either control their income imperfectly or are not well aware of the details of the tax code and their locations on the tax schedule.¹³

2.3.10. Kopczuk (2003)

Kopczuk uses the CWS data from 1979 to 1990 to study the tax changes in the 1980s. He investigates the hypothesis that the ETI is a function of the tax base, rather than a structural parameter.

Kopczuk first replicates Gruber and Saez’s work but uses the full sample. He does not exclude taxpayers with less than \$10,000 of income. Using the log of initial income to control for mean reversion, he obtains an elasticity of 1.44, versus 0.61 for Gruber and Saez. Using Gruber and Saez’s preferred specification with a 10-piece spline, Kopczuk obtains an elasticity of 0.21, versus 0.40 for Gruber and Saez.

Kopczuk argues that one cannot control for both mean reversion and exogenous changes in the income distribution by using a single control variable. So he experiments with specifications with two control variables to control separately for mean reversion and divergence in the income distribution.¹⁴ Controlling separately for those two factors yields elasticities between 0.55 and 1.37. The specification in which he is most confident, which includes both a spline based on the log of 1979 income and a spline based on the difference between the log of taxable income in the beginning year of each of three-year pair and the log of 1979 taxable income, yields an elasticity of 0.57.

To evaluate influence of the tax base on the elasticity of taxable income, Kopczuk derives the following regression specification in first differences:

$$(2.11) \quad \Delta \ln(B_{is}) = \varepsilon \Delta \ln(\tau_{is}) + \beta \Delta [\gamma_{is} \ln(\tau_{is})] + \eta \Delta \ln(B_{is} - T_{is}) + \Delta \delta^v Z_i^v + \delta^h \Delta Z_s^h + \Delta \theta_{is},$$

where i denotes individuals and s denotes time index, B is the reported income or broad income, τ is the marginal net-of-tax rate, γ is the share of deductible consumption¹⁵, T is tax liability, η measures the income effect, Z^v is the set of time-invariant variables and Z^h is the set of time-variant variables, $\Delta \theta$ subsumes the effects of any other variables not controlled for.

Following Gruber and Saez’s methodology, he uses a 2SLS approach with instruments for both the change in the log net-of-tax rate and for the interaction of that variable with the tax base. For instruments, he uses the log of the predicted changes of these variables, absent any behavioral response. For this specification, Kopczuk obtains an estimated ETI of 0.53.

¹³ Saez (2004).

¹⁴ Kopczuk defines the transitory income component by the difference between the current year’s income and 1979 income. This variable is used to control for mean reversion. To control for divergence in the income distribution, he uses the 1979 income as a measure of an individual’s rank in the income distribution.

¹⁵ γ equals $\frac{GD}{B}$, where D is a typical deductible commodity and G is the number of deductible commodities.

2.3.11. Saez (2004)

Saez uses aggregated SOI time-series data from 1960 to 2000 to study responses of taxable income to taxation.

First, Saez runs regressions of the log of average income on the log of average net-of-tax rate with different controls for non-tax related trends in taxable income. In the regression model with a control variable for a time trend, he obtains an overall estimated ETI of zero. Including the time trend and the square of the time trend raises the overall estimated ETI to 0.20. For the top 1 percent of the taxable income distribution, the results become much higher and more significant. With the time trend, the estimated ETI is 0.71. Adding the square of the time trend lowers the ETI estimate to 0.50.

Saez then runs regressions that use taxable income shares to estimate ETIs for different segments of the income distribution. For different income groups, he runs regression of the log of the group's share of taxable income against the log of the net-of-tax rate.¹⁶ The specification with both the time trend and square of the time trend yields an estimated ETI of 0.62 for the top 1 percent.

One limitation of Saez's estimation method is that he uses time trends to control for exogenous changes of the income distribution. The researchers often do not have a precise understanding about non-tax factors affecting the income distribution. They do not know exactly what time-trend specifications are necessary to control for non-tax related changes. Adding too many time controls can destroy the time-series identification.¹⁷

2.3.12. Giertz (2007)

Giertz uses both CWSHS and full SOI data for years from 1979 – 2001 to study the variation of the ETI in the 1980s and the 1990s.

He applies Gruber and Saez (2002)'s methodology to the larger panel data sets of tax returns. Using the data from CWSHS, he obtains an estimated ETI for the 1990s of 0.20. The corresponding estimate for the 1980s is 0.43. When he uses broad income, the estimated elasticity is 0.15 for the 1990s, and 0.12 for the 1980s. Calculating the ETI for 1979 to 2001, Giertz obtains an estimate of 0.30.

Following Kopczuk (2003), Giertz includes separate, nonlinear controls for mean reversion and exogenous changes in the income distribution. This estimation method lowers the SOI-based estimate of ETI in the 1980s from 0.43 to 0.40, and raises the estimate in the 1990s from 0.20 to 0.26.

¹⁶ Saez also uses a 2SLS approach, where the top net-of-tax rate is used as an instrument for the tax rate variable. However, his results show that the 2SLS approach does not affect the results.

¹⁷ Saez et. al. (2009).

2.3.13. Summary

To measure the ETI, the empirical ETI studies have used different methodologies with different kinds of data. Three types of data sets are used to estimate the ETI: repeated cross-section individual tax return data, panel individual tax return data, and time-series aggregated data.

In general, there are two approaches to estimate the ETIs with respect to different kinds of data. These approaches are the differences-in-differences and the multivariate regression approach.

Table 1-1 Empirical Studies on the ETI

| <i>Paper</i> | <i>Data</i> | <i>Ap- proach</i> | <i>Focus</i> | <i>Tax Change (years)</i> | <i>Permanent vs. transitory</i> | <i>Best estimated ETI</i> |
|------------------------|--------------------|-----------------------|-------------------------------|-------------------------------------------------|-----------------------------------------|-------------------------------------|
| Lindsey (1987) | SOI | CS | All income groups | ERTA (1981) | Not clear | 1.6 to 1.8 |
| Feldstein (1995) | SOI/CWHS | PS | All income groups | TRA86 (1985, 1988) | Permanent | 1.04 to 3.05 |
| Auten & Carroll (1999) | SOI | PS | Joint>\$21k Single>\$15.6k | TRA86 (1985, 1989) | Permanent | 0.45 to 1.13 0.57 best estimate |
| Carroll (1998) | SOI | PS | >\$50k | OBRA90&93 (1989-1995) | Permanent | 0.4 |
| Goolsbee (2000) | S&P EXECUCOMP | PS | Upper income | OBRA90&93 (1989-1995) | Both | 0 to 0.4 |
| Gruber&Saez (2002) | SOI/CWHS | PS | All income groups | ERTA&TRA86 (1979-1990) | Permanent | 0.4 |
| Kopczuk (2003) | SOI/CWHS | PS | All income groups | ERTA&TRA86 (1979-1990) | Permanent | 0.21 to 0.51 w/o tax base effect |
| Saez (2003) | SOI/Michigan Panel | PS | All income groups | Bracket creep (1979-1981) | Transitory | 0.311 |
| Giertz (2007) | SOI | PS | All income groups | ERTA&TRA86 (1979-1990) OBRA90&93 (1988-2001) | Permanent | 0.43 0.20 |

Source: Giertz (2004), Table 1 and Saez et al. (2009). Note: PS= Panel sample; TS= Time-series; CS= Cross-sectional.

In studies using a multivariate regression approach, most researchers apply the two stage least square procedure with some instruments to control for tax rate endogeneity.

The major weakness of the differences-in-differences approach is that this estimation method does not control effectively for exogenous changes in the income distribution.

The most challenging problem facing the multivariate regression approach is how to control for secular income trends. For the studies using individual tax return data (both cross-sectional and panel data), mean reversion of individual income is another difficult problem.

Over the last two decades, the ETI literature has made much improvement in controlling for mean reversion and exogenous changes in the income distribution. However, controlling for both of them is still the most challenging issue in estimating ETI. Saez et. al (2009) assert that “analysis of panel data does not seem likely to resolve the identification issues raised by trends in income inequality and mean reversion at the top and bottom ends of the income distribution”. And they state that “Estimates of the long-run elasticity of taxable income are plagued by extremely difficult issues of identification, so difficult that we believe that there are no convincing estimates of the long-run elasticity of reported taxable income to changes in the marginal tax rate.”¹⁸

For the value of ETI, Saez et. al. (2009) suggests the most reliable longer-run estimates of ETI range from 0.12 and 0.4. Table 2.1 summarizes basic information about the empirical studies on the ETI.

2.4. What Do We Know about Behavioral Responses of Taxable Income?

Lindsey (1987) points out that the responses of taxable income to tax rate include a variety of decisions by the taxpayer. Feldstein (1995) lists a wide variety of ways in which a change in marginal tax rates can induce taxpayers to alter their behavior:

- Changes in labor supply (both labor force participation and working hours): Individuals can also vary their labor supply by changing how hard they work or by changing their location or types of jobs that they accept.
- Changes in the form of employee compensation: High marginal tax rates encourage individuals to take their compensation in forms that are untaxed or are subject to lower tax rates.
- Changes in portfolio investments: Income from assets provides further opportunities for taxpayers to adjust to changes in tax rates. High marginal tax rates encourage individuals to invest their assets in ways that reduce the portion of the return that is included in taxable income.
- Changes in itemized deductions and other expenditures that reduce taxable income: Higher levels of deductions for mortgage interest, investment interest charitable contributions, health insurance, and so on can reduce taxable income further when tax rates rise.
- Changes in taxpayer compliance: High marginal tax rates may induce taxpayers to take more aggressive interpretations of tax rules, or even to evade taxes by underreporting income or claiming unjustified deductions.

To this list from Feldstein, one could add that higher tax rates motivate taxpayers to spend more effort keeping track of their permitted deductions.

¹⁸ Saez et. al. (2009), p.62.

Giertz (2004) give a brief explanation of behavioral responses of taxable income to taxation. The taxable income consists of different components. Incomes from different sources are taxed differently, or sometimes not at all. Taxpayers have many opportunities for tax deductions, exclusions, and credits. Some of those opportunities allow income to escape the tax base. Others allow taxpayers shift when and under what base income is reported and taxed.

Taxpayers can respond to income taxes in different ways. Substitution responses include individuals changing their consumption or the amount they work, moving away from taxed goods or activities toward those that are untaxed or taxed more lightly. Circumvention includes bypassing the tax system both illegally (by evasion) and legally (by avoidance). For evasion, income is concealed or at least is not reported to the tax authorities. For avoidance, income is shifted between time periods or between sources in order to receive more favorable tax treatment.

Reviewing the empirical ETI literature, Giertz (2004) concludes that one of difficulties for estimating ETI accurately is that “the process underlying (or sources driving) the taxable income response is not fully understood.”¹⁹ This suggests that there is a lack of deep understanding of the mechanism underlying behavioral responses of the taxable income and the factors determining responses of taxable income in the current ETI literature. This understanding is important because it provides essential knowledge to quantify effects of tax rate and non-tax factors on taxable income responses.

Actually, there are at least two papers suggesting a theory of behavioral responses of taxable income. Slemrod (1995) suggests that it is necessary to construct a theory of behavioral response of taxpayers to taxation. Such a theory would recognize varieties of behavioral responses to taxation and the interrelationships among these responses.²⁰ Slemrod and Yitzhaki (2000) is the first attempt to integrate into a common framework all types of behavioral responses of taxpayers to the taxation system. However, these papers only give some general ideas of a theoretical framework for behavioral responses of taxable income. They do not provide a theoretical framework which explains in detail the mechanism underlying the behavioral responses of taxable income as well as factors determining those responses.

2.5. What Do We Know about the ETI Function? What Factors Determine the ETI Function?

Slemrod (1998a) points out that the ETI is not an immutable parameter of preference. It is a function of tax policy instruments. Kopczuk (2005) provides evidence that ETI is a function of tax base.

¹⁹ Giertz (2004), p.13.

²⁰ Slemrod (1995), p.175.

Giertz (2004) confirms that administration and compliance policy can affect how taxpayers respond to taxes. Rigorous enforcement and low compliance costs should limit evasion and lead to smaller income responses to tax changes. In contrast, lax enforcement and high compliance costs will tempt taxpayers to hide income, and this will result in larger income responses for a given change in tax rates. That implies the ETI is endogenous and a function of institutional factors of the tax system, rather than an immutable parameter of taxpayers' preferences.

The empirical ETI literature provides evidence that the ETI changes with income level, occupations, marital status, itemization status, size of tax base, tax regimes, and income sources.

2.5.1. ETI Changes across Income Distribution

Lindsey (1987) finds evidence that the ETI increases with level of income. A specification in which elasticity varied with the log of income showed a substantial elasticity for most levels of income. The average elasticity implied for taxpayers with incomes of \$50,000 is 0.728. This figure rises to 1.023 for taxpayers with incomes of \$100,000, 1.413 for taxpayers with incomes of \$250,000, and 2.003 for taxpayers with incomes of \$1,000,000.

Feldstein (1995) sorts a sample of higher income taxpayers into three groups by their 1985 marginal tax rates. The medium group includes taxpayers whose marginal tax rates were in the range of 22% to 38%, the high group between 42% and 45%, and the highest group between 49% and 50%. Using the medium group as a control one, Feldstein obtains estimated ETI of 2.14 for the highest groups, and 1.1 for the high group.

Gruber and Saez (2002) find evidence that the responsiveness of taxable income is driven by the highest income taxpayers. The estimated ETIs are only 0.18 for taxpayers in the range of \$10,000-50,000 and 0.11 for the range \$50,000-100,000. But the ETI estimate is much larger (0.57) for those with income greater than \$100,000.

Saez (2004) runs 2SLS regressions with time controls to estimate the elasticity of income share with respect to net-of-tax rate. He finds that the elasticities vary substantially among various upper income groups. Particularly, the estimated elasticity increases consistently from 0.32 for the top 10% to 1.09 for the top 0.01% of the income distribution.

2.5.2. ETI Changes across Occupations

Auten and Carroll (1999) and Carroll (1998) find evidence that the ETI changes across occupations. They use dummy variables for occupation as a control for non-tax factors that may affect income growth over the period spanning the tax change.

Auten and Carroll study responses of taxable income to TRA86. They obtain estimated ETIs of 1.63 for executives and managers, 2.90 for investors, 0.99 for doctors and other health related

occupations, 1.26 for blue collar workers, 1.65 for farm workers and self-employed persons, and 1.47 for sales workers.²¹

Carroll studies responses of taxable income to OBRA90 and OBRA93. He obtains lower estimates of ETI. For example, the estimated ETI is 0.024 CEOs and other senior executives, -0.027 for investors, 0.008 for doctors and health related occupations, 0.002 for artists, athletes and journalists, and 0.012 for sales-related occupations.²²

2.5.3. ETI Changes along Marital and Itemization Status

Saez (2003) finds that the ETIs are higher for married taxpayers than for singles (around 0.4 for married and around 0.2 for singles).²³ He also finds evidence that the elasticity for non-itemizers is always much smaller than the elasticity of itemizers. The estimated ETI of itemizers is 0.417 and that of non-itemizers is -0.026.²⁴

Gruber and Saez (2002) also find evidence of the difference in the ETI between itemizers and non-itemizers in the same direction as Saez (2003).²⁵ Kopczuk (2005) find evidence for the difference in the ETI between married and single taxpayers, but his result is not consistent with those in Saez (2003).

2.5.4. ETI is a Function of Tax Base

Kopczuk (2005) provides evidence that the ETI is a function of tax base. The tax base is defined in terms of the share of broad income that is spent on non-taxable commodities. In this framework, the ETI is modeled as: $ETI = \epsilon + \beta\gamma$, where γ is tax base. The estimated coefficients of γ are positive and significant for both broad income and taxable income elasticities.²⁶

For broad income, the estimated coefficients for the change in the log of the net-of-tax rate and the interaction term between the change in the log of net-tax rate and the change in tax base are 0.003 and 0.727, respectively. For taxable income, the respective estimated coefficients are 0.123 and 1.063.

2.5.5. ETI Changes across Tax Regimes

Saez (2004) and Giertz (2007) find evidence that ETI changes across tax regimes.

Saez (2004) documents that there were large and immediate responses in the reported income of the top 1% income group to the tax cuts of the 1980s, but no evidence of short or long-term response of this income group to the large changes in the tax rates following the Kennedy tax cuts in the early 1960s.

²¹ Auten and Carroll (1999), p.690.

²² Carroll (1998), Table 6.

²³ Saez (2003), p.1252.

²⁴ Saez (2003), Table 5.

²⁵ Gruber and Saez (2002), Table 9.

²⁶ Kopczuk (2005), Table 5 and 6.

He reports estimated ETIs that vary greatly over some subsets of the period 1960 – 2000. For example, for the sub-period of 1981 – 1984 he reports an estimated ETI of 0.77. The estimated ETI is 1.7 for the sub-period 1985 – 1988, and about zero for the sub-period 1991 – 1994.

Giertz (2007) finds evidence that estimated ETIs are different between the 1980s and the 1990s. Using Gruber and Saez (2002)'s methodology, he obtains the estimated ETI of 0.43 in the 1980s and of 0.20 in the 1990s. Following Kopczuk (2003) approach, he obtains the SOI-based estimated ETI of 0.40 in the 1980s, and 0.26 in the 1990s.

The variation in ETIs over time provides another evidence for Kopczuk's (2003) finding that the ETI depends on the size of the tax base.

2.5.6. Different Income Components Have Different Response to Income Taxation

Moffitt and Wilhelm (2000) use panel data from the 1983 and 1989 SCF to study responses of individual income to TRA86. They decompose the individual income into three major components: wage and salary income, business income, and other income. Then, they calculate elasticities for the total income, the wage and salary income, and the sum of wage and salary income and business income, respectively.²⁷

Moffitt and Wilhelm find evidence that different sources of income have different income elasticities with respect to the net-of-tax rate. Using Feldstein's differences-in-differences method, they obtain estimated elasticity of 0.983 for the total income, of 0.701 for the sum of wage and salary and business income, and of 0.23 for the wage and salary income. These results suggest that the estimated elasticity of the wage and salary income is 0.23, the estimated elasticity of business income is about 0.47, and the estimated elasticity of the other income is about 0.28.

Saez (2004) and Saez et. al. (2009) also document that different income sources response in different ways to change in tax rates. Particularly, in the top 0.01% and the top 1% of the income distribution, wage and salaries, dividends, interest, and business income response in different ways to change of tax rates over a long period, from 1960-2006.

Remark: What has not done yet?

That is about a summary of estimates concerning the ETI function and factors that affect the ETI. In general, the ETI literature has greatly improved the understanding of the relationship between taxable income and taxation. It has provided evidence of factors affecting ETI, such as level of income, occupations, marital status, itemization status, tax base, and tax regime. However, there has not been an adequate study of the functional form of the ETI and the factors determining the ETI function.

²⁷ Moffitt and Wilhelm (2000), Table 9.

2.6. Conclusion

This chapter points out that there are two lacks in the current ETI literature:

- A lack of a full understanding of the mechanism underlying behavioral responses of taxable income to taxation.
- A lack of study of the functional form of ETI and factors determining the ETI function.

This research aims at filling these gaps in the current ETI literature. It will

- Construct a theoretical framework of behavioral responses of taxable income, which gives an explanation of the underlying mechanism of behavioral responses of taxable income to taxation and factors determining responses of taxable income (Chapter 3).
- Quantify effects of tax rate, non-tax factors on taxable income, and estimate the ETI from a new framework (Chapter 4).
- Study functional form of the ETI and the set of factors determining the ETI function (Chapter 5).

3. Nature of Taxpayer Compliance Behavior – A Theoretical Framework

This chapter presents a theoretical review of taxpayer compliance literature. This review focuses on the development of theoretical models of taxpayer compliance behavior. The chapter is an effort to build up a theoretical framework of taxable income responses. The main purposes are (i) to give an explanation about the underlying mechanism of taxable income responses, and (ii) to identify factors that determine those responses.

3.1. Tax Compliance Literature Review: Economic Models of Taxpayer Compliance Behavior

A rich literature on evasion and taxpayer compliance has been written since the early 1970s.²⁸ During that period, there have been several researchers who have reviewed the literature on taxpayer compliance. The outstanding review papers are Witte and Woodbury (1983b), Roth et al. (1989), and Alm (1999).²⁹

It is commonly recognized that the models of taxpayer compliance based on microeconomic theory are derived from Becker's (1968) pioneering model of criminal choice. According to Roth et al. (1989), models of taxpayer compliance based on microeconomic theory can be divided into three types: static-random audit models, interactive audit strategy models, and multiperiod dynamic models.

3.1.1. Static Random-audit Models

The static random-audit models are called "random audit", because all taxpayers are assumed to face the same audit rate regardless of the nature of their tax returns or compliance status. This generation of the microeconomic models of taxpayer compliance has been reviewed firstly by Witte and Woodbury (1983b).

The static random-audit models are based on the expected utility theory. Under this framework, the individual taxpayer maximizes utility under uncertainty about his after-tax income. The taxpayer has to make decision about how much income to report after considering the marginal tax rate, the probability of detection on underreported income, and the penalty that will be imposed if the underreported income is detected.

The first formal model of taxpayer compliance behavior was developed by Allingham and Sandmo in 1972.³⁰ Numerous extensions of this basic model were developed in the 1970s,

²⁸ The modern tax evasion and compliance literature is recognized to originate from Allingham and Sandmo's seminal paper in 1972, which relied on the economics-of-crime methodology pioneered by Becker (1968).

²⁹ These papers summarize the development of theoretical models of taxpayer compliance literature through the year 2000. I have not seen any new developments in theoretical models of taxpayer compliance behavior during the 2000s.

³⁰ Srinivasan (1973) formulated a theoretical model of tax evasion at the same time as Allingham and Sandmo (1972), but the paper was published one year later.

1980s, and 1990s. The extensions retain the basic features and attempt to incorporate new factors into the compliance decision.

In general, these theoretical models examine how the amount of unreported income changes due to changes in probability of detection, penalties, tax rates, and total income. The exact nature of the effect of changes in the probability of detection, penalties, tax rates, and total income on the extent of tax evasion depends on number of factors, namely nature of the model, assumptions made about attitudes toward risk, and mathematical form of the utility function.

The choice variables of the taxpayer to maximize expected utility vary among studies. A majority of the models assume that the individual chooses either the amount of income to report or the amount not to report.³¹ Other models assume that the individual chooses how much in tax to evade.³² Some others combine the amount of declared income with the amount of time spent working³³, type of occupation³⁴, or amount of tax avoidance³⁵.

Some other factors that affect taxpayer compliance behavior are also included in theoretical models. For example, the impact of complexity and uncertainty are analyzed by Alm (1988b), Scotchmer and Slemrod (1989), and Cronshaw and Alm (1995); the effect of paid practitioners on taxpayer compliance is examined by Klepper and Nagin (1989b), Scotchmer (1989), Reinganum and Wilde (1991), and Erard (1993).

Extension models generally give few unambiguous predictions concerning the effects of changes in policy variables. Alm (1999) argues that the basic model is unable to explain the high level of compliance of the taxpayer in the United States. He interprets the data on compliance as suggesting that the compliance decision must be affected by other factors not mentioned by the basic model. Even though other factors are relevant, no single theory has been able to incorporate more than a few of these factors in a meaningful way. The numerous refinements and extensions considerably complicate the theoretical analyses, and generally render clear-cut analytical results impossible.³⁶

3.1.2. Models of Interactive Audit Strategies

It is well known that the Internal Revenue Service (IRS) selects many returns for audit using an interactive strategy – selection is based on characteristics of the return that have been associated in the past with substantial income underreporting. The second type of microeconomic model deals with interactions between the IRS and the taxpayers.³⁷

³¹ Allingham & Sandmo (1972), Kolm (1973), Srinivasan (1973), Singh (1973), Yitzhaki (1974), McCaleb (1976).

³² Christiansen (1980).

³³ Weiss (1976), Andersen (1977), Pencavel (1979).

³⁴ Pestieu and Possen (1991).

³⁵ Cross and Shaw (1982), Alm (1988a).

³⁶ Alm (1999), p.745.

³⁷ Reinganum and Wilde (1985, 1986), Graetz et al. (1986), Beck and Jung (1989b), Cronshaw and Alm (1995).

There are two game-theoretic approaches to model interaction between a strategic taxpayer and a strategic IRS: the principal-agent model and the Nash equilibrium model.

The principal-agent model was introduced by Reinganum and Wilde (1985). In this model, the IRS is taken to be the principal who seeks to control the behavior of the taxpayer (agent). The IRS asks the taxpayer to report income and, on the basis of this imperfect information about true income, decides whether to audit the return. The taxpayer is assumed to maximize his or her own expected after-tax income. This model suggests that an audit cutoff strategy – in which a report of taxable income below some threshold always triggers an audit while a report above the threshold never does – raises revenue for the tax agency at least as efficiently as a random-audit strategy, so long as taxpayers are risk neutral.³⁸

One difficulty of the principal-agent model is that it assumes the tax agency announces its strategy in advance. With advance knowledge of the audit cutoff strategy, taxpayers would anticipate and attempt to defeat it. The tax agency would then be forced to abandon the audit cutoff strategy.

The Nash equilibrium model has been developed by Graetz et al. (1984a, 1984b) and Reinganum and Wilde (1986). Under this framework, the tax agency and taxpayer are treated more symmetrically and are assumed to play against each other without pre-announcing their strategies.

In its most widely explored form (Graetz et al., 1986), the Nash equilibrium model allows taxpayers to earn one of two incomes, called “high” and “low”. The taxpayer maximizes expected net income by reporting either high or low income, and the tax agency audits some fraction of the taxpayers who report low income. Under these assumptions, the model predicts that increases in the penalty rate, the differential between low and high income, and the tax rate will all increase the probability of true reporting.

The Nash equilibrium models have some limitations. Firstly, these models all imply that in equilibrium the tax agency is indifferent between auditing and not auditing taxpayers. This implication, in some cases, may be unreasonable. Secondly, the comparative statics of these models are not always intuitive.³⁹

In short, the models of interactive audit strategies focus on finding an optimal audit policy of the tax agency (the IRS). This type of models lends insight to the enforcement policy of the IRS and the interaction mechanism between the IRS and taxpayers. However, these models do not contribute much to the theoretical understanding of taxable income responses.

³⁸ For more discussion, see Border and Sobel (1987), Mookherjee and Png (1989), Sanchez and Sobel (1993), Andreoni et al. (1998).

³⁹ Alm (1999), p.750.

3.1.3. Multiperiod Dynamic Models

In contrast to interactive models, which all relate to a single return-filing period, multiperiod models have begun to consider more complex timing and audit selection strategies. In these models, audit selection rules explicitly recognize the dynamic aspect to compliance. Particularly, the tax agency can use a taxpayer's history in selecting tax returns to audit.

There are two types of audit selection rules which are commonly considered in the multiperiod dynamic models: the "conditional back audit" rule and the "conditional future audit" rule.⁴⁰ In the conditional-future-audit models, taxpayers found to be noncompliant in the past will be audited more frequently in the future.⁴¹ In the conditional-back-audit models, if individuals were audited and found to be dishonest in the current period, the tax agency would go back in time to previous periods' declarations.⁴²

The multiperiod dynamic models rely on more realistic assumptions of audit selection rules of the tax agency. These models provide more insights to understand the compliance behavior of taxpayers as well as the interaction between the taxpayers and the tax agency. The more complicated comparative static results and the more ambiguous effects of policy variables on taxpayer compliance behavior are two of the limitations of this model.

Among the three types of theoretical models of taxpayer behavior, the static random-audit models lend the most insight to the behavioral responses of the taxpayers. The static random-audit models could be considered as background for constructing a theoretical framework for analyzing behavioral responses of taxable income.

3.2. Theoretical Framework: Analysis of Behavioral Responses of Taxable Income

Slemrod and Yitzhaki (2000) generalize the taxpayers' behavioral responses to the tax system. They categorize the taxpayers' efforts to minimize the impact of the tax system into three kinds of activities: substitution responses, tax avoidance, and tax evasion. Substitution responses are responses which occur because the tax law changes the relative prices of different activities, inducing taxpayers to respond by choosing a different consumption basket. Tax avoidance activities are legal efforts of a taxpayer to reduce his tax liability without altering the consumption basket. These are actions taken in response to the tax system that do not involve shifts along a given budget set. Tax evasion activities are illegal efforts to reduce tax liability of a taxpayer. Therefore, the distinguishing characteristic of evasion is illegality.

Slemrod and Yitzhaki make the first attempt to establish a general framework to analyze the interaction among these behavioral responses of taxpayer. In this paper, they focus mostly on the

⁴⁰ Alm (1999).

⁴¹ Landsberger and Meilijson (1982), Greenberg (1984).

⁴² Rickard et al. (1982), Engel and Hines (1999).

interaction between tax avoidance, tax evasion, and tax administration. The underlying mechanism of these behavioral responses of taxpayers or of taxable income is not of interest. Nevertheless, Slemrod and Yitzhaki give a guidance for establishing an analytic framework of the behavioral responses of taxpayers. The taxpayers' behaviors are considered in the context of a given structure of the tax system and enforcement process. In this context, taxpayers face opportunities to reduce their tax payments or expected tax payments. However, reducing tax payments involves a private cost. This private cost may take the form of an altered consumption basket, an increasing probability of detection and penalty for evasion, and/or a real resource cost of conducting avoidance or concealing evasion. This private cost depends on the government policies, such as tax rates and tax bases, as well as the tax administration and enforcement policies.

The tax system establishes the relative prices among this broad set of taxpayer behavioral responses. In the standard labor supply model, it establishes the relative price of leisure as well as the relative prices of other goods. In a more general framework, it also sets the price of the incentives to evade, and sets the cost and the reward to legally reducing taxes via avoidance activities. In addition, the dimensions of taxpayer responses can interact with each other.⁴³

Reviewing the theoretical studies of taxpayer compliance behavior, the rest of this section aims at constructing a theoretical framework to explain the underlying mechanism of behavioral responses of taxpayers, as well as how the tax rate and other factors impact the responses of taxable income.

3.2.1. Substitution Responses: Labor Supply Analysis

One of the principal forms of substitution response is the substitution of leisure for labor. The literature on labor supply has developed over a long time. Here we consider labor supply theory in a static framework (i.e., one time period only).

3.2.1.1. Theory of Labor Supply: A Static Model⁴⁴

The standard static, within-period labor supply model is an application of basic consumer theory. In this model, each individual is assumed to have a quasi-concave utility function, $U(C_t, L_t, X_t)$, in which C_t, L_t, X_t are within-period consumption, leisure hours and individual attributes, in period t .

The individual maximizes utility subject to a budget constraint:

$$(3.1) C_t + W_t L_t = Y_t + W_t T,$$

where W_t is the hourly wage rate, Y_t is non-labor income, T is the total time available. The right-hand side includes the full value of one's endowment of time as well as all other sources of

⁴³ Slemrod and Yitzhaki (2000), p.5-6.

⁴⁴ Blundell and McCurdy (1999).

income. This is often defined as “full income” from which the consumer purchases consumption goods and leisure. This income concept is denoted by M_t , so that

$$(3.2) M_t = Y_t + W_t T.$$

The first-order conditions take the form:

$$(3.3) U_C(C_t, L_t, X_t) = \lambda_t, \quad U_L(C_t, L_t, X_t) \geq \lambda_t W_t,$$

where λ_t is the marginal utility of income.

Solving the first-order condition yields the Marshallian demand functions:

$$(3.4) C_t = C(W_t, M_t, X_t), \quad L_t = L(W_t, M_t, X_t) \leq T.$$

Equivalently, using $H_t = T - L_t$ and the definition of M_t in terms of Y_t , we have the hours of work rule,

$$(3.5) H_t = H(W_t, Y_t, X_t).$$

This is a common specification used in the empirical studies of labor supply. The number of hours of work, H_t , is measured in terms of wage rate W_t , the income variable Y_t , and the vector of demographic factors X_t .

3.2.1.2. *Labor Supply with Taxes*⁴⁵

The static labor supply model is extended to include the effect of income taxation. The individual’s labor supply is still considered in the context of the individual’s utility maximization, subject to a budget constraint. Taxation affects the labor supply by lowering the net after-tax wage.

The effect of taxation on labor supply can be decomposed into the substitution effect and income effect by the Slutsky equation:

$$(3.6) \frac{dh}{dt} = \frac{\partial h}{\partial w} \Big|_{u=\bar{u}} \frac{\partial w}{\partial t} + h \frac{\partial h}{\partial y}.$$

where h is working hours, w is wage rate, u is utility level, \bar{u} is a constant utility level, and y is non-labor income.

Because labor is supplied while leisure is demanded, the substitution effect is positive, while the income effect is negative provided leisure is a normal good. As a result, the sign of the sum of the effects is indeterminate. It depends on the budget constraint curve and the individual’s preferences.

⁴⁵ Hausman (1983).

Empirical results provide evidence that the income effect is very small and can be ignored. The substitution effect is positive and generally quite small.⁴⁶

3.2.2. Theoretical Models of Tax Evasion

3.2.2.1. The Standard Static Model: The Allingham-Sandmo (AS) Model

In this model, an individual taxpayer is assumed to receive a fixed amount of actual income W , which is known by the taxpayer but not by the tax agency. A tax is levied at a constant rate θ , on declared income X , which is the taxpayer's decision variable. The taxpayer is subject to investigation by the tax authorities with some probability p . The taxpayer must pay tax on the undeclared income if it is detected, at a penalty rate π that is higher than θ .

The taxpayer's behavior is assumed to conform to the Von Neumann-Morgenstern axioms for behavior under uncertainty. Income is the only argument of his utility function. Marginal utility is assumed to be everywhere positive and strictly decreasing, so that the individual is risk averse.

Under this framework, the taxpayer will choose X to maximize expected utility:

$$(3.7) \quad E[U] = (1 - p)U(W - \theta X) + pU(W - \theta X - \pi(W - X)).$$

Define $Y = W - \theta X$ and $Z = W - \theta X - \pi(W - X)$. Then the first-order condition for an interior maximum of (3.7) is

$$(3.8) \quad -\theta(1 - p)U'(Y) - (\theta - \pi)pU'(Z) = 0.$$

The second-order condition

$$(3.9) \quad D = \theta^2(1 - p)U''(Y) - (\theta - \pi)^2pU''(Z) < 0$$

is satisfied by the assumption of concavity of the utility function.

Using the Arrow-Pratt risk aversion measures to evaluate the comparative static results⁴⁷, Allingham and Sandmo derive the effects of policy variables and actual income on the reported taxable income.

Effect of actual income on reported income:

$$(3.10) \quad \frac{\partial X}{\partial W} = -\frac{1}{D}\theta(1 - p)U'(Y)[R_A(Y) - (1 - \pi)R_A(Z)].$$

⁴⁶ Hausman (1983), Blundell and MaCurdy (1999).

⁴⁷ The Arrow-Pratt absolute and relative risk aversion measures are defined as $R_A(Y) = -\frac{U''(Y)}{U'(Y)}$ and $R_R(Y) = -\frac{U''(Y)*Y}{U'(Y)}$, respectively.

On the assumption of decreasing absolute risk aversion, $R_A(Y) < R_A(Z)$. The sign of this derivative is ambiguous because it depends on the value of π .

Effect of tax rate on reported income:

$$(3.11) \quad \frac{\partial X}{\partial \theta} = \frac{1}{D} X \theta (1 - p) U'(Y) [R_A(Y) - R_A(Z)] + \frac{1}{D} [(1 - p) U'(Y) + U'(Z)].$$

The second term on the right is unambiguously negative. The first term is ambiguous. Its sign depends on the functional form of absolute risk aversion. This term is positive, zero or negative as absolute risk aversion is decreasing, constant or increasing. This suggests that no clear-cut hypothesis emerges about the connection between the tax rate and reported income.

We can explain the two terms in equation (3.11) as the income effect and the substitution effect, respectively. The substitution effect (the second term) is negative because an increase in the tax rate makes it more profitable to evade taxes on the margin. The income effect is positive under the assumption of decreasing absolute risk aversion. An increased tax rate makes the taxpayer less wealthy, reducing both Y and Z for any level of X , and this tends to reduce evasion.

Effect of probability of detection on reported income:

$$(3.12) \quad \frac{\partial X}{\partial p} = \frac{1}{D} [-\theta U'(Y) + (\theta - \pi) U'(Z)].$$

This derivative is positive. An increase in the probability of detection will always lead to a larger income being reported.

Effect of penalty rate on reported income:

$$(3.13) \quad \frac{\partial X}{\partial \theta} = -\frac{1}{D} (W - X) (\theta - \pi) p U''(Z) - \frac{1}{D} p U'(Z).$$

Both terms in the right hand side are positive, so that the derivative is positive. An increase in the penalty rate will always increase the amount of reported income.

3.2.2.2. An Extension: Allingham-Sandmo-Yitzhaki (ASY) Model

Yitzhaki (1974) extends the AS model to the case where the penalty for discovered evasion depends on the tax on unreported income rather than on the amount of income that was underreported. In this case, the taxpayer will choose X to maximize

$$(3.14) \quad E[U] = (1 - p)U(W - \theta X) + pU(W - \theta X - F\theta(W - X)).$$

where F is the fine imposed on the evaded tax ($F > 1$).

Then Yitzhaki derives the following result of the effect of taxation on reported income

$$(3.15) \quad \frac{\partial X}{\partial \theta} = -\frac{\theta}{D}(1-p)U'(Y)\{X[R_A(Z) - R_A(Y)] + F(W - X)R_A(Z)\},$$

where $D = \theta^2[(1-p)U''(Y) + p(F-1)^2U''(Z)]$. It is notable that there is no longer a substitution effect, but only a pure income effect. Under the assumption of decreasing absolute risk aversion, $R_A(Z) > R_A(Y)$, so $\frac{\partial X}{\partial \theta} > 0$. This implies that an increase in marginal tax rate will reduce evasion as long as there is decreasing or constant absolute risk aversion.

3.2.3. Tax Evasion with Labor Supply

Pencavel (1979) extends the ASY model to consider the case in which an individual taxpayer makes a decision about labor supply simultaneously with a decision about amount of income tax to declare.⁴⁸

The basic assumptions are similar to those in the ASY model, but with some modifications. The utility function is defined over total income (Y) and hours of work (h): $U = U(Y, h)$. The utility function is assumed to be strongly separable in income and hours of work.

The individual's true income is defined by Z , y is the income the individual reports to the tax authorities, and X is the individual's actual tax payments.

Pencavel also makes another modification of the income tax function. He approximates the piecewise linear income tax system by a continuous function:

$$(3.16) \quad X = -S + \tau y^\sigma; 0 < \tau \leq \frac{S+y}{y^\sigma}; \sigma > 0,$$

where S measures welfare grants from the government to individuals who would otherwise have no income, and τ and σ are parameters governing the relationship between changes in reported income and changes in tax payments. The marginal tax rate increases with increases in y when $\sigma > 1$ (i.e., a progressive tax system), decreases when $\sigma < 1$ (i.e., a regressive tax system), and is independent of income when $\sigma = 1$ (i.e., a proportional tax system).

The individual's net income (Y^o) when he underreports his income and is not audited is simply $Z-X$ or

$$(3.17) \quad Y^o = Z(h) + S - \tau y^\sigma.$$

If the individual's underreporting is detected, he is obligated to pay a penalty that renders his post-penalty income (Y^c) less than Y^o . Because $\tau(Z^\sigma - y^\sigma)$ is the taxes not voluntarily paid by the individual, the taxpayer's net income when he is caught cheating on his income tax is

⁴⁸ Cowell (1985) constructs another theoretical model of tax evasion focusing on labor supply. In this model, Cowell assumes that a taxpayer can take one or more jobs. In this case, evasion behavior can be considered as a kind of real behavioral response. The taxpayer makes a choice among three possible activities: legal work, illegal work, and leisure. In this study, I consider evasion as a behavior of the taxpayer as underreporting actual (legal) income. Cowell's model is not considered in this study.

$$(3.18) Y^c = Z(h) + S - \tau y^\sigma - \lambda \tau (Z^\sigma - y^\sigma),$$

where $\lambda > 1$ is the multiplier that penalizes him for his underreporting.

Denote the individual's taxable income by $Z = wh + I$, where w is the gross hourly wage rate and I is nonwage income. In this framework, the individual taxpayer selects y and h to maximize the expected utility:

$$(3.19) EU(Y, h) = \pi U(Y^c, h) + (1 - \pi)U(Y^o, h),$$

where π is the probability of being detected.

The comparative static results are showed in Table 3.1 below. This table shows how the reported income changes when the environment variables are altered. These results are derived under the assumptions that there are interior solutions and absolute risk aversion is a decreasing function of income.

Columns (i), (ii), (iii) report the results when hours of work and true income are exogenous. In these cases, the comparative static results are consistent with those of the ASY model. The probability of detection (π) and the penalty rate (λ) have positive effects on the reported taxable income (or compliance). With an assumption of absolute risk aversion decreasing with income, an increase in marginal tax rate (τ) would induce an increase in the reported taxable income.

Columns (iv), (v), (vi) report the results for the case when hours of work and true income are endogenous (h is variable). The effects of taxation as well as effects of the other factors on reported income are ambiguous.

Table 3-1 *Qualitative Effects on Reported Income*

| | <i>h</i> fixed | | | <i>h</i> variable | | |
|-----------|-----------------------|----------------|----------------|--------------------------|----------------|----------------|
| | $\sigma < 1$ | $\sigma = 1$ | $\sigma > 1$ | $\sigma < 1$ | $\sigma = 1$ | $\sigma > 1$ |
| | (i) | (ii) | (iii) | (iv) | (v) | (vi) |
| π | > 0 | > 0 | > 0 | > 0 or < 0 | > 0 or < 0 | > 0 or < 0 |
| λ | > 0 | > 0 | > 0 | > 0 or < 0 | > 0 or < 0 | > 0 or < 0 |
| σ | > 0 | | > 0 | > 0 or < 0 | | > 0 or < 0 |
| τ | > 0 | > 0 | > 0 | > 0 or < 0 | > 0 or < 0 | > 0 or < 0 |
| S | < 0 | < 0 | < 0 | > 0 or < 0 | < 0 | > 0 or < 0 |
| Z | > 0 or < 0 | > 0 or < 0 | > 0 or < 0 | > 0 or < 0 | > 0 or < 0 | > 0 or < 0 |

Source: Pencavel, 1979, p.119.

When true taxable income is held fixed, an increase in the penalty rate (λ) increases reported income. But when hours of work are variable, an increase in the penalty rate may decrease hours

of work, which causes a decline in true income, which inclines the taxpayer to reduce reported income. As a result, the effect of penalty rate on the reported income is ambiguous.⁴⁹

Similarly, when true income is held fixed, an increase in the tax parameters (τ and σ) induces more reporting of income. However, when true income becomes an endogenous variable, an increase in τ or σ may reduce hours of work and thus may reduce true income which may lead the individual to report less income to the tax authorities.

The effect of the exemption level (S) on reported income is unambiguously negative for $\sigma \geq 1$. An increase in S reduces hours of work which reduces true taxable income, and this fall in true taxable income reinforce the negative effect of S on reported income when true income is held fixed.

3.2.4. The Models of Tax Avoidance and Evasion

There are other models that consider tax avoidance and evasion simultaneously, but these models differ with respect to assumptions about the cost functions of avoidance and evasion, as well as the uncertainty of avoidance and evasion income. In this section, I present three models of tax avoidance and evasion, developed by Cross and Shaw (1982), Alm (1988a), and Alm and McCallin (1990).

3.2.4.1. Cross and Shaw's Model

Cross and Shaw (1982) extend the AS model to account for tax avoidance as well as evasion. The basic assumptions in the AS model are maintained. Cross and Shaw use a simple model of interdependence in which expected utility depends on levels of both avoidance and evasion. They discuss the way in which the results are modified by the introduction of a joint cost function of tax avoidance and evasion.⁵⁰

When there are two separate cost functions for evasion and avoidance, $C(E)$ and $C(A)$, the expected utility is given by:⁵¹

$$(3.20) \quad E[U] = (1 - p)U[Y] + pU[Z], \text{ where}$$

$$(3.21) \quad Y = W(1 - \theta) + (A + E)\theta - C(A) - C(E),$$

$$(3.22) \quad Z = W(1 - \theta) + A\theta + E(1 - F)\theta - C(A) - C(E),$$

with $0 < p, \theta < 1; F > 1; C_A, C_E, C_{AA}, C_{EE} > 0; U'(Y) > 0, U''(Y) < 0$.

⁴⁹ For the models of tax evasion with labor supply, the ambiguities of effects of probability of detection and penalty rate on reported income have been also noted by Andersen (1977), Baldry (1979), Sandmo (1981), and Cowell (1985).

⁵⁰ Cross and Shaw also consider an extension of their model of both evasion and avoidance with progressive tax rates. In this case, the comparative static results are more complicated and ambiguous for all policy variables.

⁵¹ Cross and Shaw use the same notion as is used in the ASY model.

The first order conditions are

$$(3.23) (\theta - C_A)[(1 - p)U'(Y) + pU'(Z)] = 0, \text{ and}$$

$$(3.24) (\theta - C_E)(1 - p)U'(Y) + [(1 - F)\theta - C_E]pU'(Z) = 0.$$

The conditions for an interior solution imply:

$$(3.25) \theta - C_E > pF\theta; pF < 1; C_E - (1 - F)\theta > 0.$$

Tax rate effects:

Differentiating the first order condition equations with respect to marginal tax rate θ we obtain

$$(3.26) \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} \frac{\delta A}{\delta \theta} \\ \frac{\delta E}{\delta \theta} \end{bmatrix} = \begin{bmatrix} b_1 \\ b_2 \end{bmatrix}$$

where

$$a_{11} = C_{AA} > 0; a_{12} = 0; b_1 = 1; a_{21} = 0;$$

$$a_{22} = (\theta - C_E)^2(1 - p)U''(Y) + [(1 - F)\theta - C_E]^2pU''(Z) - C_{EE}[(1 - p)U'(Y) + pU'(Z)] < 0$$

$$b_2 = (W - A - E)(\theta - C_E)(1 - p)U''(Y) + [W - A - (1 - F)E][(1 - F)\theta - C_E]pU''(Z) - [(1 - p)U'(Y) + (1 - F)pU'(Z)]$$

Then we can derive

$$(3.27) \frac{\delta A}{\delta \theta} = \frac{1}{C_{AA}} > 0; \frac{\delta E}{\delta \theta} = \frac{b_2}{a_{22}} \text{ is of ambiguous sign; } \frac{\delta X}{\delta \theta} \text{ is of ambiguous sign.}$$

An increase of the tax rate causes an increase in tax avoidance, but the effect on tax evasion is ambiguous. As a result, the effect of tax rate on reported income (X) is ambiguous.

Fine rate effects

Differentiating the first order condition equations with respect to penalty rate F we obtain

$$(3.28) \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix} \begin{bmatrix} \frac{\delta A}{\delta F} \\ \frac{\delta E}{\delta F} \end{bmatrix} = \begin{bmatrix} d_1 \\ d_2 \end{bmatrix}$$

where

$$c_{11} = C_{AA} > 0; c_{12} = 0; d_1 = 0; c_{21} = 0;$$

$$c_{22} = (\theta - C_E)^2(1 - p)U''(Y) + [(1 - F)\theta - C_E]^2pU''(Z) - C_{EE}[(1 - p)U'(Y) + pU'(Z)] < 0;$$

$$d_2 = [(1 - F)\theta - C_E]\theta E p U''(Z) + \theta p U'(Z) > 0.$$

Then, we can derive

$$(3.29) \quad \frac{\delta A}{\delta F} = 0; \quad \frac{\delta E}{\delta F} = \frac{d_2}{c_{22}} < 0; \quad \frac{\delta X}{\delta F} > 0.$$

An increase in the penalty rate does not influence tax avoidance, but it does lead to a decrease in the level of tax evasion. As a result, the penalty rate has a negative effect of the reported income.

Probability of detection effects

Differentiating the first order condition equations with respect to probability of detection, p , we obtain

$$(3.30) \quad \begin{bmatrix} e_{11} & e_{12} \\ e_{21} & e_{22} \end{bmatrix} \begin{bmatrix} \frac{\delta A}{\delta p} \\ \frac{\delta E}{\delta p} \end{bmatrix} = \begin{bmatrix} f_1 \\ f_2 \end{bmatrix}$$

where

$$e_{11} = C_{AA} > 0; \quad e_{12} = 0; \quad f_1 = 0; \quad e_{21} = 0;$$

$$e_{22} = (\theta - C_E)^2(1 - p)U''(Y) + [(1 - F)\theta - C_E]^2 p U''(Z) - C_{EE}[(1 - p)U''(Y) + p U''(Z)] < 0;$$

$$f_2 = (\theta - C_E)U'(Y) - [(1 - F)\theta - C_E]U'(Z) > 0.$$

Then we can derive

$$(3.31) \quad \frac{\delta A}{\delta p} = 0; \quad \frac{\delta E}{\delta p} = \frac{d_2}{c_{22}} < 0; \quad \frac{\delta X}{\delta p} > 0.$$

The probability of detection, like the penalty rate, has a positive effect on reported income.

In short, the comparative static results are consistent with those of the AS model. The probability of detection and the penalty rate have positive effects on reported taxable income. The tax rate has an ambiguous effect on reported taxable income.

In the other case, the two separate cost functions of avoidance and evasion are replaced by a joint function of avoidance and evasion $C(A, E)$. In this case, the comparative static results are slightly different, but the effects of policy variables on the reported taxable income are still consistent with those of the AS model.⁵²

⁵² Cross and Shaw (1982), p.40-45, for detail.

3.2.4.2. Alm Model

Alm (1988a) develops a model in which avoidance and evasion are jointly chosen. The individual is allowed to choose the amounts of a fixed endowment of income to allocate among taxable, avoidance, and evasion income (where taxable income is subject to taxes, evasion to penalties if detected, and avoidance to tax shelter or compliance costs).

This model is more general than Cross and Shaw's model. Alm defines tax rate and penalty rate functions in general forms. Typically, he only considers the cost function of tax avoidance in the model.

a) *The model:*

The individual is assumed to have a fixed amount of income I that he can allocate between legal income L and evasion income E .

Legal compensation L can in turn be allocated between reported, or taxable, income and avoidance or tax shelter income, which is not taxable. The share of taxable income in L is denoted s , and the avoidance share is $(1-s)$. Reported income is subject to a progressive income tax $T(\cdot)$, where $T' > 0$ and $T'' > 0$. Avoidance income is assumed to be excluded from the income tax.⁵³ There are costs incurred with tax avoidance, represented by $C(\cdot)$. It is assumed that the marginal cost of avoidance is positive and increasing, or $C' > 0$ and $C'' > 0$.⁵⁴

For evasion income, the individual is audited by the tax authorities with a fixed probability π , at which point all of evasion income E is detected and the individual is penalized an amount equal to $P(\cdot)$. It is assumed that $P' > 0$ and $P'' > 0$.

The income of the individual after taxes, shelter costs and penalties depends on the state of the world that occurs. If the individual is detected evading his income I_D is:

$$(3.32) \quad I_D = I - T(sL) - C((1-s)L) - P(E).$$

If the individual is not detected, his income I_N is:

$$(3.33) \quad I_N = I - T(sL) - C((1-s)L),$$

for $I = sL + (1-s)L + E = L + E$.

The individual's behavior is assumed to satisfy the Von Neumann-Morgenstern utility function. He maximizes an expected utility function $E(U)$ such that:

⁵³ More generally, avoidance income may be assumed to be taxed, but at a lower rate than reported income. The results are not affected.

⁵⁴ For some individuals it seems plausible to argue that the marginal cost of avoidance is decreasing, so the implication is that $C'' < 0$ can be examined.

$$(3.34) \max_{L,s} \phi = E(U) = \pi U(I_D) + (1 - \pi)U(I_N).$$

It is assumed that $U' > 0$ and $U'' < 0$. The first order conditions for interior solutions for s and L are:

$$(3.35) \frac{\partial \phi}{\partial L} = \phi_L = \pi U'(I_D)[-sT' + P' - (1 - s)C'] + (1 - \pi)U'(I_N)[-sT' - (1 - s)C'] = 0$$

$$(3.36) \frac{\partial \phi}{\partial s} = \phi_s = \pi U'(I_D)(-T' + C')L + (1 - \pi)U'(I_N)(-T' + C')L = 0$$

An interior solution for L requires that

$$(3.37) \pi P'(0) < sT'(sI) + (1 - s)C'((1 - s)I)$$

$$(3.38) \pi P'(I) > [sT'(0) + (1 - s)C'(0)] \left[\pi + (1 - \pi) \frac{U'(I_N)}{U'(I_D)} \right].$$

Equation (3.37) means that the individual will choose some evasion if the expected penalty at zero evasion is less than a weighted average of the costs of legal income. Equation (3.38) means that the individual will declare some legal income if the expected penalty exceeds some positive number.

An interior solution for s requires that

$$(3.39) C'(0) < T'(L)$$

$$(3.40) C'(L) > T'(0).$$

Equation (3.39) means that the marginal cost of sheltered income must be less than the marginal tax rate on taxable income when all legal income is allocated to taxable income. Equation (3.40) means that the marginal cost must exceed the marginal tax rate when all L is allocated to tax shelters. A necessary condition for these two equations to hold is that $T'' + C'' > 0$.

b) Comparative static results:

Alm derived a set of comparative static results for the effects of key model variables on legal income L , the taxable share of legal income s , and the taxable income Y .⁵⁵

There are some definitions that are convenient for the derivation:

$$(3.41) a \equiv \pi U'(I_D)$$

$$(3.42) b \equiv \pi U'(I_D) + (1 - \pi)U'(I_N)$$

$$(3.43) d \equiv \phi_{LL}\phi_{ss} - (\phi_{Ls})^2$$

⁵⁵ The comparative static results are derived by totally differentiating the equations for the first order condition, and then solving for the partial derivatives of legal income L , the taxable share of legal income s , and taxable income Y .

$$(3.44) e \equiv \frac{ab}{d} L(P' - C')$$

$$(3.45) \phi_{LL} = \frac{\partial \phi_L}{\partial L} = \pi U''(I_D)(P' - C')^2 + (1 - \pi)U''(I_N)(C')^2 - aP'' - b[s^2T'' + (1 - s)^2C'']$$

$$(3.46) \phi_{ss} = \frac{\partial \phi_s}{\partial s} = -bL^2(T'' + C'')$$

$$(3.47) \phi_{Ls} \equiv \frac{\partial \phi_L}{\partial s} = bL[-sT'' + (1 - s)C'']$$

The second order conditions require

$$(3.48) \phi_{LL} < 0, \phi_{ss} < 0, \text{ and } \phi_{LL}\phi_{ss} - (\phi_{Ls})^2 = d > 0.$$

The effects of the probability of detection:

$$(3.49) \frac{\partial L}{\partial \pi} = \frac{b}{d} L^2[U'(I_D)(P' - C') + U'(I_N)C'](T'' + C'') > 0$$

$$(3.50) \frac{\partial s}{\partial \pi} = -\frac{b}{d} L[U'(I_D)(P' - C') + U'(I_N)C'](sT'' - (1 - s)C'')$$

$$(3.51) \frac{\partial Y}{\partial \pi} = \frac{b}{d} L^2[U'(I_D)(P' - C') + U'(I_N)C']C''$$

The effect of an increase in the probability of detection, π , on legal income is positive. Its effect on s depends on the term $sT'' - (1 - s)C''$. Therefore its effect is ambiguous.

The effect of an increase in π on taxable income depends on the value of C'' .

*The effects of the marginal penalty cost ρ :*⁵⁶

$$(3.52) \frac{\partial L}{\partial \rho} = eL \left[ER_A(I_D) + \frac{1}{(P' - C')} \right] (T'' + C'') > 0$$

$$(3.53) \frac{\partial s}{\partial \rho} = -e \left[ER_A(I_D) + \frac{1}{(P' - C')} \right] (sT'' - (1 - s)C'')$$

$$(3.54) \frac{\partial Y}{\partial \rho} = eL \left[ER_A(I_D) + \frac{1}{(P' - C')} \right] C''$$

The effect of an increase in ρ on legal income is positive. Its effects on the taxable share of legal income (s) and on taxable income (Y) are ambiguous.

The effects of the marginal tax rate τ :

$$(3.55) \frac{\partial L}{\partial \tau} = eL \left[sL(T'' + C'')(R_A(I_D) - R_A(I_N)) - \frac{P'}{(P' - C')} \frac{C''}{C'} \right]$$

⁵⁶ Alm explains in an Appendix how he derives the effects of the marginal penalty cost, the marginal tax rate, and the marginal shelter cost of legal income, the taxable income share, and taxable income. [Alm (1988a), pp. 57-59]

$$(3.56) \frac{\partial s}{\partial \tau} = e[-sL(sT'' - (1-s)C'')(R_A(I_D) - R_A(I_N)) - (P' - C')R_A(I_D) - C'R_A(I_N) - (1-s)\frac{P'}{(P'-C')}\frac{C''}{C'} - \frac{P''}{(P'-C')}]$$

$$(3.57) \frac{\partial Y}{\partial \tau} = eL[sLC''(R_A(I_D) - R_A(I_N)) - (P' - C')R_A(I_D) - C'R_A(I_N) - \frac{P'}{(P'-C')}\frac{C''}{C'} - \frac{P''}{(P'-C')}]$$

The effects of the marginal tax rate on L , s , and Y are all ambiguous.

The effects of the marginal shelter cost γ :

$$(3.58) \frac{\partial L}{\partial \gamma} = eL\left[(1-s)L(T'' + C'')(R_A(I_D) - R_A(I_N)) - \frac{P'}{(P'-C')}\frac{T''}{T'}\right]$$

$$(3.59) \frac{\partial s}{\partial \gamma} = e[-(1-s)L(sT'' - (1-s)C'')(R_A(I_D) - R_A(I_N)) + (P' - C')R_A(I_D) + C'R_A(I_N) + s\frac{P'}{(P'-C')}\frac{T''}{T'} + \frac{P''}{(P'-C')}]$$

$$(3.60) \frac{\partial Y}{\partial \gamma} = eL[(1-s)LC''(R_A(I_D) - R_A(I_N)) + (P' - C')R_A(I_D) + C'R_A(I_N) + \frac{P''}{(P'-C')}]$$

The effects of marginal shelter cost on L , s , and Y are all ambiguous.

c) *A possible explanation of effects of key variables on legal income, taxable income and avoidance (L , s , and Y):*

Table 3.2 shows a summary of the effects of changes in environmental variables on an individual's optimal choices.

The effects of an increase in the probability of detection:

The individual responds first by increasing the amount of legal income. The effect on the share of taxable income is ambiguous and depends upon the relative slopes of the marginal tax rate and the marginal shelter cost functions in response to a change in L . If the tax function is steeper than the cost function, then taxes rise more rapidly than shelter costs as income is put into L , and the individual responds by decreasing the proportion of reported income. The opposite result occurs if the cost function is steeper than the tax function.

Table 3-2 Comparative Static Results

| | π | | $P'(\rho)$ | | $T'(\tau)$ | | $C'(\gamma)$ | |
|-----|----------------|-----------|----------------|-----------|----------------|-----------------------------|-----------------------------|----------------|
| | $C'' > 0$ | $C'' < 0$ | $C'' > 0$ | $C'' < 0$ | $C'' > 0$ | $C'' < 0$ | $C'' > 0$ | $C'' < 0$ |
| L | > 0 | > 0 | > 0 | > 0 | <i>unclear</i> | <i>unclear</i> ^a | <i>unclear</i> | <i>unclear</i> |
| s | <i>unclear</i> | < 0 | <i>unclear</i> | < 0 | <i>unclear</i> | <i>unclear</i> ^b | <i>unclear</i> | <i>unclear</i> |
| Y | > 0 | < 0 | > 0 | < 0 | <i>unclear</i> | <i>unclear</i> | <i>unclear</i> ^a | <i>unclear</i> |

Note: a) If there is decreasing absolute risk aversion, then the sign is positive; b) If there is decreasing absolute risk aversion, then the sign is negative.

Source: Alm (1988a), Table 1, p.48.

The effects of an increase in the marginal penalty cost of evasion:

The response of legal income, L , to an increase in the marginal penalty cost of evasion is unambiguously positive, and the greater absolute risk aversion is, the greater is the response of L . The increased penalty raises the price of I_N relative to I_D , and the individual responds via the substitution effect by increasing I_D and decreasing I_N , which requires that legal income increases. It might appear that the income effect makes the net impact on L ambiguous. However, as long as absolute risk aversion is positive, the income effect also acts to increase L .

The effects on the share and on the dollar amount of taxable income are ambiguous for the same reasons as those discussed above. Taxable income declines when $C'' < 0$.

The effects of a positive shift in the marginal tax rate function:

The effects of a positive shift in the marginal tax rate function on L , s , and Y are generally ambiguous. There are now offsetting income and substitution effects in the choice of L . The substitution effect raises the price of I_D relative to I_N , and so increases I_N and decreases L . The income effect depends on absolute risk aversion in the two states of the world. If there is decreasing absolute risk aversion, then the lower income acts to increase the individual's aversion to risk, so that legal income increases. The net effect on L is therefore ambiguous.

The uncertain impact on L , in turn, makes the effects on s (and Y) uncertain.

However, there is an additional factor that reduces the share and amount of reported income if L is constant. The upward shift in the tax function alone lowers s and Y , regardless of the shape of the marginal shelter cost function, because taxable income is now more costly to the individual.

The effects of a shift in the marginal shelter cost function:

These effects are ambiguous. Legal income may rise or fall, for reasons similar to those discussed with respect to the marginal tax rate, and ambiguity there makes it impossible to sign the effects on s and Y . However, the increase in shelter costs by itself increases the share and amount of reported income if L does not change.

3.2.4.3. Alm and McCallin's Model

Alm and McCallin (1990) extend the model of avoidance and evasion to the case in which both avoidance and evasion have uncertain returns. The return to evasion is uncertain because the individual does not know whether unreported income will be detected by the tax authorities. The return to avoidance is also uncertain because the strategies of avoidance often yield returns that depend on uncertain future events. Cross and Shaw (1982) and Alm (1988a) also examine individual behavior when avoidance and evasion are jointly selected; however, they do not allow for uncertainty in the return to avoidance.

Alm and McCallin argue that a natural approach that allows simultaneous choice among risky assets is the application of portfolio theory to the avoidance-evasion decision. The individual is assumed to choose simultaneously the amounts of taxable income, avoidance income, and evasion income from a fixed, total income. The individual selects these amounts to maximize his expected utility, which is assumed to be a function of the mean and the variance of the portfolio.

a) *Model:*

An individual taxpayer is assumed to have a fixed amount of income I , which can be allocated among taxable (or reported) income, avoidance income, and evasion income. The amount of reported income is denoted by Y . The sum of avoidance and evasion income is denoted X , with s the share of avoidance in X and $(1 - s)$ the share of evasion in X .

Taxable income is subject to a proportional income tax at rate t_Y . The certain return per dollar of income allocated to Y is $r_Y = 1 - t_Y$.

Income allocated either to avoidance or to evasion is subject to an uncertain return. The uncertain return to avoidance is denoted by \tilde{r}_A (a random variable) with a mean $E(\tilde{r}_A) = \mu_A$ and a variance $Var(\tilde{r}_A) = \sigma_{AA}$. The corresponding variables for evasion are \tilde{r}_E , μ_E and σ_{EE} . The covariance between the random variables in avoidance and evasion is $\sigma_{AE} = \rho\sigma_A\sigma_E$, where ρ is the correlation coefficient between the random returns and σ_i is the standard deviation of income i .

The total return to income, \tilde{R} , as a function of the allocation of income is

$$(3.61) \quad \tilde{R} = r_Y Y + \tilde{r}_A s X + \tilde{r}_E (1 - s) X.$$

The mean and the variance of the total return are

$$(3.62) \quad E(\tilde{R}) = \mu_R = r_Y Y + (I - Y)[s\mu_A + (1 - s)\mu_E],$$

$$(3.63) \quad Var(\tilde{R}) = \sigma_{RR} = [s^2\sigma_{AA} + (1 - s)^2\sigma_{EE} + 2s(1 - s)\sigma_{AE}(I - Y)^2].$$

The individual is assumed to choose Y and s to maximize expected utility $E(U)$, defined as a function of the mean μ_R and the variance σ_{RR} of income.⁵⁷ Then the problem facing the individual is

$$(3.64) \quad \text{Max}_{Y,s} E(U) = \alpha\mu_R - \frac{1}{2}\beta\sigma_{RR},$$

where $\alpha > 0$ and $\beta > 0$, so that the individual is assumed to be risk-averse.

⁵⁷ Expected utility depends only on the mean and variance of income if the underlying utility function is a quadratic function of income or if the distribution of the random variables can be completely described by their means and their variances. [See Haley and Schall (1979)]. In this model, it is assumed that both of these conditions are met.

The first order conditions from this maximization can be solved for the optimal values of \hat{Y} and \hat{s} :

$$(3.65) \quad \hat{Y} = I - \frac{\alpha (\mu_A - r_Y)(\sigma_{EE} - \sigma_{AE}) + (\mu_E - r_Y)(\sigma_{AA} - \sigma_{AE})}{\beta \sigma_{AA}\sigma_{EE} - \sigma_{AE}^2}$$

$$(3.66) \quad \hat{s} = \frac{(\mu_A - r_Y)\sigma_{EE} + (\mu_E - r_Y)\sigma_{AE}}{(\mu_A - r_Y)(\sigma_{EE} - \sigma_{AE}) + (\mu_E - r_Y)(\sigma_{AA} - \sigma_{AE})}$$

b) Comparative static results:

The means and variances of the avoidance and evasion income depend primarily on parameters determined by the government.

The random return to evasion and its mean and variance can be defined in terms of policy parameters as follows:

$$(3.67) \quad \tilde{r}_E = 1 - \tilde{\gamma}f; \mu_E = 1 - E(\tilde{\gamma})f = 1 - \bar{\gamma}f; \text{ and } \sigma_{EE} = f^2\sigma_{\gamma\gamma};$$

where $\tilde{\gamma}$ is defined as the random fraction of underreported income that the government detects (i.e., probability of detection); f is a fine imposed per dollar of underreported detected income; $\sigma_{\gamma\gamma}$ is the variance of $\tilde{\gamma}$.

The random return to avoidance and its mean and variance can be defined in terms of policy parameters as follows:

$$(3.68) \quad \tilde{r}_A = 1 - \tilde{\theta}t_A - c; \mu_A = 1 - E(\tilde{\theta})t_A - c = 1 - \bar{\theta}t_A - c; \text{ and } \sigma_{AA} = t_A^2\sigma_{\theta\theta};$$

where t_A is the tax rate on avoidance income; $\tilde{\theta}$ is the random fraction of avoidance income that is subject to the tax; c is the cost of participating in the avoidance schemes; and $\sigma_{\theta\theta}$ is the variance of $\tilde{\theta}$.

The covariance between \tilde{r}_A and \tilde{r}_E , then, is defined by $\sigma_{AE} = \rho\sigma_A\sigma_E = \rho t_A f \sigma_{\theta} \sigma_{\gamma}$.

Table 3-3 Comparative Statics Results of Alm and McCallin (1990)

| Parameters | Definition | Partial derivative | |
|----------------|--------------------------------------------------|--------------------|-----------|
| | | \hat{Y} | \hat{s} |
| f | Fine per dollar of evasion income | + | + |
| $\bar{\gamma}$ | Mean fraction of evasion income that is detected | + | + |
| t_Y | Tax rate on taxable income | - | + |
| t_A | Tax rate on avoidance income | + | - |
| $\bar{\theta}$ | Mean fraction of avoidance that is taxed | + | - |
| c | Compliance cost per dollar of avoidance income | + | - |

Source: Alm & McCallin, 1990 (Table 1, p.196).

Table 3.3 summarizes the results for partial derivatives of taxable income Y and the share of avoidance income s with respect to policy parameters $f, \bar{\gamma}, t_Y, t_A, \bar{\theta}$, and compliance cost c .⁵⁸

c) A possible explanation for effects of key variables on taxable income and its share:

The effects of $t_Y, c, \bar{\theta}$, and $\bar{\gamma}$:

An increase in compliance cost c or an increase in the mean fraction of avoidance income that is subject to tax $\bar{\theta}$ lowers the return to avoidance schemes, and the individual responds by increasing taxable income Y and by substituting from avoidance to evasion (reducing s).

An increase in the mean fraction of evasion income that is detected $\bar{\gamma}$ has a positive effect on Y , but opposite effects on the shares of avoidance and evasion.

An increase in t_Y lowers taxable income because taxable income is less attractive than either avoidance or evasion. The share of avoidance income will increase if the mean of avoidance return is greater than the mean of evasion return.

The effects of t_A and f :

Changes in the tax rate on avoidance income t_A and in the fine rate on detected evasion f are more difficult to explain because each of them affects a mean, a variance, and the covariance between avoidance and evasion income.

An increase in the fine rate reduces the mean return to evasion μ_E , which increases taxable income Y and the share of avoidance income s . It also increases the standard deviation of the return to evasion σ_E , which has the same effects. It changes the covariance between avoidance and evasion income σ_{AE} , with the direction of the change depending on the sign of the correlation coefficient, so its impact on Y and s is ambiguous.

An increase in the tax rate on avoidance income has similar effects on μ_A, σ_A , and σ_{AE} . Both the net effects on taxable income, Y , and on the share of avoidance income, s , are ambiguous. However, in view of the assumptions about the relative magnitudes of the variance and covariance terms,⁵⁹ there is no ambiguity because the magnitude of the effects via the covariance must be less than the magnitude via the variance. An increase in the fine rate therefore increases both taxable income and the share of avoidance, and an increase in the tax rate on avoidance income raises \hat{Y} and lowers \hat{s} .

⁵⁸ These comparative results can be derived from the first order conditions by taking partial derivative of Y and s with respect to each policy parameter.

⁵⁹ Because evasion is generally thought to be riskier and to give a higher return than avoidance, it is assumed for simplicity that $\sigma_{EE} \geq \sigma_{AA}$ and $\mu_E \geq \mu_A$.

3.3. Summary

The static labor supply model suggests that the substitution response (labor supply) depends on the magnitudes of the substitution effect and the income effect. These effects, in turn, depend on the budget constraint curve and the individual taxpayer's preferences. In short, the substitution behavioral response of a taxpayer depends on the tax policy parameters (such as tax rates, tax transfer, etc.) and on the taxpayer's preferences.

The basic models of tax evasion (the AS and ASY models) suggest that the key factors determining reported taxable income are the probability of detection, penalty rate, marginal tax rate, and actual income. Particularly, the effects of these factors on reported income depend on the assumption about the taxpayers' risk preferences. In other words, these effects depend upon the preferences of taxpayers.

The model of evasion with labor supply (Pencavel 1979) suggests that reported taxable income is a function of following factors: probability of detection, penalty rate, income tax parameters (including marginal tax rate, government transfer), wage rate, and non-labor income. Conclusions about the signs of these effects also depend on the assumption of decreasing absolute risk aversion.

The models of both tax avoidance and tax evasion (Cross and Shaw, 1982; Alm, 1988a) suggest that the reported taxable income is a function of the probability of detection, penalty rate, and marginal tax rate. However, the effects of these factors on reported taxable income depend upon the form of the evasion and avoidance cost functions. In addition, these effects also depend on assumptions about the utility function (i.e., the preferences) of individual taxpayers.

Alm and McCallin's (1990) model confirms the effects of the probability of detection, penalty rate, marginal tax rate, and cost of avoidance on the reported taxable income. In addition, this model suggests that reported taxable income also depends upon the tax rate on avoidance income as well as the fraction of avoidance that is taxed.

In short, it could be generalized that the reported taxable income can be determined as a function of key following factors:

- Tax enforcement factors: such as probability of detection, penalty rate
- Income taxation factors: marginal tax rate on taxable income, marginal tax rate on avoidance income, and other factors concerning the income tax code.
- Taxpayer preferences
- Total actual income
- The cost functions of evasion and avoidance

In general, the function of reported taxable income should take the form:

(3.69) *Reported taxable income = f(tax enforcement factors; income taxation factors; total income; costs of avoidance and evasion; taxpayer's preferences)*

4. Estimating the Elasticity of Taxable Income from the Taxpayer Compliance Perspective

This chapter reviews the empirical taxpayer compliance studies to see how the tax rate and other factors affecting taxpayers' compliance are quantified. It then presents an estimation framework for estimating ETI and quantifying the effects of the other factors on reported taxable income, from the taxpayer compliance approach.

4.1. A Review of Empirical Taxpayer Compliance Studies

This section reviews some major empirical studies of taxpayer compliance to see how researchers in this field determine the effects of the tax rate and other factors on compliance, including the level of reported income. By evaluating the data and empirical specifications used in the empirical studies, this section seeks to find appropriate data sets and specifications, which can be used to estimate effects of the tax rate and other factors on reported income.

4.1.1. Clotfelter (1983)

Clotfelter uses individual tax return data from the Taxpayer Compliance Measurement Program (TCMP) from 1969 to estimate the effect of the marginal tax rate and other factors on the level of tax compliance. He uses the Tobit maximum likelihood method for different types of taxpayers and several audit classes. Underreported income is used as a measure of tax evasion, even though it contains an error term and a pure evasion component. The econometric analysis is performed separately by type of return and by audit class.

The dependent variable is the logarithm of the understatement of adjusted gross income if positive, zero if negative or zero. The explanatory variables include the logarithm of after-tax income, marginal tax rate, wages as proportion of adjusted gross income (AGI), interest and dividends as proportion of AGI, and some control variables for marital status, age, and region.

Clotfelter's empirical model may be misspecified because it does not account for the audit rate as an independent variable. In addition, the data set is not accessible by researchers outside the IRS.

4.1.2. Witte and Woodbury (1985)

Witte and Woodbury use a data set prepared by the IRS which relates to 1969 returns filed in 1970. All data are aggregated to the three-digit zip code level.

The dependent variable is a direct measure of voluntary compliance level (VCL) calculated by the IRS. The explanatory variables are grouped into three categories: the variables related to IRS actions, the variables related to opportunities for noncompliance, and the variables designed to

measure attitudes.⁶⁰ In addition, there are some other control variables (for example, education, race, ethnicity, marital status).⁶¹

There are seven regression equations, one for each of the seven audit classes. The explanatory variables appear in linear form, except for a squared term for income.

Witte and Woodbury estimate the set of seven audit specific equations using the seemingly unrelated regression technique developed by Zellner (1962).

Witte and Woodbury consider the audit rate as an exogenous variable. Thus it may suffer from endogeneity because the audit rates can be highly correlated with the level of taxpayer compliance.

4.1.3. Crane and Nouzard (1985)⁶²

Crane and Nouzard use time-series data for the period 1947-1982 to estimate effects of the interest rate and other factors on an aggregate measure of tax evasion in the United States.

The dependent variable is the proportion of underreported income, which is measured by Park's estimates of the AGI gap.⁶³ The AGI gap is the difference between the AGI figures derived by the Bureau of Economic Analysis (BEA) from the National Income Accounts and the AGI figures reported by the IRS. Because the AGI gap includes the income of taxpayers who are not legally required to file tax returns, the gap is adjusted by removing the estimated value of these incomes.

Independent variables include the probability of detection, penalty rate, tax rate, true income, inflation rate, and interest rate.

The empirical specification has the form:

$$(4.1) \lambda_t = a_0 + a_1\Pi_t + a_2\delta^*_t + a_3\Theta_t + a_4\ln y_t^* + a_5\dot{p}_t + a_6r_t + a_7w_t + a_8t + \epsilon_t,$$

where: λ is the proportion of underreported income in the total true income; Π is probability of detection; δ is the penalty rate; Θ is the marginal tax rate; y is the true income; p is the price deflator; r is the interest rate; w is the wage and salary share of total income; t is an annual time index; the asterisk (*) indicates that the corresponding variable has been instrumented; the dot (·) indicates that the variable is a first difference.

⁶⁰ The variables related to IRS actions include: probability of audit, probability of civil fraud penalty, probability of criminal sanctions, criminal fraud penalty, and IRS notices sent as result of data processing efforts. The variables related to opportunities for noncompliance include: average number of special tax schedules filed with 1969 return, and percent employed in manufacturing. The variables reflecting attitudes include: percent of taxpayers filing a 1969 return who received a Taxpayer Delinquent Account notice, percent of 1969 taxpayers who had a 1968 delinquent account written off, income, and the percent of population 65 and over. Witte and Woodbury (1983a) use a richer set of explanatory variables including the marginal tax rate and more demographic variables.

⁶¹ See Witte and Woodbury (1983a), Table 4, for the detailed list of explanatory variables.

⁶² Crane and Nourzad (1986) use a very similar empirical specification to estimate the effect of inflation on tax evasion for the period 1947-81 in the United States.

⁶³ Park, T.S. (1981).

indicates that a variable represents a relative rate of change. This equation is estimated using the Cochrane-Orcutt second-order autoregressive procedure.

Crane and Nouzard's specification may be appropriate for estimating the effects of the tax rate and other factors on the reported taxable income; however, it suffers from several important weaknesses, such as a limited set of explanatory variables, a limited number of observations of the time-series data, and measurement errors of the data.

4.1.4. Dubin and Wilde (1988)

Dubin and Wilde use a cross-section data set from 1969 IRS individual federal income tax returns and data taken from the *Annual Report of the Commissioner of Internal Revenue* to examine the relationship between audit rate and compliance. The IRS individual tax return data are aggregated to the three-digit zip code level.⁶⁴

The dependent variable is measured by VCL. The independent variables include audit rate, unemployment rate, percentage nonwhite, percentage manufacturing, age, education, and self-employment. Because the data set is segmented by audit classes, which explicitly includes income, the authors do not include an income variable directly in the model.

Dubin and Wilde assume a relationship between audit rates and compliance levels and allow for the possible endogeneity of the audit rate variable. Consistent estimation requires an instrumented variable. The IRS budget per tax return filed is used as an instrument.

Dubin and Wilde adopt the following simple linear specification:

$$(4.2) \quad vcl_{ij} = \alpha_{0j} + \alpha_{1j}audit_{ij} + \alpha_{2j}unemp_{ij} + \alpha_{3j}nw_{ij} + \alpha_{4j}manuf_{ij} + \alpha_{5j}old_{ij} + \alpha_{6j}hsedu_{ij} + \alpha_{7j}perself_{ij} + \epsilon_{ij}$$

They use an instrumental variables regression to estimate this equation. The IRS state-level budget per return is used as an instrument for audit rates.

Instead of using a seemingly unrelated regression technique, Dubin and Wilde use a single-equation estimation technique. They estimate equation (4.2) for each audit class, because, they argue, the efficiency gained from the additional observations is greater than that gained from inter-equation correlation.

Dubin and Wilde's specification accounts for possible endogeneity of the audit rates variable. However, it still has the weakness that it does not account for marginal tax rate as an explanatory variable. Therefore, the estimation results do not provide an explanation for the effect of the tax rate on taxpayers' compliance level.

⁶⁴ The data set is identical to the one used by Witte and Woodbury (1985).

4.1.5. Beron et al. (1988) ⁶⁵

This study uses a 1969 data set that combines information from the IRS's Statistics of Income, the Census, internal IRS documents, and a special data set compiled by the IRS in the mid 1970s.⁶⁶ The data are aggregated to the three-digit zip code level.⁶⁷

The empirical model includes three equations for reported AGI (AGI^r), reported total tax liability (T^r), and the log probability of an audit (A):

$$(4.3) \quad AGI^r = a_0 + a_1A + a_2D + a_3I + a_4TC + a_5S^r + e_g,$$

$$(4.4) \quad T^r = b_0 + b_1A + b_2D + b_3I + b_4TC + b_5S^r + e_t,$$

$$(4.5) \quad A = c_0 + c_1AGI^r + c_2T^r + c_3S^a + c_4R + e^a,$$

where the e 's are random error terms.

The reported AGI and reported total tax liability are determined by the log probability of an audit (A), the degree to which noncompliance can be detected in an audit (D), the level of income (I), a vector of variables that reflect important aspects of the tax code regarding filing requirements, income exclusions and subtractions from income (TC), and a vector of socio-demographic variables that control for differences in tastes and preferences (S^r).

Beron et al. do not explicitly introduce a measure of the marginal tax rate as an explanatory variable because the tax rate in their data set has no variation that is independent of income. To reflect relevant features of the tax code, they include variables for the percent of the population over 65, average family size, the percent of the population owning their own home, and the percent unemployed.⁶⁸

The two variables measuring employment structure (the percent of the population employed in manufacturing and in services) are used to control for the adjustment for employee business expenses and detectability.

The variables that reflect tastes and preferences include sex, race, education, age, and place of birth.

⁶⁵ Tauchen et al. (1989) use a similar empirical framework to analyze the taxpayer compliance behavior of U.S. taxpayers. They use a data set combining the 1979 TCMP data with IRS administrative records for District Offices and 1980 Census data at the five-digit zip code level. However, their empirical specification does not include an audit equation because of the IRS's restriction on revelation of the audit selection rules.

⁶⁶ It is the IRS's Project 778 data base.

⁶⁷ Except for the data on IRS work load, which is aggregated to the IRS District Office level.

⁶⁸ These variables control for legitimate non-filings by very low income individuals, the special allowances for senior citizens, the exemptions for dependents, the tax deductibility of mortgage interest and property taxes, and the exclusion of unemployment benefits from income. Some of these variables may also be related to tastes and preference regarding tax compliance.

The equation for the log probability of an audit is determined by reported AGI (AGI^r) and reported tax liability (T^r), a vector of variables that are observed by the IRS and that may be legally used to select returns for audit (S^a), and the level of IRS resources (R).

The variables that are available from the filed tax return and that the IRS may potentially use for audit selection (S^a) are measures of employment structure, the unemployment rate, the percent of the population over 65, average family size, and the percent of the population who own their own homes. The measure of IRS resources (R) is the number of returns per full-time equivalent district employee.

The model is estimated by two-stage least squares. Beron et al. use a single equation method rather than a system method of estimation because they are concerned about spreading any omitted variable bias across equations.

Beron et al. provide an effective empirical structural model for estimating the effects of tax policy variables, the effects of the tax rate, and other factors on the reported AGI and reported taxable income. However, the limitation of this model, as in the case of Dubin and Wilde (1988), is that Beron et al. do not account for the marginal tax rate as an explanatory variable. There would be limited variation in the marginal tax rate variable because the study uses cross-sections of individual tax returns aggregated at the three-digit zip code level.⁶⁹

4.1.6. Dubin et al. (1990b)

Dubin et al. use a state level time-series cross-section data set for the years 1977-1986 to estimate two empirical equations of tax compliance. One equation specifies reported taxes per return filed as a function of audit rates and a variety of socio-economic factors. The other equation specifies returns filed per capita as a function of the same variables.

The dependent variables are reported tax per return (RTR), returns per capita ($RCAP$). The independent variables include: the individual audit rate ($AUDIT$), the average state income tax rate ($STAXR$), personal income per capita ($INCOME$), a dummy variable for a change beginning in 1980 ($DUM80$), the proportion of returns involving farm income ($FARMS$), the proportion of households on welfare ($WELFARE$), the proportion of households owning houses ($HOUSES$), the percentage of persons over age 65 ($PER65$), the percentage of persons with a college education ($PERED$), the percentage of workers in the manufacturing sector ($PMAN$), the percentage of workers in the service sector ($PSERV$), and the unemployment rate (UR).

Instrumental variables include: budget per return (BPR), and number of information returns other than W2 forms filed divided by total number of individual returns filed ($INFRATE$).

⁶⁹ Beron et al. (1988) do not explicitly include the marginal tax rate as an explanatory variable because, for their data set, the tax rate has no variation that is independent of income.

Dubin et al. pool state level data for the years 1977 to 1986 and estimate RTR and $RCAP$. The reporting and filing equations are

$$(4.6) \quad RTR_{it} = \alpha_0 + \alpha_1 PER65_{it} + \alpha_2 HOUSES_{it} + \alpha_3 WELFARE_{it} + \alpha_4 UR_{ij} + \alpha_5 INCOME_{it} \\ + \alpha_6 STAXR_{it} + \alpha_7 PERED_{it} + \alpha_8 PMAN_{it} + \alpha_9 PSERV_{it} + \alpha_{10} FARMS_{it} \\ + \alpha_{11} AUDIT_{it} + \alpha_{12} DUM80_t + \epsilon^{RTR}_{it}$$

$$(4.7) \quad RCAP_{it} = \beta_0 + \beta_1 PER65_{it} + \beta_2 HOUSES_{it} + \beta_3 WELFARE_{it} + \beta_4 UR_{ij} + \beta_5 INCOME_{it} \\ + \beta_6 STAXR_{it} + \beta_7 PERED_{it} + \beta_8 PMAN_{it} + \beta_9 PSERV_{it} + \beta_{10} FARMS_{it} \\ + \beta_{11} AUDIT_{it} + \beta_{12} DUM80_t + \epsilon^{RCAP}_{it}$$

There is a possible endogeneity of audit rates in any estimation procedure. Consistent estimation requires the use of instruments that are correlated with audit rates but not with the unobservable variables. The IRS budget per return filed (BPR), and the rate of filing of information returns ($INFRATE$) are used as instrument.

The statistical analysis provides evidence of a correlation between the unobservables ϵ^{RTR}_{it} and ϵ^{RCAP}_{it} over time, which is consistent with the random effects model. To account for this correlation in the unobservables, Dubin et al. use the random effects generalized least squares procedure to estimate the model.

Dubin et al. (1990b) use an appropriate empirical model to estimate the effects of the tax rate and other factors on the level of taxpayer compliance. This empirical model can be modified to estimate the effects of tax rate and other factors on the reported taxable income.

4.1.7. Plumley (1996)

Plumley uses a panel data over a ten-year period (1982-1991) aggregated to the state level to estimate one filing compliance equation and three separate reporting compliance equations. The purpose of this study is to quantify the indirect behavioral response of taxpayers to changes in IRS enforcement, IRS's responsiveness, and basic tax policies. The estimation approach is similar to that of Dubin et al. (1990b). This approach involves attempting to estimate the impacts of various factors (including audits and tax rates) on the voluntary income tax filing and reporting compliance of individuals, using a panel of data aggregated to the state level. It also accounts for the endogeneity of audit rates.

The dependent variables include Filing Rate and three reporting variables. The three reporting variables are Income Percentage ($IncomePct$), Offsets Percentage ($OffsetsPct$), and Net Income Percentage ($NetIncomePct$).

Independent variables include Filing Rate⁷⁰ and five categories of variables:

⁷⁰ Filing rate is used as an independent variable in the three reporting equations.

Tax policy variables: Filing threshold percentage (*FThresholdPct*); Amnesty in the last 5 years (*Amnesty5*); Marginal tax rate at \$15K taxable income (*MargTaxRate@\$15K*); Marginal tax rate at \$57K taxable income (*MargTaxRate@\$57K*); Children exemptions (*ChildExemptsPct*); State income, property and sales tax revenues (*StateTaxPct*).

Burden/Opportunity variables: Average burden (*AvgBurden*); Sole proprietors (*SoleProps*); Interaction variable of Sole proprietors and non-farm employment in Trade, Finance and Service sectors (*SolePropTFS*), Returns prepared by paid practitioner (*PaidPrep*).

IRS enforcement variables: Audit rate (*AuditRate*); Rate of Information Return Program's documents matched against returns (*IRP_DocRate*); Rate of Taxpayer Delinquency Investigation's notices issued (*TDI_TotRate*); Rate of refunds offset for outstanding debts (*RefOffRate*); Rate of Criminal Investigation Division's criminal convictions (*CID_ConvRate*).

IRS responsiveness variables: Rate of telephone calls handled by Taxpayer Services (*TPS_CallsPC*); Rate of returns prepared by Taxpayer Services (*TPS_RetPrepPC*).

Demographics/economics variables: Rate of singles (*Singles*), Age under 30 (*Under30*), Age over 64 (*Over64*); Rate of births (*PCBirths*), Average personal income (*AvgPI*); Annual growth of AvgPI (*AvgPIgrowth*); Percentage of income on untaxable potential returns (*ExclIncomePct*); Unemployment rate (*UnemplRate*).

The empirical model consists of four compliance equations (*FilingRate*, *IncomePct*, *OffsetsPct*, and *NetIncomePct*), and one first-stage audit rate equation. They are all estimated using single-equation procedures (Two-Stage Least Squared Dummy Variables) to avoid the likelihood of introducing omitted variable bias across equations. The equations are estimated from the panel of 49 states over ten years (1982-1991).

First-stage audit rate equation: It is acceptable to estimate a first-stage *AuditRate* equation using appropriate instruments, and then use the predicted audit rate in the structural compliance equations. Plumley introduces two instruments unrelated to compliance to explain the audit rate. These instruments are the percentage of auditor time directly devoted to audits (i.e., Direct Examination Time, or *DET*), and the average DET per audit.

The *AuditRate* equation takes the form:

$$(4.8) \text{ AuditRate} = \delta_0 + \sum \sigma_{1i} \text{State}_i + \sum \tau_{1t} \text{Year}_t + \delta_1 \text{DET}\% + \delta_2 \text{Ln}(\text{AvgDET}_{-1} + 1) + \varepsilon_1$$

The four compliance equations take the following forms:

(4.9) *FilingRate*

$$\begin{aligned} &= \phi_0 \\ &+ \sum \sigma_{2i} State_i + \sum \tau_{2t} Year_t + \phi_1 FThresholdPct + \phi_2 Amnesty5 \\ &+ \phi_3 Ln(AvgBurden) + \phi_4 SoleProps + \phi_5 SolePropTFS + \phi_6 IRP_DocRate \\ &+ \phi_7 Ln(TDI + 1) + \phi_8 Ln(RefOffRate + 1) + \phi_9 TPS_RetPrepPC \\ &+ \phi_{10} Singles + \phi_{11} Under30 + \phi_{12} Over64 + \phi_{13} AvgPI + \phi_{14} AvgPIgrowth \\ &+ \phi_{15} UnemplRate + \varepsilon_2 \end{aligned}$$

(4.10) *IncomePct*

$$\begin{aligned} &= \alpha_0 \\ &+ \sum \sigma_{3i} State_i \\ &+ \sum \tau_{3t} Year_t + \alpha_1 FilingRate + \alpha_2 FThresholdPct \\ &+ \alpha_3 MargTaxRate@\$15Kt + \alpha_4 MargTaxRate@\$57K \\ &+ \alpha_5 ChildExemptsPct + \alpha_6 Ln(AvgBurden) + \alpha_7 SoleProps \\ &+ \alpha_8 SolePropTFSt + \alpha_9 PaidPrep + \alpha_{10} Ln(pAuditRate + 1) + \alpha_{11} Ln(IRP \\ &+ 1) + \alpha_{12} Ln(CID + 1) + \alpha_{13} TPS_CallsPC + \alpha_{14} TPS_RetPrepPC \\ &+ \alpha_{15} Singles + \alpha_{16} Under30 + \alpha_{17} Over64 + \alpha_{18} PCBirths \\ &+ \alpha_{19} ExclIncomePct + \alpha_{20} UnemplRate + \varepsilon_3 \end{aligned}$$

(4.11) *OffsetsPct*

$$\begin{aligned} &= \beta_0 \\ &+ \sum \sigma_{4i} State_i \\ &+ \sum \tau_{4t} Year_t + \beta_1 FilingRate + \beta_2 FThresholdPct \\ &+ \beta_3 MargTaxRate@\$15Kt + \beta_4 MargTaxRate@\$57K \\ &+ \beta_5 ChildExemptsPct + \beta_6 StateTaxPct + \beta_7 Ln(AvgBurden) \\ &+ \beta_8 SoleProps + \beta_9 SolePropTFS + \beta_{10} PaidPrep + \beta_{11} Ln(pAuditRate + 1) \\ &+ \beta_{12} Ln(CID + 1) + \beta_{13} TPS_CallsPC + \beta_{14} TPS_RetPrepPC + \beta_{15} Singles \\ &+ \beta_{16} Under30 + \beta_{17} Over64 + \beta_{18} PCBirths + \beta_{19} UnemplRate + \varepsilon_4 \end{aligned}$$

(4.12) *NetIncomePct*

$$\begin{aligned}
&= \gamma_0 \\
&+ \sum \sigma_{5i} State_i \\
&+ \sum \tau_{5t} Year_t + \gamma_1 FilingRate + \gamma_2 FThresholdPct \\
&+ \gamma_3 MargTaxRate@\$15Kt + \gamma_4 MargTaxRate@\$57K t \\
&+ \gamma_5 ChildExemptsPct + \gamma_6 StateTaxPct + \gamma_7 Ln(AvgBurden) \\
&+ \gamma_8 SoleProps + \gamma_9 SolePropTFS + \gamma_{10} PaidPrep + \gamma_{11} Ln(pAuditRate + 1) \\
&+ \gamma_{12} Ln(IRP + 1) + \gamma_{13} Ln(CID + 1) + \gamma_{14} TPS_CallsPC \\
&+ \gamma_{15} TPS_RetPrepPC + \gamma_{16} Singles + \gamma_{17} Under30 + \gamma_{18} Over64 \\
&+ \gamma_{19} PCBirths + \gamma_{20} ExclIncomePct + \gamma_{21} UnemplRate + \varepsilon_5
\end{aligned}$$

Plumley uses an estimation approach similar to that of Dubin et al. (1990b) but with some improvements.

Plumley's data set includes a richer set of explanatory variables. This data set includes information on tax policy variables, tax burden and opportunities, the IRS's enforcement policies, the IRS's responsiveness, and other demographic and economic factors.

Plumley introduces new instruments to control for endogeneity of audit rates. The instruments are the percentage of auditor time directly to audits (*DET*) and the average *DET* per audit. These variables are productivity-related measures, which are quite independent of taxpayer compliance.

Plumley's study is the first to use the audit start rate instead of the audit close rate. He argues that audits are typically closed several years after the returns are filed, and closures in any given year relate to many different prior tax years. Therefore, the start rate better represents the percentage of return filed those are audited in a given year.

Plumley uses three different definitions of income to control for changes of the tax rules.

Plumley's empirical model includes three reporting equations. These reporting equations are relevant to quantify the effects of tax rate and other factors on the levels of reporting compliance. Particularly, the concept of net income is very close to the concept of reported taxable income in the ETI literature. Therefore, the *NetIncomePct* equation may be an appropriate specification to be modified to estimate effects of tax rate and other factors on the reported taxable income.

4.1.8. Summary

Clotfelter's (1983) specification is inappropriate because it does not account for audit rate as an independent variable. In addition, the data set is not accessible to all researchers. Witte and Woodbury (1985) consider audit rate as an exogenous variable. Thus, any endogeneity of the audit rate is problematic for their estimates.

Crane and Nouzard's (1985) specification might be appropriate. However, this kind of specification has several important weaknesses, namely a limited set of explanatory variables, a limited number of observations of the time-series data, and measurement errors of the data.

Dubin and Wilde (1988) and Beron et al. (1988) use specifications that account for possible endogeneity of audit rates. These specifications would be appropriate. However, these specifications have the important weakness of not accounting for the marginal tax rate as an explanatory variable. These studies use cross-sectional data of tax returns aggregated at the 3-digit zip code level. There is thus limited variation in the marginal tax rate variable.

Dubin et al. (1990b) and Plumley (1996) have similar specifications. These specifications would be appropriate for the purpose of estimating effects of the tax rate and other factors on reported taxable income. However, Plumley's specification has some important advantages over the Dubin et al. (1990b).

4.2. Estimating the ETI from the Taxpayer Compliance Perspective

The purpose of this section is to estimate the effects of tax rate and other factors on reported taxable income. It introduces a new approach to estimate the ETI from the taxpayer compliance perspective.

4.2.1. General Specification Model

The theoretical framework (Chapter 3) suggests that the reported taxable income would be determined by the function:

$$(4.13) \text{ Reported taxable income} = f(\text{tax enforcement factors; income taxation factors; total income; costs of avoidance and evasion; taxpayer's preferences})$$

Witte and Woodbury (1983a) use a number of attitudinal and demographic variables (such as education, age, etc.) in their empirical model. They argue that these variables may be seen as factors determining "tastes" of individual taxpayers.⁷¹ Roth et al. (1989) confirm that many researchers incorporate certain demographic and socioeconomic characteristics of taxpayers in their model of compliance, and these variables are used as indicators of tastes.⁷² These references suggest that taxpayers' preference can be represented by certain demographic and socioeconomic variables.

Slemrod (1998b) suggests that tax avoidance technology can be represented by an avoidance cost function. Slemrod defines avoidance cost as a function of the total income and the amount of avoidance. The amount of avoidance depends upon characteristics of the current tax system and preference of individual taxpayers. Therefore, the component "costs of avoidance and evasion"

⁷¹ Witte and Woodbury (1983a), p.12

⁷² Roth et al. (1989), p.133.

in the function of reported taxable income is absorbed into other components of the function (such as tax enforcement factors, taxation factors, and taxpayers' preference).

As a result, we can derive a specific form of the reported taxable income function as follows:

$$(4.14) \text{ Reported taxable income} = f(\text{tax enforcement factors; income taxation factors; total income; demographic and socio-economic factors})$$

A review of the empirical studies suggest that Plumley's (1996) dataset and specifications are appropriate for estimating the effects of the tax rate and other factors on reported income. For that reason, I decided to use the data set used by Plumley. I made some modifications to Plumley's empirical model to construct a specification for estimating the effects of the tax rate and other factors on reported taxable income, as well as estimating the ETI.

Plumley uses a panel data set aggregated to the state level, which covers 49 states of the United State from 1982-1991.⁷³

4.2.2. Empirical Specification

Consider the reported taxable income function:

$$(4.14) \text{ Reported taxable income} = f(\text{tax enforcement factors; income taxation factors; total income; demographic and socio-economic factors})$$

For a more specific specification, the *NetIncomePct* equation in Plumley (1996) is used with some modifications.

4.2.2.1. Dependent Variable

In Plumley's data set, the net income is an appropriate variable for the reported taxable income.⁷⁴

$$(4.15) \text{ Net income} = \text{Total income} - \text{Offsets},$$

where *Offsets* include all subtractions from income and subtractions from tax (i.e., tax credits).⁷⁵

For the purpose of estimating the ETI, *NetIncome* is measured in logarithmic form.

To control for changes in the tax rules over time, Plumley defines *NetIncome* in three different ways:

⁷³ The District of Columbia (DC) and Alaska are excluded from the data set. The District of Columbia is excluded because it is included in Maryland data [Plumley (1996), footnote 8]. Alaska is excluded because the data on the Filing rate variable is especially fatal for this state [Plumley (1996), footnote 14].

⁷⁴ In most empirical ETI literature, taxable income is defined as the difference between AGI and all subtractions from income (adjustments, exemptions, and deductions).

⁷⁵ In order to obtain a single concept of offsets, Plumley converted the credit amounts on a given return to the equivalent income offset amounts by dividing them by the marginal tax rate faced by the return.

Definition A: excludes all components of income or offsets whose reporting rules changed during the period, except for ones that could be controlled for by using constant-law data or by including appropriate explanatory variables.

Definition B: excludes only those components of income or offsets whose rules changed in years other than 1986 (i.e., in the TRA86).⁷⁶

Definition C: includes all components of income and offsets regardless of rule changes.

4.2.2.2. *Independent Variables*

(1) For the purpose of estimating the ETI, the key explanatory variable is log of the net-of-tax rate.

There are five variables related to income tax rates in Plumley's data set:

- Average marginal tax rate reported among filed returns (*MTaxRate*),
- Marginal tax rate at \$15,000 of taxable income (*MTR15K*),
- Marginal tax rate at \$50,000 of taxable income (*MTR50K*),
- Marginal tax rate at \$57,000 of taxable income (*MTR57K*), and
- Marginal tax rate at \$85,000 of taxable income (*MTR85K*).

All these variables are federal tax rates.

To calculate the average marginal tax rate variable, Plumley used the SOI sample of individual returns and deduced which tax bracket each return was in. Then he simply averaged those rates across all taxpayers, weighting all taxpayers equally.

The *MTR15K*, *MTR50K*, *MTR57K*, and *MTR85K* variables are federal marginal tax rate variables, which are calculated from the Form 1040 tax package.

In this section, I use the average marginal tax rate (*MTaxRate*) to calculate the log of the net-of-tax rate variable:

$$(4.16) \log(\text{net} - \text{of} - \text{tax rate}) = \log(1 - \text{MTaxRate}).$$

A problem with the average marginal tax rate is that it is endogenous with income.⁷⁷ To control for endogeneity, I use *MTR15K*, *MTR50K*, *MTR57K*, and *MTR85K* as instruments for the log of the net-of-tax rate.⁷⁸

⁷⁶ Definition B is more consistent with the definitions of income used in the current ETI literature. Appendix A presents a comparison between the income definitions in Plumley (1996) and those used in the ETI literature.

⁷⁷ Plumley (1996), p.15.

⁷⁸ To check for the validity of these instruments, I regressed the average marginal tax rate on *MTR15K*, *MTR50K*, *MTR57K*, and *MTR85K*. The regression results suggest a strong correlation between the instruments and the average marginal tax rate. The regression of log of net income on those instruments suggests a weak correlation among them.

(2) Total income variable: log of Personal Income

In Plumley (1996), total income is not an explanatory variable in *NetIncomePct* equation. Actually, the dependent variable is a ratio of Net Income to Personal Income in the National Income and Product Accounts (NIPA).

Plumley argues that, although NIPA Personal Income does not correspond exactly to the total “true” income that must be reported on federal income tax returns,⁷⁹ it is a very effective control for this concept. Because it is probably the most comprehensive individual income variable available annually at the state level, and it is derived substantially independently of tax return data, Personal Income is reasonably exogenous to income tax compliance and income tax administration decisions.⁸⁰

In my specification, the dependent variable is level of Net Income. Therefore, it is reasonable to include Personal Income as an explanatory variable. However, the Personal Income variable should have a logarithm form to account for the non-linear relationship between total income and reported taxable income.⁸¹ One important advantage of the Personal Income variable is that it is exogenous to income tax compliance and income tax administration variables.

(3) *FilingRate*:

Filing rate should be included as a variable because it should be related positively to the reported taxable income. This variable is not endogenous because the amounts reported on filed returns do not affect whether or not people file returns.⁸²

(4) Other tax policy variables:

The changes in the values of standard deductions and exemptions can be controlled by using two variables:

FThresholdPct: The aggregate filing threshold value among all required returns, expressed as a percentage of Personal Income.

ChildExemptsPct: The aggregate exemption value for all children among all required returns, expressed as a percentage of Personal Income.

⁷⁹ It includes the income of all those who do not need to file returns.

⁸⁰ Plumley (1996), p.10.

⁸¹ Clotfelter (1983) and Crane and Nouzard (1985) include the logarithm of income; Witte and Woodbury (1985) and Feinstein (1991) include income squared as an explanatory variable to control for a non-linear relationship between income and underreported income. Entering income in both linear and squared form was suggested by the finding of Mason and Lowry (1981) that lower and higher income groups show the greatest amount of income underreporting, while middle income group shows the least. Also, this allows for risk-averse behavior on the part of the taxpayer [see Witte and Woodbury (1985), footnote 19].

⁸² Plumley (1996), p.25.

A tax policy variable related to state taxes is *StateTaxPct*. It is the amount of state income, property, and sales tax revenues that were deductible federally, expressed as a percentage of Personal Income.

(5) Burden/Opportunity variables

The burden of tax compliance is associated with getting, learning how to use, completing, and filing the various required tax forms and schedules. The burden of tax compliance can be represented by *AvgBurden* (i.e, average burden), which is the ratio of the total burden estimated for the state and year and the corresponding number of potential returns indicated by the Current Population Survey (CPS).

The complexity of tax system and opportunity for tax noncompliance can be measured by three following variables:

SoleProps: The percent of potential returns having non-farm sole proprietor income.

SolePropTFS: An interaction term between *SoleProps* and the percent of nonfarm employment in the Trade, Finance and Services sectors.

PaidPrep: The number of returns prepared by paid practitioner as a proportion of the total number of returns filed.

(6) IRS enforcement variables

AuditStartRate: Audits started as a percent of returns filed one year prior

Traditionally, an average audit coverage rate is usually measured as the number of audits closed in a given fiscal year divided by the corresponding number of returns filed in the prior calendar year. Since the length of audits varies widely, and is often longer than one year, the traditional measurement of audit rate does not accurately reflect the average percentage of returns filed in a given year that are eventually audited. It is better captured by the percentage of audits started in a given year. For this reason, Plumley uses the audit start rate as a measurement for audit rate variable.

Because the audit rate is endogenous with compliance, there should be instrumental variable(s) for *AuditStartRate*. Plumley suggests two audit productivity-related measures to be used as instruments: DET (Direct Examination Time) percent (*DET_pct*) and the one-year lag of the average DET per audit (*AvgDET*). *DET_pct* measures the Direct Examination Time as a percentage of total time in the fiscal year. *AvgDET* measures the Direct Examination Time per exam closed in fiscal year.

IRP_DocRate: This is the average number of IRP (Information Returns Program) documents processed per potential returns.

Much of the decline in conventional, labor-intensive audits has been accompanied by a very significant rise in the IRS's ability to detect noncompliance through the use of automated matching of third-party information documents with tax returns in its Information Returns Program (IRP). It is important to control for this shifting of enforcement resources. The number of documents actually matched does reflect the level of enforcement. Therefore, the *IRP_DocRate* should be included as an explanatory variable.

CID_ConvRate: This is the number of criminal convictions obtained per million people in the population.

Another IRS enforcement program is the IRS's Criminal Investigation Division (CID). This program is intended to improve voluntary compliance by catching and prosecuting tax fraud cases. The effect of this program on tax compliance can be represented by *CID_ConvRate*.

(7) IRS responsiveness variables

There are two types of Taxpayer Service activities:

TPS_CallsPC: The number of telephone calls handled per thousand people in the population.

TPS_RetPrepPC: The number of returns TPS helps to prepare per thousand people in the population.

(8) Demographic/economic variables

There is a variety of demographic and economic factors that influence the taxpayer compliance behavior and can be used to control for fluctuations in the dependent variable.

Singles: The prevalence of singles (unmarried persons) as a percent of potential returns

Under30: The percentage of potential returns of people under age 30

Over64: The percentage of potential returns of people over age 64.

PCBirths: The number of births per thousand in the population

UnemplRate: The unemployment rate among those age 16 and older

4.2.2.3. **Specification Equations**

The model consists of two equations: *AuditRate* equation and *Ln(NetIncome)* equation.

The *AuditRate* equation takes the form:

$$(4.17) \text{ AuditRate} = \delta_0 + \sum \sigma_{1i} \text{State}_i + \sum \tau_{1t} \text{Year}_t + \delta_1 \text{DET}\% + \delta_2 \text{Ln}(\text{AvgDET}_{-1} + 1) + \varepsilon_1$$

The *Ln(NetIncome)* equation takes the form:

(4.18) $\text{Ln}(\text{NetIncome})$

$$\begin{aligned}
&= \gamma_0 \\
&+ \sum \sigma_{5i} \text{State}_i \\
&+ \sum \tau_{5t} \text{Year}_t + \gamma_1 \text{FilingRate} + \gamma_2 \text{Ln}(\text{PI}) + \gamma_3 \text{FThresholdPct} \\
&+ \gamma_4 \text{Ln}(\text{NetTaxRate}) + \gamma_5 \text{ChildExemptsPct} + \gamma_6 \text{StateTaxPct} \\
&+ \gamma_7 \text{Ln}(\text{AvgBurden}) + \gamma_8 \text{SoleProps} + \gamma_9 \text{SolePropTFS} + \gamma_{10} \text{PaidPrep} \\
&+ \gamma_{11} \text{Ln}(\text{pAuditRate} + 1) + \gamma_{12} \text{Ln}(\text{IRP} + 1) + \gamma_{13} \text{Ln}(\text{CID} + 1) \\
&+ \gamma_{14} \text{TPS_CallsPC} + \gamma_{15} \text{TPS_RetPrepPC} + \gamma_{16} \text{Singles} + \gamma_{17} \text{Under30} \\
&+ \gamma_{18} \text{Over64} + \gamma_{19} \text{PCBirths} + \gamma_{20} \text{UnemplRate} + \varepsilon
\end{aligned}$$

The *AuditRate* equation is estimated by using the LSDV procedure. The $\text{Ln}(\text{NetIncome})$ equation is estimated by using the IV-fixed effects model procedure, where $\text{Ln}(\text{NetTaxRate})$ is instrumented by $\text{Ln}(\text{NetMTR15K})$, $\text{Ln}(\text{NetMTR50K})$, $\text{Ln}(\text{NetMTR57K})$, and $\text{Ln}(\text{NetMTR85K})$.

4.2.3. Estimation Results

Table 4.1 shows the estimation results of equation (1) and (2) in the basic form and two modifications with different definitions of income.

4.2.3.1. Estimations Results with Income Definition A

Basic specification: The estimation result is obtained with very high R^2 (0.99). But the t-values of most estimated coefficients are very small. Only the estimated coefficients of the following variables are quite significant (at least at the 10% significant level): *FilingRate*, $\text{Ln}(\text{PI})$, *PaidPrep*, *Singles*, *PCBirths*, and *UnemplRate*.

There is a symptom of multicollinearity among the explanatory variables. Table 4.2 shows the pairwise correlation coefficients among the explanatory variables. There is evidence of pairwise correlation between $\text{Ln}(\text{NetTaxRate})$ and *FThresholdPct* ($r=0.74$), $\text{Ln}(\text{NetTaxRate})$ and *ChildExemptsPct* ($r=0.71$), *FThresholdPct* and *ChildExemptsPct* ($r=0.8$), *SoleProps* and $\text{Ln}(\text{AvgBurden})$ ($r=0.61$), and *UnemplRate* and $\text{Ln}(\text{IRP}+1)$ ($r=0.67$).

Table 4-1 Estimation Results

| Explanatory variables | Definition A | | | Definition B | | Definition C | |
|------------------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|--------------------|
| | Basic Specification | Modification 1 | Modification 2 | Basic Specification | Modification 2 | Basic Specification | Modification 2 |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| <i>Ln(NetTaxRate)</i> | 2.705 (0.64) | 1.23 (0.51) | 0.75 (0.32) | 2.205 (0.53) | 0.33 (0.14) | 1.19 (0.21) | -1.94 (-0.58) |
| <i>FilingRate</i> | 0.004 (2.21) | 0.0033 (3.22) | 0.0034 (3.42) | 0.004 (2.28) | 0.0034 (3.4) | 0.002 (0.82) | 0.0015 (1.06) |
| <i>Ln(PI)</i> | 1.337 (2.7) | 1.047 (8.69) | 1.03 (9.13) | 1.31 (2.69) | 1.05 (9.4) | 1.62 (2.46) | 1.19 (7.28) |
| <i>FthresholdPct</i> | 0.014 (1.08) | --- | --- | 0.012 (0.98) | --- | 0.021 (1.25) | --- |
| <i>ChildexemptsPct</i> | 0.018 (0.68) | --- | --- | 0.02 (0.77) | --- | -0.004 (-0.11) | --- |
| <i>StateTaxPct</i> | -0.0005 (-0.09) | 0.00008 (0.01) | --- | -0.0012 (-0.19) | --- | -0.009 (-1.06) | --- |
| <i>Ln(AvgBurden)</i> | 0.119 (0.53) | --- | --- | 0.156 (0.71) | --- | 0.212 (0.71) | --- |
| <i>SoleProps</i> | 0.052 (1.7) | 0.051 (2.55) | 0.049 (2.84) | 0.055 (1.81) | 0.055 (3.15) | 0.05 (1.22) | 0.05 (1.96) |
| <i>SolePropTFS</i> | -0.001 (-1.84) | -0.001 (-2.56) | -0.0009 (-2.88) | -0.001 (-1.98) | -0.001 (-3.23) | -0.001 (-1.38) | -0.001 (-2.04) |
| <i>PaidPrep</i> | -0.004 (-2.78) | -0.004 (-3.85) | -0.0038 (-3.62) | -0.004 (-2.59) | -0.0035 (-3.36) | 0.0066 (3.22) | 0.0076 (4.94) |
| <i>Ln(pAuditRate1)</i> | 0.133 (0.78) | 0.108 (0.70) | 0.11 (0.75) | 0.186 (1.11) | 0.158 (1.08) | 0.19 (0.86) | 0.146 (0.68) |
| <i>Ln(IRP+1)</i> | 0.305 (0.57) | --- | --- | 0.221 (0.42) | --- | 0.426 (0.6) | --- |
| <i>Ln(CID+1)</i> | 0.012 (1.72) | 0.012 (1.88) | 0.012 (1.99) | 0.012 (1.73) | 0.012 (1.96) | -0.002 (-0.23) | -0.003 (-0.39) |
| <i>TPS_CallsPC</i> | -0.00008 (-1.19) | -0.00006 (-1.02) | -0.00007 (-1.14) | -0.00008 (-1.13) | -0.00006 (-1.02) | 0.00009 (1.0) | 0.0001 (1.47) |
| <i>TPS_RetPrepPC</i> | 0.005 (1.54) | 0.0039 (2.01) | 0.0036 (1.93) | 0.0046 (1.45) | 0.003 (1.77) | 0.0018 (0.42) | -0.0003 (-0.11) |
| <i>Singles</i> | 0.006 (1.76) | 0.0026 (1.59) | 0.0025 (1.54) | 0.005 (1.59) | 0.002 (1.26) | 0.0087 (1.92) | 0.004 (1.88) |
| <i>Under30</i> | -0.003 (-1.44) | -0.004 (-2.21) | -0.0034 (-2.18) | -0.0025 (-1.19) | -0.0032 (-2.1) | -0.0054 (-1.89) | -0.006 (-2.69) |
| <i>Over64</i> | -0.0007 (-0.26) | -0.001 (-0.53) | --- | -0.00005 (-0.02) | --- | -0.0003 (-0.08) | --- |
| <i>PCBirths</i> | 0.02 (3.64) | 0.016 (3.74) | 0.016 (3.64) | 0.0167 (3.12) | 0.013 (2.85) | -0.0014 (-0.2) | -0.006 (-0.9) |
| <i>UnemplRate</i> | -0.011 (-2.53) | -0.01 (-3.07) | -0.01 (-3.02) | -0.01 (-2.28) | -0.009 (-2.67) | -0.01 (-1.69) | -0.009 (-1.76) |
| <i>R² overall</i> | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.98 | 0.98 |

Note: Fixed effects IV regression models; t-statistics in parentheses.

Table 4-2 Pairwise Correlation Coefficients among Explanatory Variables

| | <i>FilingRate</i> | <i>Ln(PI)</i> | <i>FthresholdPct</i> | <i>ChildexemptsPct</i> | <i>StateTaxPct</i> | <i>Ln(AvgBurden)</i> | <i>SoleProps</i> |
|------------------------|-------------------|-----------------|----------------------|------------------------|--------------------|----------------------|------------------|
| <i>FilingRate</i> | 1.0000 | | | | | | |
| <i>Ln(PI)</i> | 0.0889 | 1.0000 | | | | | |
| <i>FthresholdPct</i> | -0.3645 | -0.3396 | 1.0000 | | | | |
| <i>ChildexemptsPct</i> | -0.2617 | -0.3381 | 0.8362 | 1.0000 | | | |
| <i>StateTaxPct</i> | 0.0330 | -0.0652 | -0.5869 | -0.5207 | 1.0000 | | |
| <i>Ln(AvgBurden)</i> | -0.1525 | -0.4035 | -0.0337 | 0.0095 | 0.3876 | 1.0000 | |
| <i>SoleProps</i> | -0.1488 | -0.4518 | 0.3497 | 0.4588 | -0.0017 | 0.6128 | 1.0000 |
| <i>SolePropTFS</i> | -0.0885 | -0.3606 | 0.2754 | 0.3891 | -0.0388 | 0.5746 | 0.9348 |
| <i>PaidPrep</i> | -0.1341 | -0.0297 | 0.1620 | 0.2112 | -0.0050 | 0.2692 | 0.2887 |
| <i>Ln(pAuditRate1)</i> | 0.0918 | -0.1492 | -0.3758 | -0.4182 | 0.5285 | 0.3312 | -0.0011 |
| <i>Ln(IRP+1)</i> | 0.1572 | 0.2624 | -0.1149 | -0.0266 | -0.0738 | -0.0073 | -0.0327 |
| <i>Ln(CID+1)</i> | 0.0060 | 0.1617 | 0.0150 | 0.0249 | -0.2317 | -0.2199 | -0.2285 |
| <i>TPS_CallsPC</i> | 0.0660 | -0.2266 | -0.1966 | -0.1688 | 0.1212 | 0.0659 | -0.0078 |
| <i>TPS_RetPrepPC</i> | 0.1334 | 0.1728 | -0.2289 | -0.2525 | 0.0374 | -0.3479 | -0.4997 |
| <i>Singles</i> | 0.1898 | 0.3968 | -0.4945 | -0.5387 | 0.1767 | -0.3651 | -0.4395 |
| <i>Under30</i> | 0.0879 | -0.2019 | -0.3657 | -0.1524 | 0.4467 | 0.2479 | 0.1571 |
| <i>Over64</i> | -0.1797 | 0.0840 | 0.2587 | 0.0136 | -0.1608 | -0.0413 | -0.2380 |
| <i>PCBirths</i> | 0.1001 | -0.1204 | -0.0620 | 0.2358 | 0.0099 | 0.0368 | 0.3181 |
| <i>UnemplRate</i> | -0.1918 | 0.0234 | -0.0560 | -0.1274 | 0.1799 | -0.0771 | -0.1498 |
| <i>Ln(NetTaxRate)</i> | -0.2386 | -0.2136 | 0.7402 | 0.7123 | -0.5676 | -0.0413 | 0.3174 |
| | | | | | | | |
| | <i>solep~fs</i> | <i>Paidprep</i> | <i>lpaudi-1</i> | <i>lirp1</i> | <i>lcid1</i> | <i>tps_ca~c</i> | <i>tps_re~c</i> |
| <i>soleproptfs</i> | 1.0000 | | | | | | |
| <i>paidprep</i> | 0.2933 | 1.0000 | | | | | |
| <i>lpauditrate1</i> | -0.0839 | 0.0395 | 1.0000 | | | | |
| <i>lirp1</i> | 0.1817 | -0.0907 | -0.4619 | 1.0000 | | | |
| <i>lcid1</i> | -0.0512 | 0.0375 | -0.2619 | 0.2249 | 1.0000 | | |
| <i>tps_callspc</i> | 0.0770 | -0.0634 | 0.1825 | -0.1441 | 0.1011 | 1.0000 | |
| <i>tps_retpre~c</i> | -0.5215 | -0.2695 | -0.0098 | 0.0882 | -0.0340 | -0.1757 | 1.0000 |
| <i>Singles</i> | -0.2598 | -0.2385 | -0.0733 | 0.4592 | 0.1185 | 0.0982 | 0.2838 |
| <i>under30</i> | 0.1016 | 0.0592 | 0.4043 | -0.2080 | -0.2881 | 0.2670 | 0.0123 |
| <i>over64</i> | -0.2472 | 0.1244 | 0.0127 | -0.0574 | 0.1009 | -0.2715 | 0.0839 |
| <i>Pcbirths</i> | 0.3031 | 0.1523 | -0.0144 | -0.2037 | -0.0886 | 0.2619 | -0.3681 |
| <i>unemplrate</i> | -0.2800 | -0.0933 | 0.3889 | -0.6703 | -0.1211 | -0.0246 | 0.0439 |
| <i>lnnettaxrate</i> | 0.3163 | 0.2610 | -0.5525 | 0.1502 | 0.1781 | -0.2139 | -0.3145 |
| | | | | | | | |
| | <i>singles</i> | <i>under30</i> | <i>over64</i> | <i>pcbirths</i> | <i>unempl~e</i> | <i>lnetta~e</i> | |
| <i>Singles</i> | 1.0000 | | | | | | |
| <i>under30</i> | 0.1110 | 1.0000 | | | | | |
| <i>over64</i> | -0.1563 | -0.5045 | 1.0000 | | | | |
| <i>Pcbirths</i> | -0.1543 | 0.3566 | -0.4543 | 1.0000 | | | |
| <i>Unemplrate</i> | -0.2915 | 0.0329 | 0.0992 | -0.0336 | 1.0000 | | |
| <i>Lnnettaxrate</i> | -0.3498 | -0.4317 | 0.2031 | 0.0095 | -0.2455 | 1.0000 | |

To improve the estimation result, selected variables that show symptoms of pairwise correlation are excluded. *FThresholdPct*, *ChildExemptsPct*, *Ln(AvgBurden)*, and *Ln(IRP+1)* are excluded because the estimated coefficients of these variables are insignificant.

Modification 1: Exclude FThresholdPct, ChildExemptsPct, Ln(AvgBurden), Ln(IRP+1)

Some improvements are noted in the estimation result. The R^2 is still very high (0.99). Estimated coefficient of $\ln(\text{NetTaxRate})$ is positive and smaller (1.23). However, it is still insignificant (the t-value is 0.51).

The estimated coefficients of the *FilingRate*, $\ln(\text{PI})$, *PaidPrep*, *Singles*, *PCBirths*, and *UnemplRate* are more significant.

The estimated coefficient of the audit rate is positive, but still insignificant (the t-value is 0.70). The estimated coefficients of *StateTaxPct* and *Over64* are highly insignificant.

Modification 2: Exclude *StateTaxPct* and *Over64* variables, whose estimated coefficients are insignificant. There is much improvement in the estimation result from this modification. The R^2 is very high (0.99) and the estimated coefficient of $\ln(\text{NetTaxRate})$ is positive and smaller (0.75).

The estimated coefficients of the most explanatory variables are more significant: *FilingRate*, $\ln(\text{PI})$, *SoleProps*, *SolePropTFS*, *PaidPrep*, *TPS_RetPrepPC*, *Under30*, *PCBirths*, and *UnemplRate*.

The estimated coefficient of the audit rate variable is positive, but still insignificant (the t-value is 0.75). Comparing the two modifications, it appears that modification 2 yields better results.

4.2.3.2. Estimations Results with Income Definition B

Basic specification: The estimation result is similar to the result of definition A. The estimated coefficient of $\ln(\text{NetTaxRate})$ is positive, smaller (2.2), and insignificant.

Modification 2: The R^2 is still very high (0.99). The estimated coefficient of $\ln(\text{NetTaxRate})$ is positive and much smaller (0.33). However, it is still insignificant (the t-value is 0.14). The variables whose estimated coefficients are more significant include *FilingRate*, $\ln(\text{PI})$, *SoleProps*, *SolePropTFS*, *PaidPrep*, $\ln(\text{CID}+1)$, *TPS_RetPrepPC*, *Under30*, *PCBirths*, and *UnemplRate*. The estimated coefficient of the audit rate is positive and more significant.

The implied estimate of ETI (0.33) is very close to the estimate of ETI in the current ETI literature. Saez et al (2009) suggests that the most reliable longer-run estimates of ETI range from 0.12 to 0.40.

4.2.3.3. Estimation results with income definition C

Basic specification: The estimation result is almost the same as the result of definitions A and B. The estimated coefficient of $\ln(\text{NetTaxRate})$ is smaller (1.2), but still insignificant.

Modification 2: Estimated coefficient of $\ln(\text{NetTaxRate})$ becomes negative (-1.94). There are more variables with insignificant estimated coefficients. This is because definition C includes all

income and offset items regardless of changes of tax rules. Therefore, excluding variables that control for changes of tax rules may result in a less accurate estimation.

A remark: The estimation results for ETI are not very significant; they have large standard errors. This may come from a collinear problem between year dummies and the net-of-tax rate.⁸³

4.2.4. Findings

This section presents some quantitative results regarding the effects of tax rate and a large set of factors on the reported taxable income, which is expressed in terms of Net Income variable. This set of quantitative results comes from the modified specification 2 (income definition B).⁸⁴ The modification 2 excludes some relatively uninteresting explanatory variables and the insignificant ones. These variables include *FthresholdPct*, *ChildExemptsPct*, *StateTaxPct*, *Ln(AvgBurden)*, *Ln(IRP+1)*, and *Over64*.

This set of quantitative results provides an overall picture of the quantitative effects of the whole set of environmental factors on the reported taxable income. Modification 2 is the most appropriate specification of this study because its estimation results are more significant and very close to the empirical results of the current tax compliance and ETI literature.⁸⁵

Filing rate: The estimated coefficient of *FilingRate* is 0.003. It is positive and significant (at 1% level). It shows the positive effect of Filing Rate on Net Income.

Ln(PI): Estimated coefficient of *Ln(PI)* is 1.05. It is positive and highly significant (at 1% level). It confirms a dominant positive effect of Personal Income on Net Income.

Tax policy factors:

Marginal Tax Rate: the estimated coefficient of *Ln(NetTaxRate)* is 0.33. This result is very close to the empirical result of the ETI estimation in the current ETI literature. The definition B of Net Income is almost identical to the definitions of taxable income used in the ETI literature.

Burden/Opportunity factors:

Sole Proprietors: the estimated coefficient of *SoleProps* is 0.05. It is positive and significant (the p-value is 0.002). It confirms the positive effect of Sole Proprietors rate on Net Income.

Interaction factor between Sole Proprietors and percentage of employment in Trade/Finance/Services sectors: the estimated coefficient of *SolePropTFS* is -0.001. It is negative and significant (the p-value is 0.001). It confirms the negative effect of this factor on Net Income.

⁸³ In the same specifications with no year dummy variables, I obtain estimation results for ETI that are very significant (small robust standard errors) but have wrong signs (negative). This suggests that the year dummies are needed.

⁸⁴ Appendix B presents the quantitative results of the basic specification with income definition A.

⁸⁵ See Plumley (1996), Saez et al. (2009).

Paid Practitioners: The estimated coefficient of *PaidPrep* is -0.0035. It is negative and very significant (the p-value is 0.001). It confirms the negative effect of this factor on Net Income.

IRS enforcement factors:

Audit rate: the estimated coefficient of $\ln(p\text{AuditRate}+1)$ is 0.16. It is positive and insignificant (the p-value is 0.28). However, it confirms the positive effect of Audit Rate on Net Income.

Criminal Investigation Division (CID): the estimated coefficient of $\ln(\text{CID}+1)$ is positive and significant (at 5% level). It confirms the positive effect of criminal conviction rate on Net Income.

IRS responsiveness factors:

Taxpayer Service (TPS) telephone calls: the estimated coefficient of *TPS_CallsPC* is -0.00006. It is very small, negative, and insignificant (the p-value is 0.31). It suggests that the effect of TPS telephone calls is not significant at all on Net Income.

Returns prepared by TPS: the estimated coefficient of *TPS_RetPrepPC* is 0.003. It is positive and significant (at 8% level). It may confirm the positive effect of this factor on Net Income.

Demographic/Economics factors:

Marital status: The estimated coefficient of *Singles* is 0.002. It is positive but insignificant (the p-value is 0.21).

Age: the estimated coefficient of *Under30* is -0.003. It is negative and significant (at 4% level). It confirms that younger people would report lower Net Income.

Birth rate: the estimated coefficient of *PCBirths* is 0.012. It is positive and very significant (the p-value is 0.004). It confirms that the rate of birth has a positive effect on Net Income.

Unemployment rate: the estimated coefficient of *UnemplRate* is -0.01. It is negative and significant (at 1% level). It confirms that Unemployment Rate has a negative effect on Net Income.

4.3. Conclusion

Reviewing the empirical studies of taxpayer compliance provides helpful instructions to construct a suitable empirical framework to estimate effects of tax rate and other factors on the reported taxable income. The data set and the empirical specification in Plumley (1996) are appropriate for the purpose of this analysis.

The key finding of this dissertation is that the empirical framework from the taxpayer compliance perspective can be used to estimate the ETI. Particularly, the modified specification

2 with the income definition B provides an estimated ETI of 0.33, which is close to the estimated ETI in the current ETI literature.

In addition, this approach accounts for a more complete set of explanatory variables which determine the taxable income response. This set of variables includes tax policy variables, enforcement variables, total income, tax burden and opportunities, and other demographic and economic variables. Therefore, this framework can be used to quantify the effects of all these factors on the reported taxable income. It also provides a meaningful explanation of the effects of different factors on the reported taxable income.

The estimation results suggest that the reported taxable income will increase with an increase in Filing Rate or Personal Income. The increase in factors such as *SolePropTPS* and Paid Practitioner would give the taxpayers more opportunities to avoid tax, so they may reduce further the reported taxable income.

The effect of net-of-tax rate on the reported taxable income is positive; however, it is insignificant. Audit rate has a positive effect on the reported taxable income, but it is also insignificant.

The conviction rate and the Taxpayer Service for preparing returns would have small positive effects on the reported taxable income.

The taxpayers who are single or older than 30 seem to report higher taxable income than those who are married or younger than 30. The taxpayers who live in an area with higher birthrate and lower unemployment rate seem to report higher taxable income than those who live in an area with a lower birthrate and higher unemployment.

The results in this chapter suggest a new approach to ETI estimation. This approach may have some advantages over the traditional approaches of the ETI literature because it uses aggregated panel data, rather than individual tax return panel data. First, this estimation framework yields a more meaningful explanation regarding the effects of tax rate and other nontax factors on the reported taxable income. Second, by using aggregated panel data at state level, this approach can use Personal Income to control for nontax-induced changes of the taxable income. Personal Income (BEA) is quite independent on reported Net Income. Therefore, Personal Income can control for income distribution trends effectively. In addition, using the state-aggregated data also helps reduce the mean reversion problem of the individual tax return data.

This new approach also suggests new instruments to address problem of tax rate endogeneity. Under this estimation framework, *MTR@15K*, *MTR@50K*, *MTR@57K*, and *MTR@85K* are used as instruments for the average marginal tax rate. The empirical regressions provide evidence for validity of these instruments.

5. Studying the Functional Form of the Elasticity of Tax Evasion and Avoidance Behavior

The theoretical framework in Chapter 3 suggests that the ETI consists of three components, corresponding to three types of taxable income responses: a substitution response, tax evasion, and tax avoidance.

The principal form of substitution response of taxable income is the substitution of leisure for labor. Slemrod (1998a) points out that, in the standard labor supply model, the behavioral elasticity (i.e., the substitution response) depends entirely on taxpayers' preferences.⁸⁶

The theoretical models of tax evasion and tax avoidance (in Chapter 3) provide valuable foundations for studying the functional form of the elasticity of tax evasion and tax avoidance behavior.

The review of ETI literature suggests that there has been a lack of inquiry into the functional form of the ETI. This chapter attempts to fill this gap by studying the functional forms of the elasticity of tax evasion and avoidance behavior as well as factors that determine those functions. The chapter studies behavior of the elasticity function, using the empirical data on the function's arguments.

5.1. The Functional Form of the Elasticity of Tax Evasion and Avoidance Behavior

I start my investigation of functional form of the elasticity of tax evasion and avoidance behavior with the basic formula for the ETI.

$$(5.1) \quad ETI = \frac{\partial TI}{\partial(1-t)} \frac{1-t}{TI} = -\frac{\partial TI}{\partial t} \frac{1-t}{TI};$$

where TI is the taxable income, and t is the marginal tax rate.

The term $\frac{\partial TI}{\partial t}$ needs to be defined to identify the form of the ETI function. The term $\frac{\partial TI}{\partial t}$ is the first-order derivative of taxable income with respect to marginal tax rate. Chapter 3 shows that the AS model and Alm model yield specific expressions for $\frac{\partial X}{\partial t}$, where X is declared income or reported taxable income of the taxpayer. The expressions of $\frac{\partial X}{\partial t}$ in the AS model and the Alm model can be used to derive specific functional forms of the elasticity of tax evasion and avoidance behavior

⁸⁶ Slemrod (1998a), p. 778.

5.1.1. AS Model⁸⁷

In this model, Allingham and Sandmo consider only evasion behavior. That is, the model addresses the extent to which a taxpayer avoids taxes by deliberate underreporting. This model, therefore, can be used to study the functional form of the elasticity of tax evasion behavior.

Allingham and Sandmo assume that the probability of detection and penalty rate are exogenous variables, which are independent of income the taxpayer reports. They also assume that the taxpayer is risk averse and that marginal utility is everywhere positive and strictly decreasing.

Allingham and Sandmo derive the following equation⁸⁸:

$$(5.2) \frac{\partial X}{\partial \theta} = -\frac{1}{D} X [\theta(1-p)U''(Y) + (\theta - \pi)pU''(Z)] + \frac{1}{D} [(1-p)U'(Y) + pU'(Z)],$$

where

- X is the declared income, which is equivalent to taxable income
- θ is the marginal tax rate (which is identical to t)
- p is the probability that the taxpayer will be subjected to investigation by the tax authorities
- W is a fixed amount of actual income of the taxpayer
- π is the penalty rate on the undeclared amount ($W-X$), which is higher than the marginal tax rate θ
- $Y = W - \theta X$
- $Z = W - \theta X - \pi(W - X)$
- $D = \theta^2(1-p)U''(Y) - (\theta - \pi)^2 p U''(Z)$

To derive the function form of the elasticity of declared income (X) with respect to the net-of-tax rate (holding true taxable income constant), we need a specific functional form of the utility function $U(Y)$. In the AS model, the utility function is understood as an indirect utility function with constant prices, which has income as its only argument and has marginal utility everywhere positive and decreasing with income.⁸⁹

I assume that the marginal utility is an exponential function of the following form:

$$(5.3) U'(Y) = Y^{\beta-1} > 0, \text{ and}$$

$$(5.4) U''(Y) = (\beta - 1)Y^{\beta-2} < 0.$$

⁸⁷ The ASY model can be considered to study the functional form of the elasticity of tax evasion behavior. In the ASY model, the penalty for discovered evasion depends on the tax on unreported income rather than on the amount of income that was underreported. As a result, this model implies that the term $\frac{\partial X}{\partial t} > 0$. It suggests that the elasticity of declared income is negative.

⁸⁸ Allingham and Sandmo (1972), p.329.

⁸⁹ Allingham and Sandmo (1972), p.324.

It is required that $\beta < 1$ for $U'' < 0$.

For $\beta \neq 0$, the indirect utility function has the form:

$$(5.5) U(Y) = \frac{1}{\beta} Y^\beta.$$

For $\beta = 0$, the indirect utility function has the form:

$$(5.6) U(Y) = \ln(Y).$$

Denote the elasticity of declared income with respect to the net-of-tax rate by EDI. From (5.1) and (5.2), we can derive formula for the EDI as follows:

$$(5.7) EDI = -\frac{\partial X}{\partial t} \frac{1-t}{X} = -\frac{1-t}{X} \left\{ -\frac{1}{D} X [t(1-p)U''(Y) + (t-\pi)pU''(Z)] + \frac{1}{D} [(1-p)U'(Y) + pU'(Z)] \right\}.$$

Now, we have:

$$(5.8) U'(Y) = U'(W - tX) = (W - tX)^{\beta-1}.$$

$$(5.9) U'(Z) = U'[W - tX - \pi(W - X)] = [W - tX - \pi(W - X)]^{\beta-1}.$$

$$(5.10) U''(Y) = U''(W - tX) = (\beta - 1)(W - tX)^{\beta-2}.$$

$$(5.11) U''(Z) = U''[W - tX - \pi(W - X)] = (\beta - 1)[W - tX - \pi(W - X)]^{\beta-2}.$$

Plugging the expressions (5.8) – (5.11) into (5.7), we get the following form of the EDI function:

$$(5.12) EDI = \frac{\Sigma_1}{\Sigma_2},$$

where,

$$\Sigma_1 = (1-t) \{ t(1-p)(\beta-1)X(W-tX)^{\beta-2} + (t-\pi)p(\beta-1)X[W-tX-\pi(W-X)]^{\beta-2} - (1-p)W-tX\beta-1-pW-tX-\pi W-X\beta-1,$$

$$\Sigma_2 = (\beta-1)X \{ t^2(1-p)(W-tX)^{\beta-2} + (t-\pi)^2 p [W-tX-\pi(W-X)]^{\beta-2} \}.$$

Looking at the function (5.12), we see that the general functional form of the EDI is

$$(5.13) EDI = f(p, \pi, t, W, X; \beta).$$

where:

- p, π, t are tax regime variables (p is the probability of detection, π is the penalty rate, and t is the marginal tax rate)

- W and X are income variables (W is the actual income, X is the declared income or tax base)
- β is a risk preference parameter

Remark: Because the actual income (W) in the AS model is an exogenous variable (W is a fixed amount of income), the EDI function does not include the substitution response component of the taxable income. The EDI function accounts only for one component of the taxable income responses - tax evasion.

5.1.2. Alm Model

Alm (1988a) develops a model in which avoidance and evasion are jointly selected. This model can be used to study the functional form of the elasticity of both tax evasion and avoidance behavior.

In the Alm model, the individual is allowed to choose the amounts of a fixed endowment of income to allocate among taxable, avoidance, and evasion income, where taxable income is subject to taxes, evasion to penalties if detected, and avoidance to tax shelter or compliance costs.

The individual is assumed to have a fixed amount of income I that he can allocate between legal income L and evasion income E .

Legal compensation L can be allocated between reported, or taxable, income and avoidance income. The share of taxable income in L is denoted s , and the avoidance share is $(1-s)$. Reported income is subject to a progressive income tax $T(\cdot)$, where $T' > 0$ and $T'' > 0$. There are costs incurred with tax avoidance, represented by $C(\cdot)$. It is assumed that the marginal cost of avoidance is positive and increasing, or $C' > 0$ and $C'' > 0$.

For evasion income, the individual is audited by the tax authorities with a fixed probability π , at which point all of E is detected and the individual is penalized an amount equal to $P(\cdot)$. It is assumed that $P' > 0$ and $P'' > 0$.

If the individual is detected evading, which happens with probability π , his income I_D is:

$$(5.14) \quad I_D = I - T(sL) - C((1-s)L) - P(E) \equiv Z.$$

If the individual is not detected, his income I_N is:

$$(5.15) \quad I_N = I - T(sL) - C((1-s)L) \equiv Y,$$

$$\text{for } I = sL + (1-s)L + E = L + E \equiv W.$$

It should be noted that I_D , I_N , and I are identical to Z , Y , and W in the AS model, respectively.

The individual's behavior is assumed to satisfy the Von Neumann – Morgenstern axioms. He maximizes an expected utility function $E(U)$ such that:

$$(5.16) \max_{L,s} \phi = E(U) = \pi U(I_D) + (1 - \pi)U(I_N).$$

It is assumed that $U' > 0$ and $U'' < 0$.

Alm derives the derivative of taxable income with respect to marginal tax rate:

$$(5.17) \frac{\partial X}{\partial \tau} = eL \left[sLC''(R_A(I_D) - R_A(I_N)) - (P' - C')R_A(I_D) - C'R_A(I_N) - \frac{P' - C''}{P' - C'} - \frac{P''}{P' - C'} \right]$$

where:

X is taxable income, which is equal to sL ;

τ is the marginal tax rate ($\equiv t$);

$$e \equiv \frac{ab}{d}L(P' - C');$$

$$a \equiv \pi U'(I_D);$$

$$b \equiv \pi U'(I_D) + (1 - \pi)U'(I_N);$$

$$d \equiv \phi_{LL}\phi_{ss} - (\phi_{Ls})^2;$$

$$\phi_{LL} = \frac{\partial \phi_L}{\partial L} = \pi U''(I_D)(P' - C')^2 + (1 - \pi)U''(I_N)(C')^2 - aP'' - b[s^2T'' + (1 - s)^2C''];$$

$$\phi_{ss} = \frac{\partial \phi_s}{\partial s} = -bL^2(T'' + C'');$$

$$\phi_{Ls} \equiv \frac{\partial \phi_L}{\partial s} = bL[-sT'' + (1 - s)C''];$$

From (5.30), the elasticity of taxable income (ETI) will take the form:

$$(5.18) ETI = -\frac{1-t}{X} \frac{\partial X}{\partial t} = -\frac{1-t}{X} eL \left[sLC''(R_A(I_D) - R_A(I_N)) - (P' - C')R_A(I_D) - C'R_A(I_N) - \frac{P' - C''}{P' - C'} - \frac{P''}{P' - C'} \right]$$

To derive a specific form of the ETI function, we need to have a specific form for the indirect utility function $U(\cdot)$, the avoidance cost function $C(\cdot)$, the penalty function $P(\cdot)$, and the income tax function $T(\cdot)$. For illustration and simplicity, let us assume the following specific forms of $U(\cdot)$, $C(\cdot)$, $P(\cdot)$, and $T(\cdot)$.

- For the indirect utility function, we assume the marginal utility function $U'(Y) = Y^{1-\beta}$ as above.

- For the avoidance cost function, we use the functional form in Slemrod (1998b).⁹⁰ For simplicity, we assume the avoidance cost function takes the form $C(A) = \gamma A^2$, where A is the amount of tax avoidance. If $A=L-X$, then $C'(A) = 2\gamma A > 0$ and $C''(A) = 2\gamma > 0$ (i.e., $\gamma > 0$).
- For the penalty function, we assume P is an exogenous variable such that $P'=0$ and $P''=0$ ($P \equiv F$).
- For the income tax function, we assume that $T(X) = tX - G$, where G is a constant government transfer. Then $T' = t$ and $T'' = 0$.

Now, we have

$$(5.19) Y = I_N = I - T(sL) - C((1-s)L) = W - tX + G - \gamma(L-X)^2,$$

$$(5.20) Z = I_D = I - T(sL) - C((1-s)L) - P(E) = W - tX + G - \gamma(L-X)^2 - F.$$

$$(5.21) \frac{\partial X}{\partial t} = eL[sLC''(R_A(Z) - R_A(Y)) + C'R_A(Z) - C'R_A(Y)].$$

$$(5.22) e \equiv \frac{ab}{d} L(P' - C') = -\frac{ab}{d} LC' = -\frac{\pi U'(Z)[\pi U'(Z) + (1-\pi)U'(Y)]LC'}{\phi_{LL}\phi_{ss} - (\phi_{Ls})^2}.$$

Then, we can derive

$$e = \frac{\pi(L-X)U'(Z)}{4\gamma^2 L[\pi U''(Z) + (1-\pi)U''(Y)]}.$$

Define $\Delta = L[sLC''(R_A(Z) - R_A(Y)) + C'R_A(Z) - C'R_A(Y)]$. Then $\frac{\partial X}{\partial t} = e\Delta$.

We can derive

$$\Delta = \frac{2\gamma(1-\beta)FL^2}{YZ};$$

Then,

$$\frac{\partial X}{\partial t} = e\Delta = \frac{(1-\beta)\pi FL(L-X)U'(Z)}{2\gamma YZ[\pi U''(Z) + (1-\pi)U''(Y)]}.$$

Now we can derive the ETI function as follows

$$(5.23) ETI = \frac{\Sigma_3}{\Sigma_4},$$

where,

⁹⁰ Slemrod (1998b) considers an avoidance cost function of the form $C = \alpha \left(\frac{A}{wL}\right) A$, where A is the amount of avoidance, w is the wage rate, and L is the number of working hours.

$$\Sigma_3 = \pi F(1 - t)L(L - X)[W - tX + G - \gamma(L - X)^2 - F]^{\beta-2},$$

$$\Sigma_4 = 2\gamma X[W - tX + G - \gamma(L - X)^2]\{\pi[W - tX + G - \gamma(L - X)^2 - F]^{\beta-2} + (1 - \pi)[W - tX + G - \gamma(L - X)^2]^{\beta-2}\}.$$

The general ETI function has following form:

$$(5.24) \text{ETI} = f(\pi, F, t, W, L, X; \beta, \gamma, G).$$

In this case,

- π, F, t are tax regime variables
- W, L, X are income variables (where W is actual income, L is legal (declared) income, and X is taxable income)
- β is the parameter of the taxpayer's risk preference
- γ is the parameter of the tax avoidance cost
- G is the parameter of the tax regime.

Remark: As in the case of the AS model, the ETI function derived in this section does not account for substitution response of the taxable income. This ETI function accounts for only the tax evasion and avoidance responses.

5.1.3. Summary

The AS model considers only the evasion behavior of taxpayer. From this model, I derived a specific form of the EDI function, where EDI is a function of the tax regime variables (probability of detection, penalty rate, and income tax rate) and the income variables (total actual income and declared income). Further, the EDI function is determined by the risk preference parameter. The EDI function accounts for only evasion component of the taxable income responses. It does not include the substitution and tax avoidance response of the taxable income.

The Alm model considers both evasion and avoidance behavior. From this model, I derived the way in which the ETI is a function of tax regime variables (probability of detection, penalty rate, and income tax rate) and income variables (total actual income, legal income, and taxable income). The ETI function is also determined by the risk preference parameter, the tax avoidance cost parameter, and the tax regime parameter (government transfer). The ETI function derived from the Alm model accounts for only tax evasion and avoidance responses of taxable income, and not the substitution response.

5.2. Studying the Behavior of the EDI Function

This section studies the EDI function by applying the specific form of the EDI function derived in section 5.1. The functional form derived from the Alm model is much more complicated to

study. It requires information about parameters of the tax avoidance cost function, the penalty function, as well as the income tax function.

By using the empirical data on the EDI function's arguments, I examine how the EDI changes with variations in each argument as well as the risk preference parameter (β).

5.2.1. The EDI Function for Calculation

From the AS model, I obtain a specific form of the ETI function as follows:

$$(5.12) \text{ETI} = \frac{\Sigma_1}{\Sigma_2},$$

where,

$$\Sigma_1 = (1-t)\{t(1-p)(\beta-1)X(W-tX)^{\beta-2} + (t-\pi)p(\beta-1)X[W-tX-\pi(W-X)]^{\beta-2} - (1-p)W-tX\beta-1-pW-tX-\pi W-X\beta-1,$$

$$\Sigma_2 = (\beta-1)X\{t^2(1-p)(W-tX)^{\beta-2} + (t-\pi)^2p[W-tX-\pi(W-X)]^{\beta-2}\}.$$

Define $s = \frac{X}{W}$ as the voluntary income reporting rate, I derive the EDI function as follows

$$(5.12') \text{EDI} = \frac{(1-t)\{st(1-p)(\beta-1)(1-ts)^{\beta-2} + sp(t-\pi)(\beta-1)[1-ts-\pi(1-s)]^{\beta-2} - (1-p)(1-ts)^{\beta-1} - p[1-ts-\pi(1-s)]^{\beta-2}\}}{s(\beta-1)\{t^2(1-p)(1-ts)^{\beta-2} + p(t-\pi)^2[1-ts-\pi(1-s)]^{\beta-2}\}}.$$

The EDI depends on values of t , p , π , s , and β . The EDI does not depend on actual income (W) and reported income (X), but only on the voluntary income reporting rate s .

5.2.2. Empirical Values for the EDI function's Arguments

To calculate the EDI, we should have empirical values of the arguments t , p , π , and s .

Marginal tax rate (t):

Table 5-1 Average Marginal Tax Rates, Individual Personal Income, 1979-1990

| | | | | | | |
|-----------------------|------|------|------|------|------|------|
| <i>Year</i> | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 |
| <i>Average MTR(%)</i> | 29.2 | 30.7 | 31.7 | 29.2 | 27.4 | 27 |
| <i>Year</i> | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
| <i>Average MTR(%)</i> | 27.3 | 27.3 | 24.5 | 22.9 | 23.1 | 23.1 |

Note: Marginal income tax rate is a weighted average of marginal tax rates on earned income and other income

Source: Saez (2004), Table A.

Saez (2004) provides the empirical data on average marginal tax rate of the U.S. in period 1960-2000 (Table A, column 10). Table 5.1 shows the empirical data on average marginal tax rates in the U.S. in period 1979-1990.⁹¹

The probability of detection (p):

The probability of detection can be represented by the audit rate for individual tax returns. The audit rates can be calculated by using the data from the IRS’s annual reports from 1980-1992.

Dubin et al. (1990a) provides estimates of the total audit coverage of individuals in the period 1978-1988. The total audit coverage of individuals declined from an audit rate of about 2% in 1978 to 1% in 1988.

Using data from the IRS’s annual reports from 1979-1990, I have calculated the audit rates of individuals for the period 1979-1990 in Table 5.2.⁹²

Table 5-2 Individual Audit Rates, 1979-1992

| | | | | | | |
|-------------------|-------------------|-------------------|--------|--------|--------|--------|
| <i>Year</i> | 1979 ^a | 1980 | 1981 | 1982 | 1983 | 1984 |
| <i>Audit rate</i> | 0.021 | 0.0202 | 0.0177 | 0.0152 | 0.0150 | 0.0126 |
| <i>Year</i> | 1985 ^a | 1986 ^a | 1987 | 1988 | 1989 | 1990 |
| <i>Audit rate</i> | 0.013 | 0.011 | 0.0108 | 0.0099 | 0.0089 | 0.0078 |

Note: a) Rounded estimates from Dubin et. al. (1990a), Graph 3, p.899.

Source: IRS’s annual reports, 1980-1990.

Fine rate (π):

Dubin et al. (1990a) provides rough estimates of the average penalty rates assessed by examinations for individuals from 1979-1988.⁹³

Table 5-3 Average Net Penalty Rates, Individuals, 1979-1988

| | | | | | | | | | | |
|------------------------|------|------|------|------|------|------|------|------|------|------|
| <i>Year</i> | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 |
| <i>Percent penalty</i> | 2% | 3% | 2.6% | 3.4% | 5% | 5.2% | 6% | 9% | 11% | 14% |

Sources: Dubin et al. (1990a), Graph 10, p. 905, rounded estimates.

In the AS model, the fine rate is imposed on the amount of evasion income. Therefore, the fine rate can be defined as: $\pi = \text{tax rate} + \text{penalty rate}$.

⁹¹ I calculated average marginal tax rate of the U.S. in the period 1982 – 1991 using Plumley’s data set. My calculated average marginal tax rates are lower than Saez’s figures. For example, my calculated average marginal tax rates were 22.2% in 1979, 22.0% in 1982, 19.7% in 1985, and 17.8% in 1988.

⁹² $\text{Audit rate} = \frac{\text{Number of Returns Examined}}{\text{Number of Returns Filed}}$

⁹³ To construct the civil penalty rates, Dubin et. al (1990a) use data from the *Annual Report of the Commissioner of Internal Revenue, 1978-88* and *Report on the Commissioner’s Task Force on Penalties*. They also use some information obtained directly from the IRS. Dubin et al. argue that the available data are inexact, so the specific estimates should be viewed cautiously.

Voluntary income reporting rate (s):

Bennett (2005) notes that the IRS uses a variety of measures to describe the accuracy of information reported by taxpayers on their tax returns. The measures included, among others, Voluntary Reporting Rate (VRR) and Voluntary Compliance Level (VCL), Voluntary Reporting Percentage (VRP) and Net Misreporting Percentage (NMP), and Voluntary Compliance Rate (VCR) and Noncompliance Rate (NCR).

VCL and VRR are the IRS's reporting compliance measures. VCL had been developed by the TCMP every three years in the period of 1962-1988. VRR has developed by the National Research Program since 2001. These two measures are very close.

VCL measures the amount of tax liability reported voluntarily by taxpayers as a percentage of corrected tax liability as determined by TCMP examination.

The equation for VCL is

$$VCL = \frac{\text{Total tax reported on timely filed returns}}{\text{Total tax reported} + \text{Estimate of tax underreported}} \times 100.$$

VRR is defined as the percentage of the total tax required to be reported that taxpayers voluntarily reported on their timely-filed returns. The equation for VRR is

$$VRR = \frac{\text{Total tax reported on timely filed returns}}{\text{Total tax reported} + \text{Estimate of tax misreported}} \times 100,$$

where the amount misreported is the net value of the amounts underreported and amounts overreported.

VRR is considered a more appropriate measure of income reporting compliance than VCL because it does not disregard overreporting of tax liability.

Regarding other compliance measurements, Voluntary Reporting Percentage (VRP) and Net Misreporting Percentage (NMP) are both measures of reporting accuracy for a particular return line item. The Voluntary Compliance Rate (VCR) and Noncompliance Rate (NCR) are measures associated with tax gap estimates. They are more comprehensive measures of compliance, which include filing compliance, reporting compliance, and payment compliance.

VRR can be considered as an approximate measure of the income reporting compliance rate $s = \frac{X}{W}$, where X is the taxpayer's declared income and W is the taxpayer's actual total income.⁹⁴

⁹⁴ At the aggregate level, the total tax reported should equal to the total income reported (X) times the average tax rate, the total actual tax be collected should equal to the total actual income (W) times the average tax rate. Therefore, at the aggregate level,
$$VRR = \frac{\text{Total Tax Reported}}{\text{Total Actual Tax be Collected}} = \frac{\text{Total Income Reported} \times \text{Average Tax Rate}}{\text{Total Actual Income} \times \text{Average Tax Rate}} = \frac{\text{Total Income Reported}}{\text{Total Actual Income}} = \frac{X}{W}.$$

Bennett (2005) provides the empirical estimates of VRR for the tax years 1979, 1982, 1985, 1988, and 2001 (Table 5.4).

Table 5-4 *Voluntary Reporting Rate (VRR) – Individual Income Tax Returns*

| <i>Tax Year</i> | <i>VRR</i> |
|-----------------|------------|
| 1979 | 91.6% |
| 1982 | 92.7% |
| 1985 | 92.0% |
| 1988 | 93.2% |
| 2001 (NRP) | 92.4% |

Source: Bennett (2005), Table 3, p5.

Taxpayer’s risk preference parameter (β):

The marginal utility function is assumed to be everywhere positive and decreasing in the income argument Y . Therefore, the assumed value of β should satisfy $\beta < 1$.

The empirical studies of the risk preference parameter of the indirect utility function suggest that the value of risk preference parameter is greater than minus one in most the cases.⁹⁵ In the next section, I assume that the value of risk preference parameter β lies in the range of $(-1, 1)$.

5.2.3. Studying Behavior of the EDI function

I have a set of empirical values in Table 5.5 that is used to calculate the EDI function.

Table 5-5 *Empirical Values for the EDI Function*

| <i>Tax Year</i> | <i>s</i> | <i>t</i> | <i>p</i> | <i>π</i> | <i>β</i> |
|-----------------|----------|----------|----------|-------------------------|---------------------------|
| 1979 | 0.916 | 22.22% | 0.0210 | 31.39% | $(-1, 1)$ |
| 1982 | 0.927 | 21.97% | 0.0152 | 32.62% | $(-1, 1)$ |
| 1985 | 0.920 | 19.74% | 0.0130 | 33.27% | $(-1, 1)$ |
| 1988 | 0.932 | 17.81% | 0.0099 | 36.92% | $(-1, 1)$ |

The calculations of EDI, using the empirical data of the function’s arguments in the years 1979, 1982, 1985, and 1988, suggest that the value of EDI is not sensitive to variation of the risk preference parameter (β) in the year 1982. Table 5.6 shows that the EDI is almost constant (about 4.8) for the value of β in the range of $(-1, 0.1)$, and the EDI lies in the range of $(4.8, 5.2)$ for the value of β in the range of $(-1, 0.8)$.⁹⁶

This result suggests that the empirical data in the year 1982 are the most appropriate ones for studying the behavior of the EDI function when varying each of the arguments of the function. In

⁹⁵ Houthakker (1960), Parks (1969), Akin and Stewart (1979), and Goldberger (1987).

⁹⁶ The high values of the calculated EDIs (about 5) suggest that only a small proportion of the taxpayer population behave strategically.

the rest of this section, I use the empirical data in the year 1982 and assign to the risk preference parameter (β) a constant value of -0.5^{97} to study behavior of the EDI function.

Table 5-6 *The AS Model - Calculation Results in 1982*

| <i>Year</i> | <i>s</i> | <i>t</i> | <i>p</i> | π | β | <i>EDI_AS</i> |
|-------------|----------|----------|----------|--------|---------|---------------|
| 1982 | 0.927 | 0.2922 | 0.0152 | 0.3262 | -1 | 4.780308 |
| 1982 | 0.927 | 0.2922 | 0.0152 | 0.3262 | -0.95 | 4.781597 |
| 1982 | 0.927 | 0.2922 | 0.0152 | 0.3262 | -0.9 | 4.782953 |
| 1982 | 0.927 | 0.2922 | 0.0152 | 0.3262 | -0.8 | 4.785893 |
| 1982 | 0.927 | 0.2922 | 0.0152 | 0.3262 | -0.7 | 4.789179 |
| 1982 | 0.927 | 0.2922 | 0.0152 | 0.3262 | -0.5 | 4.797067 |
| 1982 | 0.927 | 0.2922 | 0.0152 | 0.3262 | -0.3 | 4.807382 |
| 1982 | 0.927 | 0.2922 | 0.0152 | 0.3262 | -0.2 | 4.81383 |
| 1982 | 0.927 | 0.2922 | 0.0152 | 0.3262 | -0.1 | 4.82145 |
| 1982 | 0.927 | 0.2922 | 0.0152 | 0.3262 | -0.01 | 4.829599 |
| 1982 | 0.927 | 0.2922 | 0.0152 | 0.3262 | 0 | 4.830595 |
| 1982 | 0.927 | 0.2922 | 0.0152 | 0.3262 | 0.01 | 4.831611 |
| 1982 | 0.927 | 0.2922 | 0.0152 | 0.3262 | 0.1 | 4.841773 |
| 1982 | 0.927 | 0.2922 | 0.0152 | 0.3262 | 0.2 | 4.855746 |
| 1982 | 0.927 | 0.2922 | 0.0152 | 0.3262 | 0.3 | 4.873711 |
| 1982 | 0.927 | 0.2922 | 0.0152 | 0.3262 | 0.5 | 4.931203 |
| 1982 | 0.927 | 0.2922 | 0.0152 | 0.3262 | 0.7 | 5.065356 |
| 1982 | 0.927 | 0.2922 | 0.0152 | 0.3262 | 0.8 | 5.233052 |
| 1982 | 0.927 | 0.2922 | 0.0152 | 0.3262 | 0.9 | 5.736142 |
| 1982 | 0.927 | 0.2922 | 0.0152 | 0.3262 | 0.99 | 14.7918 |

Table 5-7 *The EDI with Variation in the Voluntary Income Reporting Rate (s)*

| <i>Year</i> | <i>s</i> | <i>t</i> | <i>p</i> | π | β | <i>EDI_AS</i> |
|-------------|----------|----------|----------|--------|---------|---------------|
| 1982 | 0.8 | 0.2922 | 0.0152 | 0.3262 | -0.5 | 5.901766 |
| 1982 | 0.9 | 0.2922 | 0.0152 | 0.3262 | -0.5 | 5.008377 |
| 1982 | 0.91 | 0.2922 | 0.0152 | 0.3262 | -0.5 | 4.928811 |
| 1982 | 0.92 | 0.2922 | 0.0152 | 0.3262 | -0.5 | 4.850789 |
| 1982 | 0.93 | 0.2922 | 0.0152 | 0.3262 | -0.5 | 4.774263 |
| 1982 | 0.94 | 0.2922 | 0.0152 | 0.3262 | -0.5 | 4.699184 |
| 1982 | 0.95 | 0.2922 | 0.0152 | 0.3262 | -0.5 | 4.625507 |
| 1982 | 0.97 | 0.2922 | 0.0152 | 0.3262 | -0.5 | 4.482184 |
| 1982 | 0.98 | 0.2922 | 0.0152 | 0.3262 | -0.5 | 4.412456 |
| 1982 | 0.99 | 0.2922 | 0.0152 | 0.3262 | -0.5 | 4.343964 |

⁹⁷ I do this because the EDI is not sensitive to the risk preference parameter.

Table 5.7 shows how value of the EDI changes with variations of the voluntary income reporting ratio. I checked for the value of s in the range between 0.80 and 0.99. Keeping values of the other arguments and the preference parameter constant, Table 5.7 shows that the EDI decreases when the value of s increases. This suggests that the EDI is related negatively to the voluntary income reporting rate.

Table 5-8 *The EDI with Variation in the Marginal Tax Rate (t)*

| <i>Year</i> | <i>s</i> | <i>t</i> | <i>p</i> | π | β | <i>EDI_AS</i> |
|-------------|----------|----------|----------|--------|---------|---------------|
| 1982 | 0.927 | 0.2922 | 0.0152 | 0.3262 | -0.5 | 4.797067 |
| 1982 | 0.927 | 0.2727 | 0.0152 | 0.3067 | -0.5 | 5.945181 |
| 1982 | 0.927 | 0.2292 | 0.0152 | 0.2632 | -0.5 | 9.919229 |

Table 5-9 *The EDI with Variation in the Audit Rate (p)*

| <i>Year</i> | <i>s</i> | <i>t</i> | <i>p</i> | π | β | <i>EDI_AS</i> |
|-------------|----------|----------|----------|--------|---------|---------------|
| 1982 | 0.927 | 0.2922 | 0.01 | 0.3262 | -0.5 | 4.748552 |
| 1982 | 0.927 | 0.2922 | 0.015 | 0.3262 | -0.5 | 4.795191 |
| 1982 | 0.927 | 0.2922 | 0.02 | 0.3262 | -0.5 | 4.842299 |
| 1982 | 0.927 | 0.2922 | 0.05 | 0.3262 | -0.5 | 5.135198 |
| 1982 | 0.927 | 0.2922 | 0.1 | 0.3262 | -0.5 | 5.666047 |
| 1982 | 0.927 | 0.2922 | 0.2 | 0.3262 | -0.5 | 6.923167 |
| 1982 | 0.927 | 0.2922 | 0.3 | 0.3262 | -0.5 | 8.531963 |
| 1982 | 0.927 | 0.2922 | 0.5 | 0.3262 | -0.5 | 13.62413 |

Table 5-10 *The EDI with Variation in the Fine Rate (π)*

| <i>Year</i> | <i>s</i> | <i>t</i> | <i>p</i> | π | β | <i>EDI_AS</i> |
|-------------|----------|----------|----------|--------|---------|---------------|
| 1982 | 0.927 | 0.2922 | 0.0152 | 0.3122 | -0.5 | 4.801918 |
| 1982 | 0.927 | 0.2922 | 0.0152 | 0.3422 | -0.5 | 4.791065 |
| 1982 | 0.927 | 0.2922 | 0.0152 | 0.3922 | -0.5 | 4.769126 |
| 1982 | 0.927 | 0.2922 | 0.0152 | 0.4322 | -0.5 | 4.748052 |
| 1982 | 0.927 | 0.2922 | 0.0152 | 0.4922 | -0.5 | 4.710485 |
| 1982 | 0.927 | 0.2922 | 0.0152 | 0.5922 | -0.5 | 4.631841 |
| 1982 | 0.927 | 0.2922 | 0.0152 | 0.7922 | -0.5 | 4.415411 |
| 1982 | 0.927 | 0.2922 | 0.0152 | 0.9922 | -0.5 | 4.127126 |

Table 5.8 shows how the EDI changes with variation of the marginal tax rate. I checked for the value of marginal tax rate decreasing from 29.22% (the marginal tax rate in 1982) to 22.92% (the marginal tax rate in 1988), keeping the other arguments and the preference parameter constant. Respectively, the value of EDI increases from 4.8 to 9.9. The calculation result in Table 5.8 suggests that the EDI is related negatively to the marginal tax rate.

Table 5.9 shows how the ETI changes with variation of the audit rate. The audit rate is supposed to vary in the range (0.01, 0.5). The calculation result in Table 5.9 suggests EDI is related positively to the audit rate. The EDI increases when the value of audit rate increases.

Table 5.10 shows how the EDI changes with variation of the fine rate. The penalty rate is supposed to vary in the range (2%, 70%). Respectively, the fine rate varies in the range of (31.22%, 99.22%). The calculation result in Table 5.10 suggests that the EDI is related negatively to the fine rate. The EDI decreases as the fine rate increases.

5.3. Summary

The primary contribution of this chapter is that it is first attempt to fill in the gap of the ETI literature for a lack of studying the functional form of the ETI. The chapter derives specific forms of the declared income elasticity function and the taxable income elasticity function from the AS model and Alm model, respectively.

The AS model only account for evasion behavior of taxpayers. Under this model, the declared income elasticity is a function of tax regime variables, income variables, and the taxpayer's preference parameter. The EDI function does not include the substitution and tax avoidance components of the taxable income responses.

The Alm model considers both evasion and avoidance behavior. The taxable income elasticity is a function of tax regime variables, income variables, and taxpayer's preference parameter, but the income variables include the reported taxable income, in addition to the total actual income and the declared income. The ETI function is also determined by parameters of the tax regime and parameters of the tax avoidance cost function. The ETI function derived from the Alm model does not include the substitution response of the taxable income.

The EDI function is studied by using empirical data of the function's arguments in the years 1979, 1982, 1985, and 1988.

During the period 1979-1988, the average marginal tax rate fell from 29.2% to 22.9%, the audit rate decreased from 2.1% to about 1%, the fine rate increased from 31.39% to 36.92%, the voluntary reporting rate increased from 91.6% to 93.2%.

The calculation results suggest that the EDI is not very sensitive to the variation of the risk preference parameter in the year 1982. Therefore, the empirical data in 1982 are considered to be appropriate to study behavior of the EDI function when each argument of the function varies.

The calculation results suggest that the EDI is related negatively to the voluntary income reporting rate, marginal tax rate, and fine rate. The EDI is related positively to the audit rate.

The very large calculated values of EDI relative to estimates of ETI are a reflection of the fact that the AS model assumes that all taxpayers make strategic calculations about the amount of income to report. This discrepancy between calculated results and empirical studies can be

explained if in fact only a small proportion of taxpayers make strategic decisions about how much income to report.

6. Conclusions

The ETI measures the relationship between taxable income and the marginal income tax rate. Under certain assumptions (no fiscal externalities, for example), all behavioral responses to changes in the marginal tax rate can be captured by the ETI. Thus the ETI becomes a central parameter for evaluating the efficiency cost of public revenue and to project the tax revenue from a tax policy change.

It is difficult to measure the ETI accurately. The non-tax induced trends in taxable income create a major challenge in estimating the ETI. Other technical issues include mean reversion, tax rate endogeneity, institutional factors, and transitory versus permanent responses, which all cause difficulties to elasticity estimation.

Repeated cross-sectional individual data, panel individual data, and time-series aggregated data are used to estimate ETI. Researchers can apply two approaches to estimate the ETI, the differences-in-differences approach and the multivariate regression approach. The major weakness of the differences-in-differences approach is that it does not control effectively for non-tax-induced changes in taxable income. For the multivariate regression approach, researchers often use instruments to control for tax rate endogeneity, but the most challenging problems are controlling for mean reversion and divergence in the income distribution.

The ETI literature has made substantial improvements in understanding the relationship between taxable income and taxation since Lindsey's seminal paper in 1987. This literature suggests that the most reliable longer-run estimates of the ETI in the U.S. range from 0.12 and 0.4.

However, the ETI literature provides very little in the way of explanation of behavioral responses of taxable income to taxation. A weakness of the literature is that no one has provided a complete understanding of the process underlying the taxable income responses to taxation and the factors determining those responses. An understanding of the mechanism underlying the responses of taxable income to taxation is necessary because it provides a framework for quantifying the effects of the tax rate and non-tax factors on taxable income.

The ETI literature points out that the ETI is a function of tax policy instruments, rather than an immutable parameter of taxpayer behavior. The empirical ETI literature provides evidence that the ETI changes with changes in income, occupations, tax regimes, size of tax base, marital and itemization status, and sources of income. However, there has been a lack of research that adequately addresses the functional form of the ETI as well as the factors determining the function.

There is a rich literature on taxpayer compliance behavior since the early 1970s. The theoretical literature of taxpayer compliance behavior originated with Becker's (1968) paper on criminal choice. The first formal model of taxpayer compliance behavior (tax evasion) was developed by Allingham and Sandmo in 1972. Subsequently, numerous extensions of this basic model were

developed in the 1970s, 1980s, and 1990s. The theoretical models of taxpayer compliance behavior can be categorized into static-random audit models, models of interactive audit strategies, and multiperiod dynamic models. Among the three types of models, the static-random audit models provide the most insights for understanding behavioral responses of taxpayer's reported income.

Taxpayers' responses to the tax system can be categorized into substitution responses, avoidance responses, and evasion responses.

In general, the reported taxable income can be defined as a function of tax enforcement factors (such as probability of detection, penalty rate); tax factors (marginal tax rate on taxable income, marginal tax rate on avoidance income, and other factors concerning the income tax code); taxpayer's preference; total actual income; and cost functions of evasion and avoidance.

A review of empirical compliance studies suggests that Plumley's (1996) data set and specifications are appropriate for estimating ETI and quantifying effects of the tax rate and other factors on reported taxable income. Therefore, the data set and the empirical specifications in Plumley (1996) are used, with some modifications, to estimate ETI and effects of environmental factors on reported taxable income.

The basic model specification consists of two equations: an Audit Rate equation and Log of Net Income equation. The Audit Rate equation is estimated by using the LSDV procedure, where audit rate is instrumented by two audit productivity-related variables.

The Log of Net Income equation is estimated using the IV fixed effects procedure, where $\ln(\text{NetTaxRate})$ is instrumented by $\ln(\text{NetMTR15K})$, $\ln(\text{NetMTR50K})$, $\ln(\text{NetMTR57K})$, and $\ln(\text{NetMTR85K})$.

The explanatory variables in the $\ln(\text{NetIncome})$ equation include three key variables and five other groups of variables: Log of the net-of-tax rate, Log of the Personal Income, Filing Rate, Tax Policy variables (other than tax rate), Burden/Opportunity variables, IRS Enforcement variables, IRS Responsiveness variables, and Demographic/Economic variables.

The empirical results show that modified specification 2 (using definition B of income) is the most appropriate specification in this study. This specification excludes certain explanatory variables displaying symptom of pairwise correlation. It also excludes certain uninteresting and insignificant variables.

The important finding is that modified specification 2 yields an estimated ETI of 0.33 for the period 1982-1991, which is in the range of the credible estimates of ETI in the current ETI literature. This result suggests a new approach to estimating ETI. There are some advantages of this new approach over the traditional approaches of the ETI literature. ETI can be estimated in a framework with a more complete set of explanatory variables, the estimation methodology is

simpler and the data set is accessible. Furthermore, this estimation framework accounts for a more complete set of explanatory variables that determine the behavioral response of reported taxable income. This set of variables includes tax policy variables, enforcement variables, total income, tax burden and opportunities, and other demographic and economic variables. This framework can be used to quantify effects of many non-tax factors on reported taxable income, and it provides a meaningful explanation of the effects of different factors on reported taxable income.

Another contribution of this dissertation is that it derives specific functional forms of the elasticities of tax evasion and avoidance behavior, two of three components of the taxable income responses. The forms of elasticity function are derived from models of taxpayer compliance behavior.

This dissertation studies the EDI function derived from the AS model. The EDI does not include the substitution and tax avoidance responses of the taxable income. The calculations of EDI function is conducted by using empirical data of the function's arguments in the years 1979, 1982, 1985, and 1988. The calculation results suggest that the empirical data in 1982 are more appropriate to study the behavior of the EDI function when each argument of the function varies. The calculation results show that the EDI is related negatively to variation of the voluntary reporting rate, marginal tax rate, and fine rate, but the EDI is related positively to variation of the audit rate.

Directions for further research

The estimated coefficients of $\ln(\text{NetTaxRate})$ are insignificant, which suggests that there might be a collinear problem between the year dummies and the net-tax rate. The future research should investigate and overcome this problem.

The EDI function only accounts for tax evasion behavior of taxpayers. This elasticity does not account for substitution and tax avoidance responses of taxable income. The future research should study the functional form derived from the Alm model, which considers both tax evasion and avoidance responses of taxable income. This kind of research will be more complicated, however, because it requests information about parameters of the avoidance cost, penalty, and income tax functions.

It is notable that both the EDI function (derived from the AS model) and the ETI function (derived from the Alm model) do not include substitution response of taxable income. Future research should find a way to study the functional form of ETI as a whole, incorporating all three kinds of response of the taxable income.

References

- Akin, John S. and John F. Stewart. 1979. "Theoretical on the Parameters of Indirect Addilog Demand Equations." *Econometrica* 47(3): 779-780.
- Allingham, Michael G. and Agnar Sandmo. 1972. "Income Tax Evasion: A Theoretical Analysis." *Journal of Public Economics* 1: 323-338.
- Alm, James. 1988a. "Compliance Costs and the Tax Avoidance-Tax Evasion Decision." *Public Finance Quarterly* 16(1): 31-66.
- Alm, James. 1988b. "Uncertain Tax Policies, Individual Behavior, and Welfare." *The American Economic Review* 78: 237-245.
- Alm, James. 1999. "Tax Compliance and Administration." In *Handbook on Taxation*, edited by W. Bartley Hildreth and James A. Richardson. New York: Marcel Dekker, Inc., pp. 741-768.
- Alm, James and Nancy J. McCallin. 1990. "Tax Avoidance and Tax Evasion as a Joint Portfolio Choice." *Public Finance* 45(2): 193-200.
- Andersen, Per. 1977. "Tax Evasion and Labor Supply." *Scandinavian Journal of Economics* 79: 375-383.
- Andreoni, James, Brian Erard and Jonathan Feinstein. 1998. "Tax Compliance." *Journal of Economic Literature* 36(2): 818-860.
- Auten, Gerald and Robert Carroll. 1997. "The effect of income taxes on household income." *Mimeo*, U.S. Department of the Treasury.
- Auten, Gerald and Robert Carroll. 1999. "The effect of income taxes on household income." *Review of Economics and Statistics* 81: 681-693.
- Auten, Gerald, Robert Carroll and Geoffrey Gee. 2008. "The 2001 and 2003 Tax Rate Reductions: An Overview and Estimate of the Taxable Income Response." *National Tax Journal* 61(3): 345 – 364.
- Baldry, Jonathan C. 1979. "Tax Evasion and Labor Supply". *Economics Letters* 3(1): 53-56.
- Beck, Paul and Woon Oh Jung. 1989a. "An Economic Model of Taxpayer Compliance Under Complexity and Uncertainty." *Journal of Accounting and Public Policy* 8: 1-27.
- Beck, Paul and Woon Oh Jung. 1989b. "Taxpayers' Reporting Decisions and Auditing under Information Asymmetry." *The Accounting Review* 66: 468-487.
- Becker, Gary. 1968. "Crime and Punishment: An Economic Approach." *Journal of Political Economy* 76(2): 169-217.

- Bennett, Charles. 2005. "Preliminary Results of the National Research Program's Reporting Compliance Study of Tax Year 2001 Individual Returns." Internal Revenue Service.
- Beron, Kurt J., Helen V. Tauchen, and Ann D. Witte. 1988. "A Structural Equation Model for Tax Compliance and Auditing." *Working Paper No. 2556*, National Bureau of Economic Research.
- Blundell, Richard. and Thomas MaCurdy. 1999. "Labor Supply: A Review of Alternative Approaches." In *Handbook of Labor Economics*, edited by Ashenfelter O. and Card D., Chapter 27, Vol. 3.
- Border, Kim C. and Joel Sobel. 1987. "Samurai Accountant: A Theory of Audit and Plunder." *The Review of Economic Studies* 54: 525-540.
- Carroll, Robert. 1998. "Do Taxpayers Really Respond to Changes in Tax Rates? Evidence from the 1993 Act." *Office of Tax Analysis Working Paper 78*, U.S. Department of Treasury.
- Christiansen, Vidar. 1980. "Two Comments on Tax Evasion." *Journal of Public Economics* 13: 389-393.
- Clotfelter, Charles T. 1983. "Tax Evasion and Tax Rates: An Analysis of Individual Returns." *Review of Economics and Statistics* 65(3): 363-373.
- Cowell, Frank. 1985. "Tax Evasion with Labor Income." *Journal of Public Economics* 26(1): 19-34.
- Crane, Steven E. and Farrokh Nourzad. 1985. "Time Value of Money and Income Tax Evasion under Risk-Averse Behavior: Theoretical Analysis and Empirical Evidence." *Public Finance* 40(3): 381-394.
- Crane, Steven E. and Farrokh Nourzad. 1986. "Inflation and Tax Evasion: An Empirical Analysis." *The Review of Economics and Statistics* 68(2): 217-23.
- Cronshaw, Mark B. and James Alm. 1995. "Tax Compliance with Two-sided Uncertainty." *Public Finance Quarterly* 23: 139-166.
- Cross, Rodney and G. Keith Shaw. 1982. "On the Economics of Tax Aversion." *Public Finance* 37(1): 36-47.
- Dubin, Jeffrey A. and Louis L. Wilde. 1988. "The Empirical Analysis of Federal Income Tax Auditing and Compliance." *National Tax Journal* 41(1): 61-74.
- Dubin, Jeffrey A., Michael J. Graetz and Louis L. Wilde. 1990a. "The Changing Face of Tax Enforcement, 1978 - 1988." *Tax Lawyer* 43(4): 893-914.
- Dubin, Jeffrey A., Michael J. Graetz and Louis L. Wilde. 1990b. "The Effect of Audit Rates on the Federal Individual Income Tax, 1977-1986." *National Tax Journal* 43(4): 395-409.

- Eissa, O. Nada and Seth Giertz. 2006. "Trends in High Incomes and Behavioral Responses to Taxation: Evidence from Executive Compensation and Statistics of Income Data." *Congressional Budget Office Working Paper 2006-14*.
- Engel, Eduardo and James R. Hines Jr. 1999. "Understanding Tax Evasion Dynamics." Mimeo, University of Michigan.
- Erard, Brian. 1993. "Taxation with Representation: An Analysis of the Role of Tax Practitioners in tax Compliance." *Journal of Public Economics* 52: 163-197.
- Erard, Brian and Jonathan S. Feinstein. 1994. "Honesty and Evasion in the Tax Compliance Game." *RAND Journal of Economics* 25: 1-19.
- Feenberg, Daniel and James Poterba. 1993. "Income Inequality and the Incomes of Very High Income Taxpayers: Evidence from Tax Returns." *Tax Policy and the Economy*. J. Poterba, ed., MIT Press: Cambridge, 7, pp. 145-177.
- Feinstein, Jonathan. 1991. "An Econometric Analysis of Income Tax Evasion and its Detection." *RAND Journal of Economics* 22(1): 14-35.
- Feldstein, Martin. 1995. "The effect of marginal tax rates on taxable income: A panel study of the 1986 Tax Reform Act." *Journal of Political Economy* 103: 551-572.
- Feldstein, Martin. 1999. "Tax avoidance and the deadweight loss of the income tax." *Review of Economics and Statistics*, pp.81, pp. 674-680.
- Feldstein, Martin and Daniel Feenberg. 1995. "The effect of increased tax rates on taxable income and economic efficiency: A Preliminary Analysis of the 1993 Tax Rate Increases." *Working Paper No. 5370*, National Bureau of Economic Research.
- Giertz, Seth. 2004. "Recent Literature on Taxable-Income Elasticities." *CBO Technical Paper No. 2004-16*. Washington D.C.: U.S. Congressional Budget Office.
- Giertz, Seth. 2005. "A Sensitivity Analysis of the Elasticity of Taxable Income." *CBO Working Paper No. 2005-01*. Washington D.C.: U.S. Congressional Budget Office.
- Giertz, Seth. 2006. "The Elasticity of Taxable Income During the 1990s: A Sensitivity Analysis." *CBO Technical Paper No. 2006-3*. Washington D.C.: U.S. Congressional Budget Office.
- Giertz, Seth. 2007. "The Elasticity of Taxable Income over the 1980s and 1990s." *National Tax Journal* 60(4): 743-768.
- Goldberger, Arthur S. 1987. *Functional Form and Utility: A Review of Consumer Demand Theory*. Westview Press. London.

- Goolsbee, Austan. 1998. "It's Not About the Money: Why Natural Experiments Don't Work on the Rich?" *Working Paper No. 6395*, National Bureau of Economic Research.
- Goolsbee, Austan. 2000. "What Happens When You Tax the Rich? Evidence from Executive Compensation". *Journal of Political Economy* 108(2): 352-378.
- Graetz, Michael, Jennifer Reinganum, and Louis Wilde. 1984a. "An Equilibrium Model of Tax Compliance with a Bayesian Auditor and Some "Honest" Taxpayers." *Social Science Working Paper 506*, California Institute of Technology, Division of the Humanities and Social Science, (revised June).
- Graetz, Michael, Jennifer Reinganum, and Louis Wilde. 1984b. "A Model of Tax Compliance with Budget-Constrained Auditors." *Social Science Working Paper 520*, California Institute of Technology, Division of the Humanities and Social Science, (revised November).
- Graetz, Michael, Jennifer Reinganum, and Louis Wilde. 1986. "The Tax Compliance Game: Toward an Interactive Theory of Tax Enforcement." *Journal of Law, Economics, and Organization* 2(1): 1-32.
- Greenberg, Joseph. 1984. "Avoiding Tax Avoidance: A (Repeated) Game-theoretic Approach." *Journal of Economic Theory* 32: 1-13.
- Gruber, Jonathan and Emmanuel Saez. 2002. "The Elasticity of Taxable Income: Evidence and Implications." *Journal of Political Economy*, 84(1): 1-32.
- Haley, Charles W., and Lawrence D. Schall. 1979. *The Theory of Financial Decisions*. New York: McGraw-Hill Book Co.
- Hausman, Jerry A. 1983. "Taxes and Labor Supply." *Working Paper No. 1102*, National Bureau of Economic Research.
- Heim, Bradley. 2009. "The Effect of Recent Tax Changes on Taxable Income: Evidence from a New Panel of Tax Returns." *Journal of Policy Analysis and Management* 9(1): 147-163.
- Houthakker, H.S. 1960. "Additive Preferences." *Econometrica* 28(2): 244-257.
- Internal Revenue Service. 1980. *Annual Report 1980*. Commissioner of Internal Revenue, Internal Revenue Service, U.S. Department of Treasury. Washington, D.C.: U.S. Government Printing Office.
- _____. 1981. *Annual Report 1981*. Commissioner of Internal Revenue, Internal Revenue Service, U.S. Department of Treasury. Washington, D.C.: U.S. Government Printing Office.
- _____. 1982. *Annual Report 1982*. Commissioner of Internal Revenue, Internal Revenue Service, U.S. Department of Treasury. Washington, D.C.: U.S. Government Printing Office.

- _____. 1983. *Annual Report 1983*. Commissioner of Internal Revenue, Internal Revenue Service, U.S. Department of Treasury. Washington, D.C.: U.S. Government Printing Office.
- _____. 1984. *Annual Report 1984*. Commissioner of Internal Revenue, Internal Revenue Service, U.S. Department of Treasury. Washington, D.C.: U.S. Government Printing Office.
- _____. 1985. *Annual Report 1985*. Commissioner of Internal Revenue, Internal Revenue Service, U.S. Department of Treasury. Washington, D.C.: U.S. Government Printing Office.
- _____. 1986. *Annual Report 1986*. Commissioner of Internal Revenue, Internal Revenue Service, U.S. Department of Treasury. Washington, D.C.: U.S. Government Printing Office.
- _____. 1987. *Annual Report 1987*. Commissioner of Internal Revenue, Internal Revenue Service, U.S. Department of Treasury. Washington, D.C.: U.S. Government Printing Office.
- _____. 1988. *Annual Report 1988*. Commissioner of Internal Revenue, Internal Revenue Service, U.S. Department of Treasury. Washington, D.C.: U.S. Government Printing Office.
- _____. 1989. *Annual Report 1989*. Commissioner of Internal Revenue, Internal Revenue Service, U.S. Department of Treasury. Washington, D.C.: U.S. Government Printing Office.
- _____. 1990. *Annual Report 1990*. Commissioner of Internal Revenue, Internal Revenue Service, U.S. Department of Treasury. Washington, D.C.: U.S. Government Printing Office.
- Isachsen, Arne Hone and Steinar Strom. 1980. "The Hidden Economy: The Labor Market and tax Evasion." *Scandinavian Journal of Economics* 82(2): 304-311.
- Kesselman, Jonathan R. 1989. "Income Tax Evasion: An Intersectoral Analysis." *Journal of Public Economics* 38(2): 137-182.
- Klepper, Steven and Daniel Nagin. 1989. "The Role of Tax Practitioners in Tax Compliance." *Policy Sciences* 22: 167-192.
- Kolm, Serge-Cristophe. 1973. "A Note on Optimum Tax Evasion." *Journal of Public Economics* 2(3): 265-270.
- Kopczuk, Wojciech. 2003. "Tax Bases, Tax Rates and the Elasticity of Reported Income." *Working Paper No. 10044*, National Bureau of Economic Research.
- Kopczuk, Wojciech. 2005. "Tax Bases, Tax Rates and the Elasticity of Reported Income." *Journal of Public Economics* 89(11-12): 2093-2119.

- Landsberger, Michael and Isaac Meilijson. 1982. "Incentive Generating State Dependent Penalty System." *Journal of Public Economics* 19: 333-352.
- Lindsey Lawrence. 1987. "Individual Taxpayer Response to Tax Cuts: 1982-1984, with Implications for the Revenue Maximizing Tax Rate." *Journal of Public Economics* 33(2): 173-206.
- Mason, Robert and Helen M. Lowry. 1981. "An Estimate of Income Tax Evasion in Oregon." Survey Research Center, Oregon State University, Corvallis, Oregon.
- McCaleb, Thomas S. 1976. "Tax Evasion and the Differential Taxation of Labor and Capital Income." *Public Finance* 31(2): 287-294.
- Moffitt, Robert and Mark Wilhelm. 2000. "Taxation and the Labor Supply Decisions of the Affluent," *Does Atlas Shrug? The Economic Consequences of Taxing the Rich*, Joel Slemrod, ed., New York: Harvard University Press and Russell Sage Foundation.
- Mookherjee, Dilip and Ivan Png. 1989. "Optimal Auditing, Insurance, and Redistribution." *Quarterly Journal of Economics* 104(2): 399-415.
- Park, Richard W. 1969. "Systems of Demand Equations: An Empirical Comparison of Alternative Functional Forms." *Econometrica* 37(4): 629-650.
- Park, Thae S. 1981. "The Relationship Between Personal Income and Adjusted Gross Income, 1947-78." *Survey of Current Business*, pp. 24-46.
- Pencavel, John. 1979. "A Note on Income Tax Evasion, Labor Supply and Nonlinear Tax Schedules." *Journal of Public Economics* 12(1): 115-124.
- Pestieau, Pierre and Uri M. Possen. 1991. "Tax Evasion and Occupational Choice." *Journal of Public Economics* 45: 107-125.
- Plumley, Alan H. 1996. "The Determinants of Individual Income Tax Compliance: Estimating the Impacts of Tax Policy, Enforcement, and IRS Responsiveness." *Internal Revenue Service Publication 1916*, Washington, DC.
- Reinganum, Jennifer R. and Louis L. Wilde. 1985. "Income Tax Compliance in a Principal-Agent Framework." *Journal of Public Economics* 26(1):1-18.
- Reinganum, Jennifer R. and Louis L. Wilde. 1986. "Equilibrium Verification and Reporting Policies in a Model of Tax Compliance." *International Economic Review* 27(3): 739-760.
- Reinganum, Jennifer R. and Louis L. Wilde. 1991. "Equilibrium Enforcement and Compliance in the Presence of Tax Practitioners." *Journal of Law, Economics, and Organization* 7: 163-181.
- Rickard, J.A., Russell, A.M., and Howroyd, T.D. 1982. "A Tax Evasion Model with Allowance for Retroactive Penalties." *Economic Record* 58: 379-385.

- Roth, Jeffrey A., John T. Scholz, and Ann Dryden Witte. 1989. *Taxpayer Compliance, Volume 1: An Agenda for Research Volume 2: Social Science Perspectives*. Philadelphia: University of Pennsylvania Press.
- Saez, Emmanuel. 1999. "The Effect of Marginal Tax Rates on Income: A Panel Study of 'Bracket Creep'." *Working Paper No. 7367*, National Bureau of Economic Research.
- Saez, Emmanuel. 2003. "The Effect of Marginal Tax Rates on Income: A Panel Study of 'Bracket Creep'." *Journal of Public Economics* 87: 1231-1258.
- Saez, Emmanuel. 2004. "Reported Incomes and Marginal Tax Rates, 1960-2000: Evidence and Policy Implications." *Working Paper No. 10273*, National Bureau of Economic Research.
- Saez, Emmanuel, Joel Slemrod and Seth Giertz. 2009. "The Elasticity of Taxable Income with Respect to Marginal Tax Rates: A Critical Review". *Working Paper*.
- Sanchez, Isabel and Joel Sobel. 1993. "Hierarchical Design and Enforcement of Income Tax Policies." *Journal of Public Economics* 50(3): 345-369.
- Sandmo, Agnar. 1981. "Income Tax Evasion, Labour Supply and the Equity-Efficiency Tradeoff." *Journal of Public Economics* 16(3): 265-288.
- Scotchmer, Suzanne. 1989. "The Effects of Tax Advisors on Tax Compliance" *Taxpayer Compliance, Volume 2: Social Science Perspectives*, University of Pennsylvania Press, Philadelphia.
- Scotchmer, Suzanne and Joel Slemrod. 1989. "Randomness in Tax Enforcement." *Journal of Public Economics* 38(1): 17-32.
- Singh, Balbir. 1973. "Making Honesty the Best Policy." *Journal of Public Economics* 2: 257-263.
- Slemrod, Joel. 1995. "Income Creation or Income Shifting? Behavioral Responses to the Tax Reform Act of 1986 ." *The American Economic Review* 85(2): 175-180.
- Slemrod, Joel. 1996. "High Income Families and the Tax Changes of the 1980s: the Anatomy of Behavioral Response." *Empirical Foundations of Household Taxation*. M. Feldstein and J. Poterba, eds., University of Chicago.
- Slemrod, Joel. 1998a. "Methodological Issues in Measuring and Interpreting Taxable Income Elasticities." *National Tax Journal* 51(4): 773-788.
- Slemrod, Joel. 1998b. "A General Model of the Behavioral Response to Taxation." *Working Paper No. 6582*, National Bureau of Economic Research.
- Slemrod, Joel and Shlomo Yitzhaki. 1996. "The Cost of Taxation and the Marginal Efficiency Cost of Funds." *International Monetary Fund Staff Papers* 43(1): 172-198.

- Slemrod, Joel and Shlomo Yitzhaki. 2000. "Tax Avoidance, Evasion, and Administration." *Working Paper No. 7473*, National Bureau of Economic Research.
- Slemrod, Joel and Wojciech Kopczuk. 2002. "The Optimal Elasticity of Taxable Income." *Journal of Public Economics* 84(1): 91-112.
- Srinivasan, T. N. 1973. "Tax Evasion: A Model." *Journal of Public Economics* 2(4): 339-46.
- Tauchen, Helen V., Witte, Ann D., and Kurt J. Beron. 1989. "Tax Compliance: An Investigation Using Individual TCMP Data." *Working Paper No. 3078*, National Bureau of Economic Research.
- Weiss, Lawrence. 1976. "The Desirability of Cheating Incentives and Randomness in the Optimal Income Tax." *Journal of Political Economy* 84(6): 1343-1352.
- Witte, Ann D., and Woodbury, Diane F. 1983a. "The Effect of Tax Laws and Tax Administration on Tax Compliance." *Working Paper 83-1*, Department of Economics, University of North Carolina, Chapel Hill, North Carolina.
- Witte, Ann D., and Woodbury, Diane F. 1983b. "What We Know about the Factors Affecting Compliance with the Tax Laws." In *Income Tax Compliance: A Report of the AABA Section on Taxation, Invitational Conference on Income Tax Compliance*, edited by P. Sawicki. Washington D.C.: American Bar Association, pp. 133-148.
- Witte, Ann D., and Woodbury, Diane F. 1985. "The Effect of Tax Laws and Tax Administration on Tax Compliance: The Case of the U.S. Individual Income Tax." *National Tax Journal* 38: 1-13.
- Yaniv, Gideon. 1988. "Withholding and Non-withheld Tax Evasion." *Journal of Public Economics* 35(2): 183-204.
- Yitzhaki, Shlomo. 1974. "A Note on 'Income Tax Evasion: A Theoretical Analysis'". *Journal of Public Economics* 3(2): 201-202.
- Zellner, Arnold. 1962. "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias." *Journal of the American Statistical Association* 57: 348-368.

Appendix A: Definitions of Income in the Current ETI Literature versus Definitions of Income in Plumley (1996)

A/ Plumley (1996)

Plumley defines the reporting compliance dependent variables (*IncomePct*, *OffsetsPct*, and *NetIncomePct*) according to three distinct definitions:

Definition A: excludes all components of income or offsets whose rules changed during the period, which changes could not be controlled for in any other way.

Definition B: excludes only those components of income or offsets whose rules changed in years other than 1986 (i.e., in the TRA86).

Definition C: includes all components of income and offsets regardless of rule changes.

Table A-1 indicates which specific components are included in each of the three definitions.

B/ The Current ETI Literature: Income Definitions

1. Gruber and Saez (2002)

Gruber and Saez use two definitions of income: Broad Income and Taxable Income.

Broad Income is defined as the sum of all the items that compose Total Income less Capital Gains and Social Security Benefits. Broad Income includes:

- Wages, salaries and tips
- Interest Income (taxable and exempted)
- Dividends (taxable and exempted)
- Alimony received
- Business income (or loss)
- Total IRA distributions
- Total Pensions and Annuities
- Income reported on Schedule E (Partnership, Trusts, etc.)
- Farm income
- Full Unemployment Compensation,
- Other income

Note: This income definition is similar to the income definition B in Plumley (1996).

Taxable Income is defined as Broad Income definition minus the adjustments that are made to arrive at taxable income. The definition of taxable income changes from year to year due to the numerous tax reforms. Gruber and Saez include in their Taxable Income definition only the adjustments that can be computed in all the years from 1979 to 1990. They do not include the

adjustments such as moving expenses, IRA deductions, Student loan interests, secondary earners deductions because they are not in the tax code every year and thus cannot be computed for every year.

Table A-1. Income and Offset Components Included in the Three Alternate Definitions

| Component | Definition | | | Component | Definition | | |
|-------------------------------------------|------------|---|---|-------------------------------------|------------|---|---|
| | A | B | C | | A | B | C |
| Income Items | | | | Offsets: Itemized Deductions | | | |
| Wages, salaries, tips, etc. | x | X | x | State & local income taxes | x | x | x |
| Interest (Schedule B) | x | X | x | Real estate taxes | x | x | x |
| Dividends (Schedule B) | x | X | x | Sales taxes | 2 | 2 | 2 |
| Refunds of state & local income tax | x | X | x | Other taxes | x | x | x |
| Alimony received | x | X | x | Home mortgage interest | x | x | x |
| Business income (Schedule C) | x | X | x | Deductible points | x | x | x |
| Pensions, IRA distributions, etc. | x | X | x | Investment interest | x | x | x |
| Rents, royalties (Schedule E) | x | X | x | Personal interest | | x | x |
| Partnerships, estates, trusts (Sched. E) | x | X | x | Charitable contributions (total) | x | x | x |
| Farm income (Schedule F) | x | X | x | Medical & dental expenses | | | x |
| Other income | x | X | x | Casualty & theft losses | | | x |
| Capital gain/loss (Schedule D) | | | x | Moving expenses | | x | x |
| Capital gain distribution | | | x | Miscellaneous deductions | | x | x |
| Other gain/loss (Form 4797) | | | x | Offsets: Credits | | | |
| Unemployment compensation | | X | x | Child & dependent care credit | x | x | x |
| Social Security benefits | | | x | Elderly/disabled credit | x | x | x |
| Offsets: Adjustments | | | | Foreign tax credit | x | x | x |
| Keogh/SEP deduction | x | X | x | Residential energy credit | | | x |
| Penalty on early withdrawals | x | X | x | Political contributions credit | | | x |
| Alimony paid | x | X | x | General business credit | | | x |
| Reimbursed employee business expenses | | | x | Investment credit | | | x |
| IRA contributions | | X | x | Jobs credit | | | x |
| 1/2 of self-employment tax | | | x | Alcohol fuel credit | | | x |
| Self-employed health insurance | | X | x | Research credit | | | x |
| Ded'n for married couple when both work | | X | x | Low-income housing credit | | | x |
| Disability Income exclusion | | | x | Disabled access credit | | | x |
| Foreign Housing deduction (F2555) | | | x | Enhanced oil recovery credit | | | x |
| Forestation amortization | | | x | Earned Income credit | | | x |
| Repaymnt subpay under T.A. of 1974 | | | x | Gas & special fuels credit | | | x |
| Qualified performng artist expenses | | | x | Regulated invest. co. credit | | | x |
| Jury duty pay given to employer | | | x | Nonconventional fuel credit | | | x |
| Employer-provided vehicle | | | x | Mortgage interest credit | | | x |
| Offsets: Exempts./Std. Ded./etc. | | | | | | | |
| Personal exemptions | 2 | 2 | 2 | | | | |
| Aged/Blind exemption/std. deduction | 2 | 2 | 2 | | | | |
| Standard deduction | 2 | 2 | 2 | | | | |
| Charitable contributions for nonitemizers | | | x | | | | |

1 Rule change controlled for by modifying data.

2 Rule changes controlled for with independent variables.

The definition of Taxable Income is equal to Broad Income definition less exemptions, standard deduction and itemized deductions (Schedule A).

2. *Kopczuk (2003)*

Kopczuk (2003) defines broad income as a sum of wages, dividends and interest income, unemployment income, pensions, annuities, IRA distributions, alimony received, state tax refunds, partnership and S-corporation income, Schedule C income, farm income, rental income and royalties, and other income. Capital gains are not included. This income definition is similar to the income definition B in Plumley (1996).

Kopczuk (2005) defines taxable income as broad income less the value of exemptions and the greater of the standard or itemized deductions.

3. *Giertz (2007)*

Giertz (2007) uses the income definition as same as Gruber and Saez (2002). He defines broad income equal to total income minus realized capital gains and Social Security benefits. Particularly,

Broad Income = AGI – capital gains – supplemental (Schedule E) income or loss + dividends excluded from AGI + unemployment compensation not included in AGI + Keogh and traditional IRA contributions + forfeited interest penalties + alimony paid.

Taxable income equals broad income less the value of exemptions and the greater of the standard or itemized deductions. Eligible deductions from AGI include:

- Moving expenses
- IRA and Keogh payments
- Medical expenses exceeding 7.5 percent of AGI
- State and local income taxes
- Real estate and property taxes
- Mortgage interest and payments for deductible points
- Charitable contributions
- Net casualty deduction
- Other miscellaneous deductions

Appendix B: Basic Specification - Empirical Result

The basic specification with income definition A (or B) provides an overall picture about the quantitative effects of the whole set of environmental factors on the reported taxable income.

Filing rate: Estimated coefficient of *FilingRate* is 0.004. It is positive and significant (at 3% level). It suggests that if the filing rate increases 1%, $Ln(NetIncome)$ will increase 0.004.

Ln(PI): Estimated coefficient of $Ln(PI)$ is 1.34. It is positive and very significant (at 1% level). It suggests that if $Ln(PI)$ increases 1 unit, $Ln(NetIncome)$ will increase 1.34 units. In other words, If Personal Income increases 1%, Net Income will increase 1.34%.

Tax policy factors:

In general, the estimated coefficients of tax policy variables are insignificant. It suggests that the effects of these variables on the change of Net Income are not significant in comparison with other factors.

Marginal Tax Rate: the estimated coefficient of $Ln(NetTaxRate)$ is 2.7. It is positive but insignificant (the p-value is 0.525).

Filing Threshold: the estimated coefficient of *FThresholdPct* is 0.014. It is positive and insignificant (the p-value is 0.28). It suggests that an increase of Filing Threshold would cause an increase in Net Income.

Children Exemptions: The estimated coefficient of *ChildExemptsPct* is 0.018. It is positive and insignificant (the p-value is 0.49). It suggests an increase of Children Exemptions would cause an increase in Net Income.

State Taxes: The estimated coefficient of *StateTaxPct* is -0.0006. It is negative and very insignificant (the p-value is 0.93). However, it gives an intuitive suggestion that an increase in *StateTaxPct* would reduce Net Income.

Burden/Opportunity factors:

The estimation results suggest that Burden/Opportunity factors have significant effects on Net Income

Average Burden: the estimated coefficient of $Ln(AvgBurden)$ is 0.12. It is positive and insignificant (the p-value is 0.59). It suggests an increase in $Ln(AvgBurden)$ would increase Net Income.

Sole Proprietors: the estimated coefficient of *SoleProps* is 0.052. It is positive and significant (at 9% level). It suggests a higher proportion of Sole Proprietors in the total potential returns would increase Net Income.

Interaction factor between Sole Proprietors and percentage of employment in Trade/Finance/Services sectors: the estimated coefficient of *SolePropTFS* is -0.001. It is negative and significant (at 7% level). It suggests that the bigger share of employment working in Trade/Finance/Services sectors as sole proprietors, the smaller amount of Net Income reported.

Paid Practitioners: The estimated coefficient of *PaidPrep* is -0.004. It is negative and significant (at 1% level). It suggests that if the percentage of returns filed prepared by paid practitioners increases 1%, $\ln(\text{NetIncome})$ will decrease 0.004.

IRS enforcement factors:

Audit rate: the estimated coefficient of $\ln(p\text{AuditRate}+1)$ is 0.13. It is positive and insignificant (the p-value is 0.44). Intuitively, it suggests that an increase of Audit rate would increase the amount of Net Income.

Information Return Program (IRP): the estimated coefficient of $\ln(\text{IRP}+1)$ is 0.305. It is positive and insignificant (the p-value is 0.57). However, it gives an intuitive suggestion that an increase in the rate of IRP documents matched would increase Net Income reported.

Criminal Investigation Division (CID): the estimated coefficient of $\ln(\text{CID}+1)$ is 0.012. It is positive and significant (at 9% level). It suggests that the criminal conviction rate has a positive effect on the reported amount of Net Income.

IRS responsiveness factors:

Taxpayer Service (TPS) telephone calls: the estimated coefficient of *TPS_CallsPC* is -0.00008. It is very small, negative, and insignificant (the p-value is 0.23). It suggests that the effect of TPS telephone calls is not significant at all on Net Income.

Returns prepared by TPS: the estimated coefficient of *TPS_RetPrepPC* is 0.005. It is positive and insignificant (the p-value is 0.12). Intuitively, it suggests that this factor would have a positive effect on the reported amount of Net Income.

Demographic/Economics factors:

Marital status: The estimated coefficient of *Singles* is 0.006. It is positive and significant (at 8% level). It suggests that single persons would report more Net Income than married persons.

Age: the estimated coefficient of *Under30* is -0.003. It is negative and insignificant (the p-value is 0.15). The estimated coefficient of *Over64* is -0.0007. It is very small, negative, and more insignificant (the p-value is 0.79). It would suggest that younger people would report lower Net Income.

Rate of Births: the estimated coefficient of *PCBirths* is 0.02. It is positive and very significant (the p-value is 0.00). It suggests that the rate of birth has a positive effect on Net Income. If the rate of birth increases 1 per thousand, $\ln(\text{NetIncome})$ will increase 0.02.

Unemployment rate: the estimated coefficient of *UnemplRate* is -0.01. It is negative and significant (at 1% level). It suggests that if unemployment rate increase 1%, $\ln(\text{NetIncome})$ will reduce 0.01.