

Nottingham University
Business School

# Predicting Non-Compliance in the Atlantic Canada Lobster Fishery

SCOTT DOUGLAS JAMES GRAHAM, BA, MBA

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# Abstract

This dissertation is "…the story of searching for any edge through information"(Verducci 2011 p. 41). The overall research question originated through the question "how did the underground economy in the lobster fishery arise and why". In the mid-1990s, a growing underground economy was uncovered by chance in the Atlantic Canada lobster fishery. When the Royal Canadian Mounted Police proceeds of crime unit found a series of large money transfers into a Royal Bank branch in Halifax, they thought that drug money was being moved. It turned out to have been cash sales of lobster. This represents $40 to $60 million in lost tax revenue, and a similar challenge for the common resource model for lobster fisheries management. To help answer the research question I examined the history and structure of the Atlantic Canadian lobster fishery, the impact of government and non-government policies and interactions with the lobster fishery and examined the tax evasion, statistical fraud detection and collusion/market power literature. The literature review gave rise to a number of potential variables for inclusion in a model that would serve to predict illegal and underreported activity in the lobster fishery. First, Benford's Law was tested as a possible variable for inclusion. Non-conformity with Benford's Law was observed in both the lobster fishery in LFA33 and LFA34 plus the snowcrab fishery. However, non-conformance with Benford's Law does not mean that there is certainty of fraud or human manipulation. Second, a market power screen was applied to the lobster fishery. Quantitative support for community-based differences in compliance with fisheries regulations has been demonstrated there is value in including a market power indicator variable as a variable of interest in the model. Last logistic panel data models were developed and tested. The outcome of the model building process were two models that have a better than chance discriminatory ability and a reasonable classification of transactions that may lead to sanctions. Model 4 was significant but was not able to classify licensees that were more likely to have sanctions. A factor analysis showed that there were three factors for each of the transactional and licensee models. For licensee models, sanctions were not loading on the same factor as the Benford's Law and market power independent variables. In the case of the underground economy of the Atlantic Canadian lobster fishery, the Government of Canada has information and a fresh analysis of the information that may enable them to better target audits or inspections. There is no illusion that the information will, in sports parlance, "win the championship" however, it is hoped that with this analysis and continued improvement that the Government of Canada will outperform those that seek to evade tax and fisheries policy.

# Publications based on this research

Journal Publication

Graham, S. D. J., J. Hasseldine and D. Paton (2007). "Statistical fraud detection in a commercial lobster fishery." New Zealand Journal of Marine and Freshwater Research **43**: 457-463.

Conference Presentation

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The opinions expressed throughout are my own and may not reflect current Government of Canada policy approaches.

My deepest respect for the men and women who risk their lives to make their livelihood from the sea. May you have fair winds and following seas.

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# 1. Introduction

## 1.1. Overview

The overall research question originated through the question "how did the underground economy in the lobster fishery arise and why". This is not to say that the answer is unknowable, merely not yet discovered, or documented in a public forum or adequately linked to the question. Through my literature survey, I believe that I have a viable research question that will contribute to knowledge. The research question has elements linked to economics, but I am not satisfied that economics alone can help answer the question in the most robust possible manner. For my research question, the ontology in psychology will also contribute significantly to my work. I am looking to develop a model that explains why people (or predicts who) will have the tendency to participate in the underground economy in a given sector given a set of economic circumstances – the union of psychological and economic principles. The tenets of Simon (Simon 1990) are worth keeping top of mind – one should not consider invariants, but seek to explain in the best possible way human behaviour vis-à-vis the underground economy. Indeed I have chosen the business school for the very reason that it provides the interdisciplinary environment that I feel is required to answer my research question.

## 1.2. Background

Much has been written in the literature and the popular press about non-compliance with tax policy and legislation both within Canada and around the world. Non-compliance is a growing issue for both developed and developing economies.

As outlined in the literature review, during the 1990s many researchers turned their attention to estimating the size of the underground economy or informal economy via various methodologies as well as examining the determinants of compliance and non-compliance. Such determinants have included tax policy, and the degree of industry regulation.

Also in the mid-1990s, a growing underground economy was uncovered by chance in the Atlantic Canada lobster fishery. When the Royal Canadian Mounted Police's proceeds of crime unit found a series of large money transfers into a Royal Bank in Halifax, they thought they were looking at

drug money being moved. It turned out to have been cash sales of lobster. It was reported in January 2002 that "as much as $200 million worth of lobster sales went unreported over three years in the late 1990s." (Canadian Broadcasting Corporation, 2002). This represents $40 to $60 million in lost tax revenue (McLaughlin, 2002).

The lobster fishery is regulated via licenses, seasons, quotas and lobster size/gender constraints (Atlantic Fishery Regulations 1985) . In 2000, the Department of Fisheries and Oceans (DFO) (2004a) had issued 10,107 lobster licenses in Atlantic Canada (Nova Scotia, New Brunswick, Prince Edward Island and Newfoundland and Labrador). DFO (2004b) also recorded 43,815 metric tonnes (live weight) of lobsters landed in 2000 with a value of $513,214,000 (DFO, 2004c). The value of the fishery is estimated at $805Million (Department of Fisheries and Oceans 2011), and has grown from $516Million in 2004. The size and growth of the fishery only reinforces the requirement for methodologies to ensure that taxpayers are paying their fair share. Further, the industry's desire to achieve certification as a sustainable fishery (Marine Stewardship Council 2008), the need to identify non-compliance has become increasingly important.

Another significant development in the Atlantic Canada lobster fishery was the Supreme Court of Canada's Marshall decision which was released on September 17, 1999 (R. v. Marshall 1999). The Supreme Court affirmed a treaty right of aboriginals to hunt, fish, and gather in pursuit of a moderate livelihood, based on treaties signed in the eighteenth century. The Supreme Court also ruled that regulation of this Treaty right might be justified for the purposes of conservation. In other words, notwithstanding the Supreme Court's decision, the federal government retained the authority and responsibility for regulating the fishery, with conservation as the key consideration (DFO, 2004d). DFO's response to the Marshall decision included the voluntary retirement of licences held by non-aboriginal fisherman to ensure that the overall size of the fishery remained constant and viable (DFO, 2004d).

## 1.3. Identification of Gaps in the Literature

Academia, tax administrations (e.g., Canada Revenue Agency or CRA), and non-governmental organizations (e.g., International Monetary Fund, OECD) alike are all interested in modelling and combating the underground economy. The literature has examined factors underlying tax compliance, including ethics (Henderson and Kaplan 2005) , culture (Cummings, Martinez-Vazquez and McKee 2001) , risk aversion (Giles and Johnson 1999), economic factors (Ritsema, Thomas and Ferrier 2003) and tax policy (Hill and Kabir 1996).

What appears to be lacking for the lobster fishery is a model that takes available data, (Brou and Collins 2001)administrations forecast where the underground economy may exist, develop or grow in the lobster fishery. If tax or fisheries administrations were using such a model, it would enable them to takes steps proactively through various means (e.g., policy changes, compliance activities, communication) to ensure that the fishery and the tax base is protected.

Segmentation of non-compliance risk has been researched by tax type (direct/indirect) , source of income (Erard 1997), and compliance history (CRA internal document). Segmentation by commodity (i.e., Harmonized Commodity Description and Coding System) or sector (i.e., SIC) does not appear to have been researched by academia (Giles, 1998), but has had some use in the CRA. Using the Atlantic Canada lobster fishery may serve as an indicator that research on particular segments is a feasible approach.

Having identified the background of an issue, as well as a corresponding gap in the literature, the question becomes, so what? The next sections will answer that question and justify the answer in terms of contribution to knowledge and impact on management practice. Answering the question requires a brief discussion of relevant philosophy, economics, psychology, the interdisciplinary field of economic psychology, and finally the impact on management practice.

## 1.4. Contribution

The need for research in the lobster fishery was demonstrated by news reports in December 2006 that reported that "Fishermen sometimes try to hide their total catch when they exceed their quotas…occasionally working in collusion with processing companies" (Beeby 2006). To better understand how statistical fraud detection may be used to identify which fishermen are trying to hide their true total catch, extends statistical fraud detection techniques to the lobster fishery. This research will aid the Canadian Government in developing methodologies to detect tax and fisheries management issues in this industry. Academia will also benefit from the extension of these techniques to an industry that has previously not been researched from this perspective. This research will further determine the characteristics of the underground economy in the Atlantic Canadian Lobster fishery and those that participate in this economy, and will help develop a statistical model that will provide assurance regarding the reliability of catch data.

It is essential that organizations such as the Canada Revenue Agency and the Department of Fisheries and Oceans have a sound understanding of the issues and challenges they face to enable the development of appropriate strategies and methodologies to deal with the underground economy in the lobster fishery. The first two studies will form the basis of a model that will help the CRA forecast taxpayer participation in the underground economy, thereby identifying, detecting and preventing similar circumstances.

To that end, I demonstrate in Chapter 7 that there are indications of non-compliance with Benford's Law. Non-conformance with Benford's Law does not mean that there is certainty of fraud or human manipulation (Durtschi, Hillison and Pacini 2004; Geyer and Williamson 2004). Next, I demonstrate in Chapter 8 that there are indications of market power in the Atlantic Canadian Lobster fishery, including quantitative support for community-based differences in compliance with fisheries regulations has been demonstrated, and extends the qualitative findings in Arai (1994) and McMullan et al. (2002) that some communities are more prone to compliance issues than others. Last, I develop panel data models that can provide a better than chance discriminatory ability and a reasonable classification of transactions that may lead to enforcement sanctions. The combination of these three contributions will provide a potential tool for the Canada Revenue Agency and the Department of Fisheries and Oceans aid in the development of appropriate strategies and methodologies to deal with the underground economy in the lobster fishery.

## 1.5. Philosophy

The next step is to establish my philosophical foundations for this dissertation. Epistemology, or the philosophical theory of knowledge (Benton and Craib 2001), has given us the rationalist view (i.e., I think therefore I am) and the empiricist view (i.e., knowledge of our surroundings is amassed via our senses). The overall research question originated through the question "how did the underground economy in the lobster fishery arise and why" that was being asked within the Canada Revenue Agency. There were two angles in researching the answer to that question. First, was the answer to the question known within the Agency? If the question was being asked, the presumption is no, the answer is not known within the Agency. The Department of Fisheries and Oceans is also interested in knowing the determinants and indicators of the underground economy in the lobster fishery, especially as it relates to conservation, certification and illegal, unreported and underreported catches. Second, if not, did any documentation related to the research question from academia, policy, or other sources provide sufficient and adequate response to the question? From the philosophical empiricist perspective (Benton and Craib 2001) the conclusion reached was that while the question was well known, the possible answer was not. This is not to say that the answer is unknowable, merely not yet discovered, or documented in a public forum or adequately linked to the question.

## 1.6. Economics

The research question has elements of an economic problem. Thus, how does the research question fit into economic paradigms and philosophy? In other words, to understand where I need to understand where I have been (Blaug 2001) .

Zuniga (1999) outlines an ontology of economic objects. Each individual structures their economic viewpoint of things in the world according to how those things affect their plans – economics is subjective and rooted in needs. Zuniga states that an economic object is the product of two things – the views we hold about the object and the laws that describe them. This view is based on Mengers' 1871 Principles of Economics (Zuniga, 1999). There are six general economic objects: "economic goods, commodity, money, value, price, and exchange" (Zuniga, 1999, p. 301). In Zuniga's (1999) paradigm, understanding of economic phenomena is enhanced by a common understanding of economic objects. This parallels Pfeffers' (1993)assertion that common paradigms are important to the advancement of a field.

Economics-as-science has been debated since the late 1890s by Veblen (Payson 1996), while the application of scientific methodologies can be traced back even further to 1827. Payson (1996, p. 258) then argues that the "absence of scientific practice in economics may be identified as one of the weakest links in the chain of ideas that make up economic discourse". Payson (1996) also argues that economics is not an interdisciplinary endeavour while the natural sciences are when it makes sense. Economists, Payson argues, "often do not recognize the importance of interdisciplinary scholarship" (1996, p. 259) and this is not encountered in other social sciences to the same extent. Payson (1996) concludes by saying that if economists learned more psychology (or environmental science, etc., as the case may be), in other words were more interdisciplinary, economics would be more relevant and useful.

The research question has elements of the six economic objects described by Zuniga(1999). Specifically, the issue of the underground economy is the conflict between taxpayers' needs, and the needs of a tax administration vis-à-vis money. There has been no lack of modelling the underground economy via various methodologies (e.g., currency/demand Approach (Giles and Tedds, 2002), the electricity method (Schneider 2002), and models/indicators). Some of these models are specific to the

Canadian or Commonwealth experience, and include nonparametric models (Giles and Johnson 1999), fuzzy logic (Draeseke and Giles, 2002), and MIMIC (multiple indicators, multiples causes) (Tedds and Giles, 2000). While the research question has elements linked to economics, I am not satisfied that economics alone can help answer the question in the most robust possible manner.

## 1.7. Economic Psychology

Guth (1992) asserts that scientific psychology stems reaches back to the establishment of Wilhelm Wundt's laboratory in 1879. Psychology drew upon philosophy and physiology in its early years, and has branched out into various sub-disciplines and fields. Social psychology (e.g., attitudes and persuasion, Petty and Cacioppo 1981) appears particularly relevant to the research question.

Economics has focused on the measurable, and has not done a good job regarding one of the principle drivers of economics, wants. Wants have more parallels with psychology, yet the linkages have not been made or well examined. For example, two parallel models of human needs have been developed – one economic (Marshall) and one psychological (Maslow) – yet the models were developed independently and without linkages and implications on the adjacent discipline being considered or examined (Haines 1982).

The union of economics and psychology, or economic psychology (also called psychonomics (Gilad and Kaish 1982), has stemmed from a growing disillusionment with the predictive value of economic models. However, the models can become more robust if psychological paradigms such as cognitive assumptions, learning and expectations, attitude change, and motivation are included (Gilad and Kaish 1982). Albanese (1987) takes the argument further – new cross-disciplinary paradigms are required to bring the required elements of psychology into economics.

The consummate economic psychologist was Herbert Simon. Simon, however, argued that he was neither economist nor psychologist, but a citizen of the world(Augier and March 2003). Simon "found that most (if not all) interesting research questions fell across more than one discipline" (Augier and March, p. 136). However, not all economist or psychologists are pleased with the prospect of interdisciplinary research. For example, the relationship between the disciplines of economics and psychology also sparks debate (e.g., (Lunt 1996)) regarding which discipline sets the debate. Is it really that important which discipline dominates the agenda, or is it more important to ensure that the research produced is relevant to the demands of both disciplines or has practical applications?

Experimental economists are more open to the adoption of psychological constructs than some who "hold the view that we have only to specify the correct utilities and constraints if we want to explain human…behaviour" (Guth, 1992, p. 200).

Simon (1990) also states that the pursuit of any science is to discover the so-called invariants or laws. Simon argued that the invariants in much of science approach invariability, but do not quite make it to the absolute level. Simon said:

"Psychology does not much resemble classical mechanics, nor should it aim to do so. Its laws are, and will be, limited in range and generality and will remain mainly qualitative. Its invariants are and will be the kinds that are appropriate to adaptive systems. Its success must be measured not by how closely it resembles physics but by how well it describes and explains human behaviour" (Simon, 1990, p. 2).

In other words, psychology or economics should not aspire to be a physical science, but be satisfied to be what it is and do it well.

For my research question, the ontology in psychology will contribute significantly to my work. I am looking to develop a model that predicts who will have the tendency to participate in the underground economy given a set of economic circumstances – the union of psychological and economic principles. The tenets of Simon are worth keeping top of mind – one should not consider invariants, but seek to explain in the best possible way human behaviour vis-à-vis the underground economy.

## 1.8. What implications does my research have on the business school?

Pfeffer and Fong (2002) state "there is little evidence that business school research is influential on management practice, calling into question the professional relevance of management scholarship". Further, Pfeffer and Fong (2002) argue that the possession of a business degree is not insurance that acts as a guarantor of success or insulates against failure. Leadership, according to Pfeffer and Fong, is better developed via hands-on experience. Pfeffer and Fong suggest that business schools need to change their structure to ensure their relevance in four ways: 1) concentrate on experienced students, 2) focus on interdisciplinary issues, 3) teach a system of business thought, and 4) have a practicum. Pfeffer and Fong (2004) suggest that the strength of business schools should be

teaching current and future leaders critical thinking and learning skills which can then be applied to any problems or issues that they may face.

Starkey, Hatchuel and Tempest (2004) also suggest that the role of the business school is at a pivotal point for both the future and relevance of universities, from the systems of thought, practical applications (i.e., relevance), and interdisciplinary perspectives. The systems of thought could be learned in any degree program, and from a management perspective, a diversity of thought developed in different disciplines can be beneficial to an organization. However, the interdisciplinary or applied perspectives are where the business school can position itself as the laboratory (experimental or applied) that synthesizes the requisite elements of philosophy, economics, psychology, sociology, mathematics, and law via alchemical processes into viable solutions to current business issues. Indeed I have chosen the business school for the very reason that it provides the interdisciplinary environment that I feel is required to answer my research question.

As a manager, I have had the good fortune to pursue both an MBA and two management development programs (middle and executive level). My education has given me the tools of critical thought and analysis, while the management development programs have given me practical experience. When faced with a business issue that my employer did not have immediate answers, I turned to a business school to help me develop the thought processes and interdisciplinary aspect that I believe are key to developing hypotheses and applied management research. As mentioned at the start of this paper, from the philosophical empiricist perspective the conclusion reached was that while the question was well known, the answer was not. This is not to say that the answer is unknowable, merely not yet discovered, or documented in a public forum or adequately linked to the question. My employer could have looked internally or turned to a consultant to help with the answer, rather I have turned to the business school to help us develop a viable solution to a current business issue.

I have worked in many areas of the Canada Revenue Agency, including internal audit, human resources, finance and administration, collections, client services and customs. Within the Department of Fisheries and Oceans I have worked in finance and several roles at the executive level in information technology including data centres and enterprise architecture. However, I do not have experience with the compliance continuum. It could be said that my lack of experience in this area has piqued an interest in the compliance continuum. If I do not know about something I like to learn all I can about that area. I also believe that I can contribute to the understanding of the compliance continuum within

the CRA and the Department of Fisheries and Oceans by applying my desire to learn and understand the issues surrounding the underground economy in the lobster fishery. This research will broaden my knowledge and understanding of a current policy issue that impacts my organization in an area that is outside my area of expertise.

It is essential that organizations such as the CRA and the Department of Fisheries and Oceans have a sound understanding of the issues and challenges they face to enable the development of appropriate strategies and methodologies to deal with these issues. With this research initiative, my goals are to refine and further develop my analytical skills and to develop and expand my understanding of the compliance continuum. Ultimately, I want to develop a model that will help the Government of Canada forecast sectors in which the underground economy may develop or grow, thereby identifying, detecting and preventing similar circumstances. Is this not what business school should be? Business schools should be management philosophy centres of expertise for interdisciplinary issues – coaches – that help to guide organizations that have identified issues toward appropriate applied interdisciplinary solutions. For my research question, this is exactly the role that the business school has played.

## 1.9. Structure of the Dissertation

This dissertation is structured as follows. In Chapter 2 " Lobster Fishery Overview" I provide an overview of the history and value of the lobster fishery in Atlantic Canada. In Chapter 3 " Overview of Relevant Government and Non-Government Organizations and Fisheries Policy" I outline the policies and interests of these various organizations in the Atlantic Canadian lobster fishery. Next, in Chapter 4 " Tax Evasion Literature Review" I outline the major tax evasion literature, as well as providing an overview of " Statistical Fraud Detection" and " Collusion and the Underground Economy". After that, I outline the Methodology and Data" in Chapter 5 that will be used in the following three studies that make up the body of this dissertation. In Chapter 6 I then outline the general hypotheses for the three studies. In Chapter 7 " Study 1: Benford's Law" and Chapter 8 " Study 2: Collusion in the Lobster Fishery" I outline the development of variables for possible inclusion in a model developed in Chapter 9 "Study 3: Predicting Compliance in the Atlantic Canadian Lobster Fishery". Finally, I conclude in Chapter 10.

## 1.10. Summary

I have outlined my philosophical underpinnings of this research. Next I will outline the essentials of the Atlantic Canadian lobster fishery include a brief history and overview of its economic value to the region.

# 2. Lobster Fishery Overview

## 2.1. Introduction

In this chapter I introduce the Atlantic Canadian lobster fishery and how the underground economy in the lobster fishery came to light. I will describe the essential lobster biology as well as a history of the lobster fishery. I will describe the roles and responsibilities of the various government departments and agencies involved in the lobster fishery. I will discuss the cumulative economic impact of policy on the lobster fishery. The goal of the chapter is to acquaint the reader with the lobster fishery, government involvement in the fishery, and the value of the fishery.

In the mid-1990s, a growing underground economy was uncovered by chance in the Atlantic Canada lobster fishery. When the Royal Canadian Mounted Police proceeds of crime unit found a series of large money transfers into a Royal Bank branch in Halifax, they thought that drug money was being moved. It turned out to have been cash sales of lobster. It was reported in January 2002 that "as much as $200 million worth of lobster sales went unreported over three years in the late 1990s." (Canadian Broadcasting Corporation January 9, 2002). This represents $40 to $60 million in lost tax revenue (McLaughlin 2002), and a similar challenge for the common resource model for lobster fisheries management. The need for research in the lobster fishery was demonstrated by news reports in December 2006 that reported that "Fishermen sometimes try to hide their total catch when they exceed their quotas…occasionally working in collusion with processing companies" (Beeby 2006).

## 2.2. Essential Lobster Biology

The American Lobster (*homarus americanus*) is found off the eastern coast of North America and ranges from North Carolina to Labrador (Department of Fisheries and Oceans 2004b). The highest concentrations of lobster are found within 20km from the shoreline.

The Fisheries Resource Conservation Council (Fisheries Resource Conservation Council 1995 p. 10) describes the lobster habitat as:

> …a variety of combined bottom types from mud/silt through to bedrock. The most common near-shore habitat is rock and boulders overlying sand. While generally lobsters are found in commercial numbers at depths less than 35 m, they are also commercially

fished by the offshore fleet along the outer Scotian shelf at depths to 450m. A seasonal migration related to depth is well documented. In spring, lobsters move towards shallow waters to reproduce or hatch eggs.

Lobster becomes commercially valuable only after it is 6 to 9 years old, in its adult form (Fisheries Resource Conservation Council 1995). Lobster starts as larvae which hatch annually between July and September. The larvae or planktonic phase lasts from 3 to 10 weeks. After the planktonic phase, the lobster grows. As it grows, it moults its shell, and there are up to about 2 moults per year. The time to recruitment (recruitment is the point at which lobster becomes commercially viable and consistent with any regulatory restrictions such as size) varies by geographic location and environment conditions.

## 2.3. Atlantic Canadian Lobster Fishery

### 2.3.1. The 1800s

The Canadian lobster fishery has provided a means of income for many in Atlantic Canada since the mid-1850s (Ennis 1985; Fisheries Resource Conservation Council 1995). Management of the lobster stocks stemmed from early concerns for the future of the lobster stock through such discussions as those by Johnson (1879),(1883) and later Herrick (1911). These concerns originated from an increase in lobster landings in the 1890s due to environmental and ecological factors that made this fishery more attractive (Fogarty and Gendron 2004). For example, the attractiveness of the Canadian lobster fishery was due to American companies setting up lobster canning facilities in Canada due to declining catches in the United States (Fisheries Resource Conservation Council 1995). Size restrictions as a method of protecting lobster stocks thus came into existence in the 1890s (Field 1907).

### 2.3.2. 1900-1989

According to the FRCC (1995), lobster stocks underwent a decline that started in the 1890s, but continued until the mid-1920s. Landings did not recover dramatically until the mid-1970s. Lobster harvest gear and practices remained static for many years.

Bodiguel (2002) in his analysis of fishermen's responses to licensing strategies in Atlantic Canada provides a history of licensing strategies in the Lobster fishery. Before 1918, the lobster fishery was open and without restrictions. Licensing was introduced in 1918, but the license did not require any qualifications and did not restrict where or what number of lobster were caught. By 1945, licensees were restricted to a specific lobster fishing area, but there was no restriction on the number of lobster caught. The 1960s saw an increasing number of complaints about part-time lobster fishermen who were also employed outside of the lobster fishery. The lobster fishery became Canada's first limited entry fishery in 1967.

The common resource model of the lobster fishery was in effect before the 1960s, with the only controls being for protection of the resource (Bodiguel 2002). These controls included minimum sizes, the protection of berried (egg-bearing) females, use of lobster fishing areas, seasons, and types and number of lobster fishing traps. Bodiguel (2002, p. 274) summarized the regulatory evolution of the lobster fishery as follows:

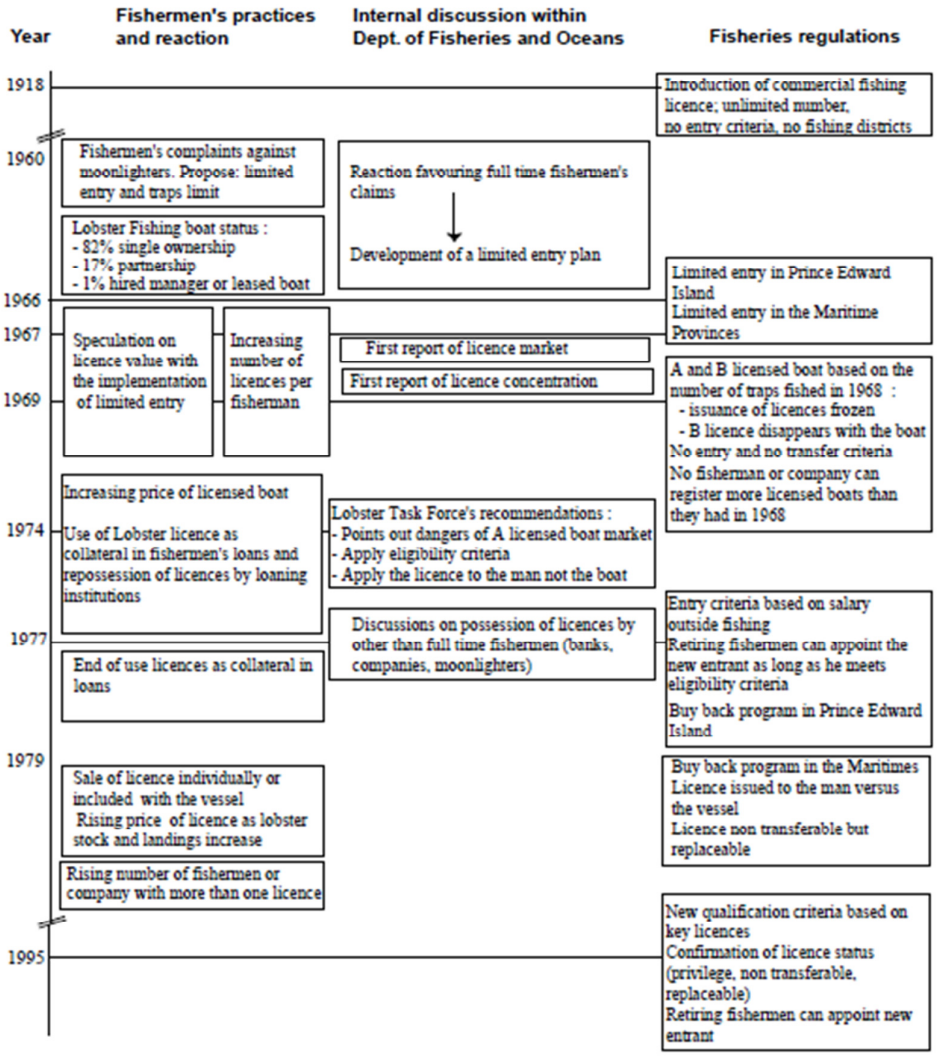



Fig. 1. Evolution of illegal practices in regard to fisheries regulation.

**Figure 2.1 Bodiguel's (2002) Summary of Regulatory Evolution in the Lobster Fishery**

Bodiguel also summarizes the economic and policy factors that have led to the illegal practices respecting licenses in the Atlantic Canadian lobster fishery. These practices discussed by Bodiguel, including the illegal trading or transfer of licenses, subsequent tax implications, and the illegal use of licenses as collateral, are beyond the scope of this dissertation.

### 2.3.3. 1990s

In the mid-1990s, a growing underground economy was uncovered by chance in the Atlantic Canada lobster fishery. When the RCMP proceeds of crime unit found a series of large money transfers into a Royal Bank branch in Halifax, they thought they were looking at drug money being moved. It turned out to have been cash sales of lobster. It was reported in January 2002 that "as much as $200 million worth of lobster sales went unreported over three years in the late 1990s." (Canadian Broadcasting Corporation January 9, 2002). This represents $40 to $60 million in lost tax revenue (McLaughlin 2002).

Another significant development in the Atlantic Canada lobster fishery was the Supreme Court of Canada's Marshall decision was released on September 17, 1999 (R. v. Marshall 1999). The Supreme Court affirmed a treaty right of Aboriginals to hunt, fish, and gather in pursuit of a moderate livelihood, based on treaties signed in the eighteenth century. The Supreme Court also ruled that regulation of this Treaty right might be justified for the purposes of conservation. In other words, notwithstanding the Supreme Court's decision, the federal government retained the authority and responsibility for regulating the fishery, with conservation as the key consideration (Department of Fisheries and Oceans 2004c). DFO's response to the Marshall decision included the voluntary retirement of licences held by non-Aboriginal fisherman to ensure that the overall size of the fishery remained constant and viable.

In the years since the Supreme Court decision disputes have ensued in the Atlantic Canada lobster fishery between DFO, Aboriginal fisherman and non-Aboriginal fisherman. Most Aboriginal groups in Atlantic Canada have signed deals with DFO and in turn have received commercial fishing licenses. One band in Burnt Church, New Brunswick did not agree to the 40 lobster trap limit, and asserted a right to set up to 5,000 lobster traps, and not to be governed by other regulations such as seasons (Canadian Broadcasting Corporation 2004). As a result of these disputes, non-aboriginal lobster fishermen were concerned over the future and viability of the lobster fishery.

### 2.3.4. 2000-Present

In 2000, the Department of Fisheries and Oceans (Department of Fisheries and Oceans 2004b) had issued 10,107 lobster licenses in Atlantic Canada (Nova Scotia, New Brunswick, Prince Edward Island and Newfoundland and Labrador). DFO (2004d) also recorded 43,815 metric tonnes (live weight) of lobsters landed in 2000 with a value of $513,214,000 (Department of Fisheries and Oceans 2004e). The lobster fishery is estimated to provide seasonal employment for upwards of 32,000 people (Fogarty and Gendron 2004).

Lobster fishermen have traditionally relied on other fisheries such as groundfish and pelagics in addition to lobster to make a living (Fisheries Resource Conservation Council 1995). Declines in the groundfish fisheries as well as increased markets for shellfish have made the lobster fishery a lucrative industry.

Technology has become more important to the success of the lobster fishery (Fisheries Resource Conservation Council 1995). For example, lobster fishing is more effective due to better boats, better navigational equipment (e.g., GPS, echo location devices), and better traps (size, design, material). These advances have allowed lobster fisherman to be more effective in their efforts by fishing in more areas and increasing the exploitation of the lobster stocks.

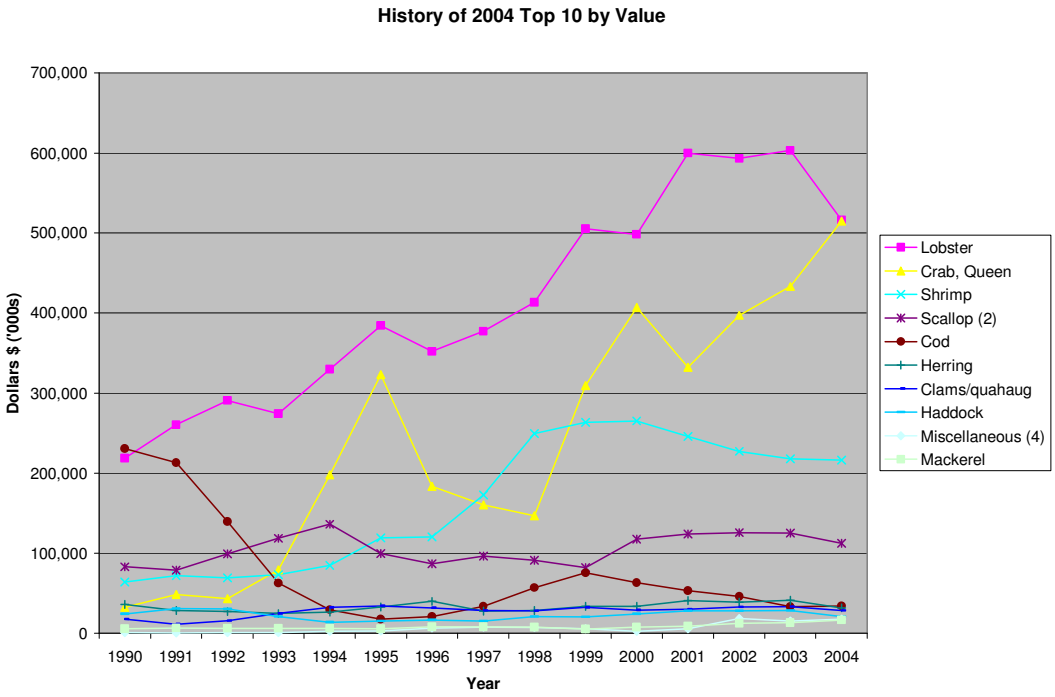
Currently, the regulatory framework for lobster includes:

- Catch restrictions on landing berried females;
- size limits;
- trap designs that permit the escape of undersized lobsters;
- limited entry via licensing of fishermen;
- restriction of trap types;
- restrictions on the number of traps;
- division of the lobster fishery into lobster fishing areas (LFAs); and
- fishing seasons determined by LFAs (Fisheries Resource Conservation Council 1995).

(Nova Scotia Department of Agriculture and Fisheries 2006)

## 2.4. Comparison to Top Fisheries in Atlantic Canada

The American Lobster (*homarus americanus)* is the most valuable sea product in Atlantic Canada (Department of Fisheries and Oceans 2004f). Since 1984, lobster has been replacing groundfish (e.g., cod) as the principal sea product by value. The value of lobster landings has increased by 135.9% from 1984 ($218,858 million) to 2004 ($516,248 million). The former principal sea product, cod, has had a significant decrease of 85.1% over the same period. The decline of the cod fishery has also led to the growth of Queen Crab (1,492%), shrimp (238.1%), mackerel (192.6%), clams (61.6%), and scallops (35.0%) (Department of Fisheries and Oceans 2005).




Based on data adapted from Department of Fisheries and Oceans (2005).

**Figure 2.2 History of Top Catches by Value**

The value comparisons shown refer to fishing as opposed to aquaculture. Aquaculture is defined by DFO (2006) as "… the farming of aquatic organisms in marine or freshwater. It implies

some form of intervention in the rearing or growing process to enhance production, such as regular stocking, feeding, and/or protection from predators and disease. It also implies individual or corporate ownership of the stock or crop being farmed."

The cod industry in Atlantic Canada suffered a collapse that started in the late 1980's and continued through the 1990's (Shelton, Rice, Rivard et al. 2003). The rapid decline in the cod stocks was due to a combination of overfishing and declines in the productivity of the stocks. Moratoriums were used to stop fishing in eight of the 10 cod fishing areas, or stocks, by 1994. Cod may still be fished during the moratorium as a bycatch or byproduct of other fishing ventures (Crowder and Murawski 1998). The timing of the decline of the cod fishery corresponds with the increase in lobster, crab, shrimp and scallops. These products have, in turn, become a valuable alternative to cod and have surpassed cod in relative value (Eurofish 2004). In 2003 Canada was fifth largest seafood exporter with over $4.5 Billion in exports, representing about 630,000 tonnes of seafood.

## 2.5. Summary

At this point I have shown that the lobster fishery is a high value fishery and has become an increasingly important fishery since the decline of the cod fishery. Further, there have been reports that there is both an underground economy in the lobster fishery and that the lost tax revenue is significant and represents $40 to $60 million in lost tax revenue (McLaughlin 2002). Next, other illegal activities in the lobster fishery include illegal practices respecting licenses in the Atlantic Canadian lobster fishery (Bodiguel 2002). Bodiguel also highlighted including the illegal trading or transfer of licenses, subsequent tax implications, and the illegal use of licenses as collateral. Last, the lobster fishery is a regulated fishery. It was this framework of illegal activity and lost tax revenue that led to my interest in the lobster fishery.

I will next review the various government departments and agencies that are involved in the regulation and administration of the lobster fishery.

# 3. Overview of Relevant Government and Non-Government Organizations and Fisheries Policy

## 3.1. Introduction

Many factors within the control of the government may contribute to the size of the UE, including: high tax rates, the tax mix between direct and indirect taxes, high social benefits contributions and transfers, high levels of regulation, high inflation, negative perceptions of the government, and level of commitment regarding future tax rates (Mirus, Smith and Karoleff 1994; Hill and Kabir 1996; Renström 1998; Schneider and Enste 2000; Brooks 2001; Schneider 2002)

From ocean to table, various levels of government plus international agencies are involved in monitoring and regulating the lobster. Still others are involved in taxing lobster production through various taxes (e.g., income taxes) and providing income security via an employment insurance regime. Courts are involved in the interpretation of laws and treaties thereby helping to define and shape policy.

There are also varying degrees of involvement with the lobster fishery. The primary level of involvement by both government and non-government organizations alike relates to policy development and enforcement that have a direct impact on the lobster fishery. For example, DFO sets regulations on trap size and construction that directly impact the lobster fisher. The secondary level of involvement by these organizations is in an auxiliary or enabler role. Health Canada and Environment Canada set toxicity levels for lobster and their habitats respectively. A primary organization such as the Canadian Food Inspection Agency (CFIA) then inspects lobster with a view to enforcing the Health Canada limits. Table 2.4.1 summarizes the primary and secondary organizations and their roles/jurisdictions. Further discussion on these roles/jurisdictions follows the table.

1 **Table 3-1 Overview of Organizations and Responsibilities**

| Organization | Level | Role | Responsibilities |
|---|---|---|---|
| Agriculture and Agri-Food Canada<br><br>http://ats-sea.agr.gc.ca | Federal Government (Canada) | Secondary | • Helps to build Canadian brand and market for agriculture and agri-food products, including seafood<br>(see Canadian Employment Insurance Commission 2005) |
| Department of Fisheries and Oceans<br><br>http://www.dfo-mpo.gc.ca | Federal Government (Canada) | Primary | • Regulates, licenses, determines harvest locations and times and minimum harvest sizes for stock management purposes.<br>• Conducts science to support policy and conservation decisions<br>• Enforces regulations and policies through such activities as patrols and prosecutions<br>(Canadian Food Inspection Agency 2005) |
| Canadian Food Inspection Agency<br><br>http://www.inspection.gc.ca | Federal Government (Canada) | Primary | The CFIA is responsible for enforcing the food safety policies and standards that Health Canada sets, including the:<br>Regulation of the import, export, processing, packaging, labelling, shipping, certification and storage of shellfish and ensures acceptable operating and sanitation conditions.<br>Evaluation of laboratories performing shellfish analyses (e.g., under Environment Canada's Canadian Shellfish Sanitation Program), and maintains a biotoxin surveillance program of shellfish growing areas.<br>regulates naming of food products (i.e., what can be marketed as "lobster" in Canada is restricted to the species *homarus americanus*) (Canadian Food Inspection Agency 2002; Canadian Food Inspection Agency 2005) |
| Health Canada | Federal Government (Canada) | Secondary | The CFIA is responsible for enforcing the food safety policies and standards that Health Canada sets.<br>(Health Canada 2006) |
| Human Resources and Skills Development Canada | Federal Government (Canada) | Primary | HRSDC administers the qualification for and payment of EI fishing benefits. (Canadian Employment Insurance Commission 2005) |

| | | | |
|---|---|---|---|
| http://www.hrsdc.gc.ca | | | |
| Canada Revenue Agency | Federal Government (Canada) | Primary | The Canada Revenue Agency (CRA) has two roles with respect to the fisheries. First, the CRA has the mandate to determine if an individual is considered a self-employed fisherman according to specific criteria (e.g., participates in the catch, not fishing for sport, plus owns/leases the boat to make the catch or owns/leases specialized fishing gear or has a species licence from DFO or has a risk of profit/loss). Only self-employed fishermen are qualified for Employment Insurance (EI). (Canadian Employment Insurance Commission 2004)<br><br>Second, the CRA has the role to administer Canada's tax legislation (Canada Revenue Agency 2006). |
| Statistics Canada<br><br>http://www.statcan.ca/ | Federal Government (Canada) | Secondary | Statistics Canada produces statistics on the Canadian population, resources, economy, society and culture. Statistics Canada may either generate these statistics directly, i.e., via census or indirectly, i.e., via statistics provided by other government departments and agencies.<br><br>Statistics Canada is legislated to serve the function of a central statistical agency, and it serves this function for the whole of Canada and each of the provinces (Statistics Canada 2004). |
| Atlantic Canada Opportunities Agency | Federal Government (Canada) | Secondary | The Atlantic Canada Opportunities Agency is the federal government department responsible for helping to build economic capacity in the Atlantic Provinces by creating jobs and enhancing earned incomes.<br><br>ACOA has supported research into the development of the seafood industry (Atlantic Canada Opportunities Agency 2004), and has supported various initiatives such as the University of Prince Edward Island's Atlantic Veterinary College Lobster Science Centre (University of Prince Edward Island 2004) and commercial ventures (e.g., lobster sales/processing) (Atlantic Canada Opportunities Agency 1999). |
| National Research Council | Federal Government (Canada) | Secondary | The National Research Council (NRC) is the Canadian Government's lead organization for research and development. The NRC has 20 research institutes, include the Institute for Marine Bioscience, with expertise in such areas as finfish and shellfish health and nutrition (National Research Council 2006a). The NRC also publishes the "Canadian Journal of Fisheries and Aquatic Sciences" (National |

| | | | |
|---|---|---|---|
| | | | Research Council 2006b). |
| Departments of Agriculture and Fisheries | Provincial Governments (Nova Scotia, New Brunswick, Prince Edward Island, Newfoundland) | Primary | Provincial governments have varied areas of responsibility, including:<br>Providing loans for procurement of fishing vessels;<br>Licensing fish processors<br>Licensing fish vendors<br>Participating in the management of fish harvesting<br>Collaborating on monitoring fish prices (Prince Edward Island 2006).<br>Supporting universities engaged in research. For example, the University of Prince Edward Island's Atlantic Veterinary College has the Lobster Science Centre (University of Prince Edward Island 2004). |
| Municipal Governments | Vendor permits | Secondary | Some municipalities (e.g., Cape Breton Regional Municipality in Nova Scotia) require vendors of lobster to be licensed (Cape Breton Regional Municipality January 26, 1999). |
| NAFO | International Organizations | Primary | NAFO is an intergovernmental fisheries science and management body. NAFO was founded in 1979 as a successor to ICNAF (International Commission of the Northwest Atlantic Fisheries) (1949-1978). NAFO's overall objective is to contribute through consultation and cooperation to the optimum utilization, rational management and conservation within the area bordered by the USA, Canada, France (i.e., St. Pierre et Miquelon) and Denmark (i.e., Faroe Islands and Greenland).<br><br>The NAFO Convention on Future Multilateral Cooperation applies to most fishery resources of the Northwest Atlantic except salmon, tunas/marlins, whales, and sedentary species (e.g. shellfish) (North Atlantic Fisheries Organization 2006). |
| FAO (UN)<br><br>http://www.fao.org/ | International Organizations | Primary | The Food and Agriculture Organization of the United Nations (FAO) provides advice and assistance to FAO Members on policies, plans and programs for fishery conservation, management and development including the development of development of fisheries technology. The FAO also provides advice to the fisheries industry in such areas as catching, handling, processing, distribution and marketing of fish and fish products (Fisheries and Agriculture Organization of the United Nations 2006). |
| International Council for the | | Primary | ICES coordinates marine research in the North Atlantic on a variety of species including lobster, snow crab, and scallops (International Council for the Exploration of the Sea 2005). |

| | | | |
|---|---|---|---|
| Exploration of the Sea (ICES CM)<br>www.ices.dk | | | |
| FRCC<br>http://www.frcc-ccrh.ca/eindex.htm | | Secondary | The Fisheries Resource Conservation Council (FRCC) makes public recommendations to the Minister of Fisheries and Oceans on conservation measures for the Atlantic fisheries. Recent work includes conservation frameworks for snow crab and lobster.<br><br>The Minister of Fisheries and Oceans has asked the FRCC to review and evaluate the Atlantic Lobster Conservation Framework developed by the FRCC in 1995. The review will identify successful and unsuccessful conservation measures and recommend changes. Other issues such as the scientific knowledge base, harvesting efforts and fishing practices, environmental and ecosystem factors will be considered in the review (Fisheries Resource Conservation Council 2006). |
| Fishermen and Scientists Research Society (FSRS)<br>http://www.fsrs.ns.ca | NGO | Secondary | The FSRS is a group of fishermen and scientists that collaborate on research of mutual interest (Fishermen and Scientists Research Society 2003). |

Of the departments, agencies and other organizations outlined, I believe that there are five that have a significant impact on the lobster fishery from the perspective of this dissertation. I will examine the roles and responsibilities and key impacts of the Canada Revenue Agency, Human Resources and Social Development Canada, the Department of Fisheries and Oceans, and the courts.

## 3.2. Canada Revenue Agency

There are four federal income tax rates (Canada Revenue Agency 2005b) -- 15% for $35,595 or less, 22% for the amount between $35,595 and $71,190, 26% between $71,190 and $115,739, and 29% on amounts more than $115,739. Provinces are free to set their own income tax rates:

| Province | Rate One | Rate Two | Rate Three | Rate Four |
|---|---|---|---|---|
| Nova Scotia | <$29,590<br>8.79% | 29,590-59,180<br>14.95% | 59,180-93,000<br>16.67% | >93,000<br>17.5% |
| New Brunswick | <$32,730<br>9.68% | 32,730-65,462<br>14.82% | 65,462-106,427<br>16.52% | >106,427<br>17.84% |
| Newfoundland and Labrador | <$29,590<br>10.57% | 29,590-59,180<br>16.16% | >59,180<br>18.02% | n/a |
| Prince Edward Island | <$30,754<br>9.8% | 30,754-61,509<br>13.8% | >61,509<br>16.7% | n/a |

**Table 3-2 Selected Provincial Tax Rates**

(Canada Revenue Agency 2005c; Canada Revenue Agency 2005d; Canada Revenue Agency 2005e; Canada Revenue Agency 2005f)

Fishermen, as self-employed individuals, are entitled to various expenses which are deducted from their taxable income. Eligible expenses include bait, ice, salt, fuel and oil, gear, insurance, interest expenses, food, licences, nets and traps, salaries, wages, benefits, office expenses, and repairs (Canada Revenue Agency 2005a). Tax policy is set by the Department of Finance while the Canada Revenue Agency is responsible for tax collection and compliance activities.

## 3.3. Human Resources and Social Development Canada (Employment Insurance)

Fishermen are the only self-employed individuals that qualify for EI benefits, and qualify based on the value of their catch. Only fishermen can have two claim periods per year due to the seasonal nature of the fisheries (summer and winter). While the types of fish species caught and catch values have increased since the introduction of the cod moratorium, the qualification amounts have not changed. As a result, 96% of fishermen qualified for benefits in 2003/2004 with catch values that exceeded the threshold requirement of $5,500. The threshold requirements vary according to regional unemployment rates and are established by the Employment Insurance Regulations. Fishermen earn approximately $31,100, of which approximately 28% is from Employment Insurance.

Fishing Employment Insurance claims have increased in the four Atlantic Provinces (Nova Scotia, 7.1%, Prince Edward Island, 4.4%, Newfoundland and Labrador, 3.4%, and New Brunswick, 2.1%). Multiple claims (i.e., claims that are for the maximum two periods per year for fishermen) have increased the most in Atlantic Canada, compared to the national average of 35.3% (Prince Edward Island, Newfoundland and Labrador, and New Brunswick, 45%, and Nova Scotia, 34%) (Canadian Employment Insurance Commission 2005).

## 3.4. Department of Fisheries and Oceans

### 3.4.1. Lobster Regulations

DFO's Atlantic Fishery Regulations (1985) sets out the specific policies that apply to different species. For lobster, the regulations dictate:

- Lobster Fishing Areas (LFAs);
- Open and close times for LFAs and restrict fishing within those areas;
- Possess a license;
- The conditions under which lobster can be transported;
- The conditions under which lobster traps can be transported (e.g., for sale, storage or repair);

- That the minimum length of the carapace of harvested lobsters ("in relation to a lobster, the distance from the rear of either eye socket to the rear end of the carapace, measured along a straight line parallel to the centre line of the carapace of the lobster") is 63.5mm (in all areas except Newfoundland where the minimum is 81mm) and ban the trade or possession of undersized lobster (known as shorts);
- A ban on the trade or possession of female, egg-bearing lobsters (known as berries) as well as a ban on the removal of eggs or possessing female lobsters that have traces of recent egg-bearing;
- How lobster is to be fished (i.e., from a vessel with a lobster trap);
- Characteristics of lobster traps (i.e.,. dimensions of 125 cm x 90 cm x 50 cm, construction materials, escape panels for undersize lobster, )
- The use of tags for each trap
- The maximum size of the vessels used in the inshore lobster fishery

The Fisheries Act (1985) provides criteria and licensing information for the storage, transport and sale of lobster during the closed season from lobster pounds (i.e., holding tanks).

The DFO regulations have the intent of controlling lobster fishing effort and activity to minimize lobster mortality. These are input controls as opposed to output or quota controls. Further mortality controls include size and gender restrictions (Gendron and Brêthes 2002). Despite these measures, the Fisheries Resource Conservation Council (1995) has supported further reductions in effort. According to Ricker (1975) (see Gendron and Brêthes 2002 p. 899), fishing effort controls assume that "fishing mortality ($F$) is proportional to fishing effort ($f$), according to the relation $F = qf$, where $q$ is the catchability coefficient, i.e., the fraction of a fish stock caught by a unit of fishing effort. If $q$ were constant, the impact on fishing mortality of reductions in fishing effort could be easily predicted. However, in practice, $q$ is rarely constant and is influenced by a number of factors affecting the vulnerability of lobster to traps, as well as by the effectiveness of the fishing gear". Unlike the inshore lobster fishery which has effort controls, the offshore is controlled by a total allowable catch (TAC) (Department of Fisheries and Oceans 2000). The offshore fishery is not within the scope of this dissertation.

There has long been speculation that there may be a forthcoming policy shift from input controls to output controls in the form of an "individual tradable quota" or ITQ (Seed 1999) may be planned for the inshore lobster fishery, and this may influence the behaviour of lobster fishermen.

## 3.5. Courts

As a result of the Supreme Court of Canada's Marshall decision which was released on September 17, 1999 (R. v. Marshall 1999), the Department of Fisheries and Oceans was tasked with implementing the treaty right of Aboriginals to hunt, fish, and gather in pursuit of a moderate livelihood, based on treaties signed in the eighteenth century. Two hundred twenty seven commercial licences were dedicated to the First Nations affected by the Marshall decision between 1999 and 2001. A further 97 licences were issued in 2002. The majority (126) were for lobster, followed by a variety of other species such as crab, scallop, shrimp, herring and other species. Under the Marshall Response Initiative, 166 boats were transferred to First Nations from November 1999 through January 2002. Almost $148 million has been spent on retirement packages for non-native fishermen and the procurement of new boats and gear through March 2002. Part of the Initiative is the voluntary retirement of commercial licences and the transfer of these allocations to First Nations. The overall objective was to maintain the level of fishing effort, with the net effect of reducing the number of commercial licences and increasing the number of First Nations licences (Department of Fisheries and Oceans 2004g).

## 3.6. Cumulative Economic Impact of Policy

From a regulatory and policy perspective, there are a lot of issues in the lobster fishery, and have spawned industry specific research on regulation (e.g., (Townsend 1990; Emery 1993; Holland, Gudmundsson and Gates 1999; Gendron and Brêthes 2002; Clark, Munro and Sumaila 2003), illegal fishing (e.g., (Sumaila, Alder and Keith 2005), enforcement issues (e.g., (Anderson 1989) and fisheries regulation (e.g., (Smith 1969). These fisheries specific articles also build on a robust base of regulation (e.g., (Stigler 1971; Posner 1974; Schmalensee 1989), and common property theories such as Hardin's (1968) classic work on "The Tragedy of the Commons". Regarding the Atlantic Canadian lobster fishery, the various regulations that are concerned with the management of the lobster have the following impacts:

| Regulation/Policy/Event | Fishermen's Response | Acts as… |
|---|---|---|
| Input controls on effort required to catch lobster | Maximize effort to maximize number of lobster caught thereby maximizing income | A common resource management issue "Tragedy of the Commons" (Hardin 1968) |
| Employment Insurance benefits | Catch enough lobster to qualify for EI benefits | "entitlement effect" (Barron, McAfee and Speaker 1986) |
| Income Tax | Catch enough lobster to qualify for EI benefits. This income needs to be declared and taxed. After reaching the threshold for qualifying for EI benefits, there may not be any incentive to declare additional taxable income. Tax paid is minimized by paying tax only on the amount of income required to reach the EI benefit threshold. | "Substitution effect" As tax rates increase, individuals have a disincentive to work harder (i.e., they substitute leisure for labour). (Lewis 1982)<br><br>The income effect is "the effect on the taxpayer's economic behaviour as a result of the change a tax makes to a person's income" (James and Nobes 1996 p. 310). The income effect and substitution effect may be at odds with each other. The overall outcome for each taxpayer will depend on which effect is greater. |
| Marshall Response | Overall size of lobster fishery unchanged, but non-native component is further restricted. Those participating in the buyback can continue to work in the industry. | Effort in non-native component increases, and conservation goals are frustrated (i.e., non-native component overfishes) (Townsend 1990; Holland, Gudmundsson and Gates 1999; Clark, Munro and Sumaila 2003) |
| Effort controls, gear restrictions | Catch as much as can in period available | Tragedy of the Commons (Hardin 1968)<br>High value fisheries (e.g., lobster) regardless of regulatory mechanism(s) in place have highest incentive to cheat. Non-compliance is maximized when the benefits of cheating outweigh the costs. (Anderson 1989)<br>"short period of risk" i.e., relative ease of disguising non-compliance since a lower probability of detection increases probability of cheating (Anderson 1989) |
| Anticipation to move to ITQ (Emery 1993; Seed 1999) | Maximize catches to ensure income protected if move to ITQs | Rent seeking behaviour (Anderson 1989) |

**Table 3-3 Cumulative Economic Impacts of Regulation**

## 3.7. Summary

In isolation the economic impacts of the individual regulations have been well studied. However the interaction and impact of multiple regulations on one industry do not appear to be well understood or researched. While beyond the scope of this dissertation, a study or model of the cumulative impacts of multiple regulations on a single item industry would be interesting.

From this overview I would like to highlight the following key elements of the lobster fishery:

a. "as much as $200 million worth of lobster sales went unreported over three years in the late 1990s." (Canadian Broadcasting Corporation January 9, 2002).
b. This represents $40 to $60 million in lost tax revenue (McLaughlin 2002)
c. The need for research in the lobster fishery was demonstrated by news reports in December 2006 that reported that "Fishermen sometimes try to hide their total catch when they exceed their quotas…occasionally working in collusion with processing companies" (Beeby 2006).
d. Illegal practices in the lobster fishery are not a new phenomenon as discussed by Bodiguel (2002). These illegal practices include the illegal trading or transfer of licenses, subsequent tax implications, and the illegal use of licenses as collateral
e. The American Lobster (*homarus americanus)* is the most valuable sea product in Atlantic Canada (Department of Fisheries and Oceans 2004f). Since 1984, lobster has been replacing groundfish (e.g., cod) as the principle sea product by value. The value of lobster landings has increased by 135.9% from 1984 ($218,858 million) to 2004 ($516,248 million). (Department of Fisheries and Oceans 2005).
f. Fishermen are the only self-employed individuals that qualify for EI benefits, and qualify based on the value of their catch. (Canadian Employment Insurance Commission 2005).

In summary, the lobster fishery is a high value fishery with a history of illegal activity that puts it at a reportedly high risk of illegal and unreported economic activity. To better understand how statistical fraud detection may be used to identify which fishermen are trying to hide their true total catch, extends statistical fraud detection techniques to the lobster fishery. This research will aid the Canadian Government in developing methodologies to detect tax and fisheries management issues in

this industry. Academia will also benefit from the extension of these techniques to an industry that has previously not been researched from this perspective. This research will further determine the characteristics of the underground economy in the Atlantic Canadian Lobster fishery and those that participate in this economy, and will help develop a statistical model that will provide assurance regarding the reliability of catch data.

It is essential that organizations such as the Canada Revenue Agency and the Department of Fisheries and Oceans have a sound understanding of the issues and challenges they face to enable the development of appropriate strategies and methodologies to deal with the underground economy in the lobster fishery. Ultimately, I want to develop a model that will help the CRA detect and forecast conditions under which the underground economy may develop or grow, thereby identifying, detecting and preventing similar circumstances.

In the next chapter I will explore the body of research on tax evasion and the underground economy from its beginnings in the economics of crime literature and its growth and development as a multi-disciplinary research area in its own right. The literature review on tax evasion will help to pinpoint possible areas for contribution to knowledge.

# 4. Tax Evasion Literature Review

## 4.1. Introduction

Having discussed some essential lobster biology, history, value and the underpinnings of illegal activity in the lobster fishery, I will now outline a literature review of tax evasion research. I will also explore research on the underground economy and introduce statistical fraud detection and Benford's Law. To better understand how statistical fraud detection may be used to identify which fishermen are trying to hide their true total catch, this chapter also provides a critique of Nigrini's (1996) application of Benford's Law to taxation data and Lu, Boritz et al.'s (2006) application of Benford's Law to accounting data. Finally, I will discuss the methodologies proposed for my research and the contribution that it will make.

In this chapter I explore the body of research on tax evasion. Most of the literature in this domain can trace its routes back to the literature on the economics of crime and specifically to Becker's (1968) essay on the economics of crime. From that essay, the literature on tax evasion developed through the 1970's to present. The literature can be divided by primary focus, that is theoretical and applied. Alternatively, the literature can be classified by the primary discipline such as economics, sociology, accounting, psychological or multidisciplinary.

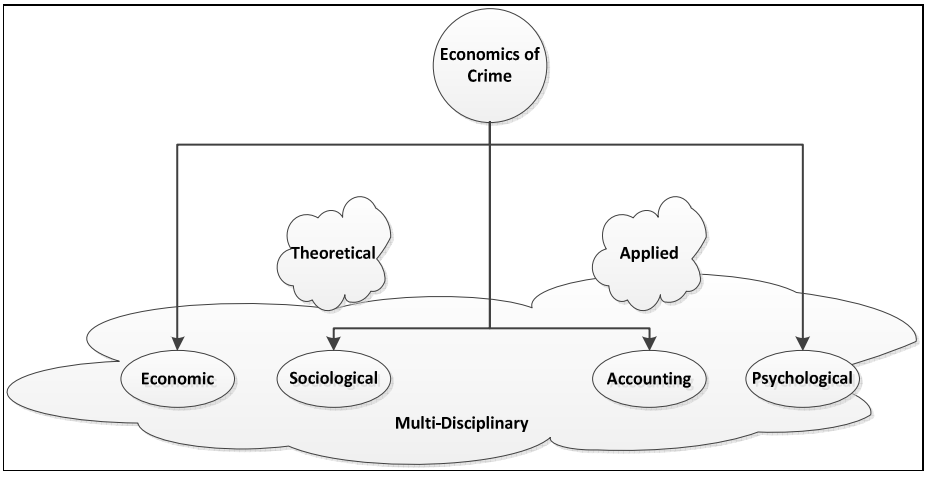



**Figure 4.1 Primary Disciplines of Tax Evasion Literature**

## 4.2. General Overview of Underground Economy Research

Academia, tax administrations (e.g., Canada Revenue Agency or CRA), and non-governmental organizations (e.g., International Monetary Fund, OECD) alike are all interested in modeling and combating the UE. Depending on the industry, other government departments are also interested in analogues to the UE (e.g., the Department of Fisheries and Oceans is interested in the underreporting of catches) (Beeby 2006). The literature has examined factors underlying tax compliance, including ethics (Henderson and Kaplan 2005), culture (Cummings, Martinez-Vazquez and McKee 2001), risk aversion (Giles and Johnson 1999), economic factors (Ritsema, Thomas and Ferrier 2003) and tax policy (Hill and Kabir 1996).

***Underground economy:*** is defined for the purposes of the Government of Canada as unreported revenue (that is suppressed sales and taxable supplies) for tax purposes – income tax, GST/HST, and excise tax. Further, it is restricted to domestic tax, not technical ("tax avoidance") and not directly related to criminal activity (Office of the Auditor General of Canada 1999).

This definition is consistent with the Department of Finance, but more restrictive than the Statistics Canada definition, which is simply that the UE is economic activity that is missed in the estimation of GDP (Drummond, Ethier, Fougere et al. 1994). Broader definitions include all illegal activity, barter, and home-based work (e.g., do-it-yourself work) (Schneider and Enste 2000). The Office of the Auditor General's definition will be used for the purposes of this research as this is consistent with the origins of my research question from a Government of Canada context.

Becker's (1968) essay on the economics of crime and punishment addressed the growth of mid-20$^{th}$ century crimes, including the growth of tax evasion and other white collar crimes. Becker sought to answer the question of how many resources and what quantum of enforcement should be used to enforce various laws. The result of this paper was that the optimal amount of enforcement was dependent on the cost of enforcement, the nature of the enforcement actions (e.g., prison versus fines), and the responses of offenders to changes in enforcement. In general, the probability of punishment decreased the number of offences committed. Becker used the general economic argument that the supply of offences is related to the expected utility of the offence being greater than the alternative utility of other presumably more legal pursuits. It was further argued that for certain crimes, fines may be the optimal punishment if the fine repayed the perceived debt to society. Assuming a fine is of

sufficient size, it could function as a deterrent. However, if it was not of sufficient size, it could be regarded as the cost of doing business. Becker (Becker 1968p. 204) states that the "anticipation of conviction and punishment reduces the loss from offenses and thus increases social welfare by discouraging some offenders".

Allingham and Sandmo (1972) built on Becker's (1968) essay to analyze the individual taxpayer's decision on whether or not to evade taxes and by how much. First a taxpayer must choose one of two strategies: 1) declare their actual income; or 2) declare less than their actual income. The payoff depended on whether or not the underreporting is detected. The model had five elements: 1) actual income; 2) declared income; 3) tax rate; 4) probability of being investigated; and 5) a penalty rate greater than the tax rate payable on the difference between declared and actual income. The taxpayer would then choose to declare income that maximizes their utility. Allingham and Sandmo acknowledged the oversimplification of their model in that it lacked a wide variety of external factors. Allingham and Sandmo then introduced the effects of risk aversion to the declaration decision. It was found that the amount of income declared increased, decreased, or remained constant with similar changes in risk aversion. From the tax policy perspective, Allingham and Sandmo found that increased penalty rates or probability of detection were substitutes for each other. Further it was noted that while actual income would only be known to the taxpayer, the tax authority would know the taxpayer's profession and be able to increase the probability of investigation for those reporting less than the average income for their profession. Allingham and Sandmo intended their explorations to be a starting point for discussion and the basis on which to add more and more complexity such as multiple tax rates, and the impact of tax policy decisions such as tax rates, penalty rates, and the probability of being investigated. Allingham and Sandmo's was the first of several papers in the 1970s that have formed the basis of tax evasion research.

Yitzhaki (1974) extended Allingham and Sandmo's (1972) model by adding a proof that showed that tax evasion decreases with increased tax rates and that declared income changes more slowly than actual income. Srinivasan (1973) describes a continuum of taxpayers from those who will always submit an honest return to those who submit an honest return only if it is optimal to do so. In all other respects, Srinivasan's model was a parallel model to Allingham and Sandmo.

Friedland, Maital et al. (1978) used a game-simulation to demonstrate some determinants of tax evasion. Fifteen Israeli students participated in the simulation. Each participant was instructed that

that they would receive a salary for each 'month' in the simulation. The salary was the same for all participants. The simulation lasted for four periods of 10 months each. A declaration of income and income tax (25% or 50%) would need to be paid for each month. Participants would be subject to a random check each month. Fines would then be imposed if any tax was evaded. Both the random checks (1 or 5 times out of 15 participants) and fines (15 times the amount evade or 3 times the amount evaded) were according to a predetermined schedule that was shared with participants. Participants were informed that their objective was to maximize their net income and that a small reward proportional to each participant's net income would be made at the end of the four periods. Friedland, Maital et al. (1978) found that as the tax rate increased, the probability of tax evasion increased from 50% to 80%. However, the extent of evasion was more related to age, gender and marital status. For example, women were more likely to evade than men, but underreported a smaller proportion of their income. Last, larger fines tended to be better deterrents than more frequent audits. Friedland, Maital et al. (1978) cautioned that replication in several countries was required to possibly negate any cultural effects related to the sample used.

Song and Yarbrough (1978) completed a survey of tax ethics, correlates of tax ethics and taxpayer attitudes. Their premise was that a high level of tax ethics was required in any taxation system based on voluntary compliance. A model of taxpayer compliance was developed that pooled a self-assessment of the legal environment, situational factors and tax ethics into a filing decision. In the survey, tax evasion ranked only slightly higher than petty theft in relative severity. The probability of detection was the single most important factor in determining compliance behaviour. Income, political efficacy, and general distrust of people were the primary explanatory variables of tax ethics in a regression. Gender and employment status were not shown be to significant explanatory variables. Another finding was that ensuring fairness by closing loopholes that were perceived to be consistently accessible to all taxpayers was the primary method suggested for improving overall compliance. This was seen as an indicator that taxpayers still had faith in the system but wanted fairness and consistency in opportunities for tax avoidance.

Pencavel (1979) added to the economic model developed by Allingham and Sandmo (1972). Pencavel had three changes. First, he challenged the assumption of linear tax schedules. Second, he proposed a different penalty structure. Last, he looked at the impact of a joint hours of work and income declaration decision. Pencavel concluded that the model set forth by Allingham and Sandmo

was too basic – it did not take into account progressive tax rates, a complex penalty structure nor the hours of work allocation decision that one might be apt to find in actual scenarios. Allingham and Sandmo (1972) acknowledged the shortcomings of their model, but Pencavel's point was that empirical research was required to validate the economic models with actual behaviour.

These papers have formed the basis for the next three decades of tax evasion research. This research can be classified into several subcategories: economic models, behavioural, estimation, correlates and detection.

## 4.3. Correlates

I believe it is particularly useful to study the correlates of tax evasion for several reasons. First, it is useful to know the relationships of variables that may either increase or decrease tax evasion behaviours. From a policy perspective governments can then attempt to influence this behaviour to either increase the beneficial relationships or decrease the unbeneficial behaviours. Second, I believe that knowing the spectrum of correlates is useful to the researcher when examining a data set. For example, if a data set has measures that are known to be correlated to tax evasion, then it follows that those measures should be included in whatever model the researcher may be developing. Alternatively, the researcher may attempt to control these variables to determine their effect in the particular context being researched. Known interactions can also be tested.

Jackson and Milliron's (1986) literature review examined, amongst other things, key tax compliance variables. The Internal Revenue Service (IRS) identified sixty four variables that were linked to tax evasion. Fourteen of the sixty four were considered to be key, and these included: age, gender, education, income level, withholding income tax at source, occupation, compliant peers, ethics, fairness, complexity, IRS contact, sanctions, probability of detection, and tax rates. Jackson and Milliron then assessed whether the studies reviewed showed that the increased levels of the variable was associated with increasing compliance, decreasing compliance or uncertain effects. The authors categorized the studies by methodology (e.g., surveys, experimental, analytical and regression modeling).

| | Age | Gender | Education | Income | Withholding | Occupation | Compliant peers | Ethics | Fairness | complexity | IRS contact | Sanctions | P(detection) | Tax rates |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Survey + | 9 | 7 | 2 | 4 | 2 | 3 | 12 | 11 | 7 | | | 4 | 8 | |
| Survey - | 1 | | 6 | 2 | 1 | 5 | | 1 | | 1 | 3 | 2 | | 2 |
| Survey 0 | 5 | 6 | 3 | 3 | 1 | 4 | | | 3 | 3 | 2 | 3 | 3 | 4 |
| Exp + | 2 | 2 | 2 | | | 1 | | 4 | | 1 | 1 | 2 | 1 | |
| Exp - | | 1 | 1 | 5 | | | | | | | 1 | | 1 | 1 |
| Exp 0 | 3 | 2 | 1 | 1 | | 1 | 2 | | 3 | | | 4 | 4 | |
| An + | | | | | 2 | | | | | | | 2 | 4 | 3 |
| An - | | | | 1 | | | | | | | | | 1 | 2 |
| An 0 | | | | | | | | | | | | 1 | | |
| Reg + | 3 | | 1 | 1 | 4 | 1 | | | | | 1 | 2 | 2 | |
| Reg - | 1 | | | 4 | | | | | | 1 | | | | 1 |
| Reg 0 | | | | | | | | | | | | | | 2 |
| Total+ | *14* | 9 | 6 | 5 | *8* | 5 | *12* | *15* | 7 | 1 | 2 | 10 | *15* | 3 |
| Total - | 2 | 1 | 7 | *11* | 1 | 5 | 0 | 1 | 0 | 2 | 4 | 2 | 3 | 6 |
| Total 0 | 8 | 8 | 0 | 4 | 1 | 5 | 2 | 0 | 6 | 3 | 2 | 8 | 7 | 6 |

**Table 4-1: Summary of Correlates (Jackson and Milliron, 1986)**

Exp = experimental + = positive correlation

An = analytical - = negative correlation

Reg = regression analysis 0 = no correlation

Table 4.2 is meant to illustrate the challenge when reporting variables with relationships to tax evasion. First, there was no unequivocal evidence of relationships. However, some variables were clearer than others (e.g., age and probability of detection can generally be expected to have a positive relationship with tax evasion). Second, the direction of the relationship can have as much to do with the restrictions on variables, model specifications (e.g., linear vs. curvilinear), or statistical artefacts (e.g., interactions between education and income). Third, the questions in, for example, survey research are not standardized. Jackson and Milliron reported that direct versus indirect questions and framing changed the degree of admitted noncompliance. Last, this type of overview is invaluable when faced with a dataset – if nothing else, it gives a starting point for model and hypothesis development.

Lewis (1982)'s book on the psychological elements of taxation examined the link between attitudes, behaviour and taxation. Lewis began by discussing general principles behind taxation. First was simplicity. A taxation system should be relatively simple and understandable by taxpayers. The second principle was equity, meaning that taxpayers pay what they ought to pay. A third principle was the ability to pay. This principle was linked to equity and was more difficult to define. Nevertheless, the majority of taxpayers should be able to afford the tax burden imposed on them. The last principle was efficiency, especially in the normative sense. For example, taxes on petroleum products in anticipation of future scarcity may be considered to be a desirable market distortion. Other principles may include flexibility, compatibility and certainty.

Lewis (1982) then linked economics and psychology but stated that the economic aspects and explanations of tax evasion could not adequately explained without an understanding of the attitudes and beliefs of taxpayers (i.e., psychological aspects). Lewis then looked at the structure of attitudes. Attitudes were described as the link between ideology and values on one hand and behaviours and actions on the other. Next, Lewis believed that not all taxpayers will behave the same due to psychological and sociological considerations. This was offered as the reason that the economic models do not hold for all taxpayers as the statistical tests mean that psychological models hold for a greater number of taxpayers than by chance alone. Using this methodology, psychologists may also be able to determine how different groups of taxpayers react to different tax policies. This in turn could lead to better or more effective tax policy.

Lewis (1982) suggested that survey data could be used to study psychological behaviours. One advantage was the widespread nature of surveys (i.e., national perspective). However, there may

be issues with social desirability biases, concerns regarding confidentiality, and consistency (e.g., Lewis and Wahl 2010). From Lewis' review of the tax evasion literature, he elaborated a revised model of tax evasion. From the perspective of the tax authority, there were four elements: 1) fiscal policy, tax structure and constitutional structure; 2) enforcement structure and policies; 3) behavioural assumptions vis-à-vis taxpayers and 4) the estimated mix between evasion and compliance. Similarly from the taxpayer perspective, there were four corresponding elements: 1) attitudes regarding fiscal policy, tax structure and constitutional structure; 2) taxpayer perceptions of the enforcement structure and opportunities for evasion; 3) taxpayer characteristics; and 4) actual compliance or evasion. The primary link to attitudes and behaviour was made by Lewis to the work of Fishbein and Ajzen's (1975) classic work in this field. In this model, beliefs, attitudes and behavioural intentions were the precursors to behaviour. Lewis noted that Fishbein and Ajzen's work did not indicate how these beliefs and attitudes could be changed or influenced. Surprisingly, Lewis neglected to address Petty and Cacioppo's (1981) seminal work on attitudes and persuasion and their elaboration likelihood model, and the precursor to later framing research. Conceivably Lewis' book was in press at the time of publication of Petty and Cacioppo's book.

Kirchler's (2009) book continued the examination of the link between psychology, economics and tax evasion. Kirchler initially grouped the determinants of tax evasion into five perspectives: 1) political including fiscal and tax policy; 2) social psychological including norms, perceptions and motivations; 3) decision-making including rational and psychological elements; 4) self-employment; and 5) the quality of the interaction between the tax authorities and the taxpayers. These perspectives guided the remainder of his book.

After a review of fiscal and tax policy, Kirchler (2009) discussed the social representations of taxation. The main principle of this section was that taxpayers' subjective perceptions of the income tax regime were thought to be more important than facts. One persistent perception was that taxes represented a loss (e.g., investment opportunities forgone). The loss would be more evident to self-employed individuals who paid taxes directly versus individuals who were on a tax withholding regime. Kirchler then reviewed word association studies – that is, studies that looked at what words subjects associated when they were asked what comes to mind when they were asked to think about the words "taxes" or "taxation". Generally, the resulting word associations were then grouped by the

subjects' occupation and further grouped into themes. For example, there were technical, negative, necessity, and nil responses. Negative associations were highest for self-employed subjects.

Kirchler (2009) then explored the impact attitudes on behaviour by linking Ajzen's (1991) theory of planned behaviour to attitudes. Attitudes and behaviours are defined as follows:

| |
|---|
| ***Attitude*** "psychological (behavioural) tendency that is expressed by evaluating a particular object or situation with some degree of favour or disfavour" (Kirchler 2009, p. 49) |
| ***Behaviour*** is defined as "intentions and actions with respect to the attitude object" (Kirchler 2009, p. 49) |

Kirchler evaluated previous research as being voluminous on the tax-attitude linkage, but difficult to compare due to the various methodologies and measures of attitudes. According to Ajzen's (1991) theory of planned behaviour, there were intermediary steps between an attitude and a behaviour. For example, behavioural intentions were thought to mediate between attitudes and norms on one hand, and behaviour on the other. Kirchler concluded that attitudes and tax evasion may be linked, but this was an indirect measure or proxy for the link between behaviour and tax evasion.

Kirchler (2009) then reviewed norms. Norms were further subdivided into personal, social and societal norms. In tax evasion research, the measurement of norms, attitudes and beliefs often overlap and there does not seem to be a clear measurement or delineation in the research between these groups. Kirchler reported that Fishbein and Ajzen's model of behavioural intentions required the influence of norms, beliefs and attitudes. Nevertheless, personal norms were deeply held and likely formed the basis for a personal tax ethic. Kirchler suggested that this personal tax ethic seems to be linked to "moral reasoning, Machiavellianism, egoism, norm dependency, and values" (Kirchler 2009 p. 59) as well as honesty and altruism. Personal norms could be influenced by guilt and shame – for example, if a taxpayer believed that they may be caught evading and this led to public shame, their personal tax ethic may be strengthened. Personal tax ethics may be influenced in turn by a taxpayer's interaction with their peers, especially their peers' frequency and acceptance of tax evasion. These interactions could be termed social norms. An example would be the likelihood of evasion is higher if a taxpayer believed that evasion was a widespread and accepted behaviour. This was especially true if the taxpayer had a higher degree of identification with the social group in question. Last, societal norms were indicative of the national norm or cultural standards, Kirchler suggested that these societal

norms were reflected in the laws and policies governing taxation in a given country. This was evidenced by the varying degrees of tax compliance across countries. The collective, national attitudes and norms vis-à-vis tax evasion made up the national tax morale.

Kirchler (2009) then reviewed fairness vis-à-vis tax evasion. In this context, Kirchler defined fairness from the perspective of justice:

| |
|---|
| ***Distributive justice*** "If rewards and costs are borne equally and distributed fairly between partners, exchange is balanced and the relationship is judged to be satisfactory…(and refers to a) taxpayers' perception of the balance of their share to the commons relative to the benefits they are entitled to receive, and to the contributions others make relative to their share of public goods." (Kirchler 2009, p. 75) |
| ***Procedural justice*** "refers to the processes of resource distribution. In other words, if people perceive the formula used to distribute resources (benefits and costs) as fair, then procedural fairness is high" (Kirchler 2009, p. 75) |
| ***Retributive justice*** is the "perceived appropriateness of sanctions in case of norm breaking" " (Kirchler 2009, p. 76) |

Tax compliance decisions and the influence of audits, fines and framing were also examined by Kirchler (2009). Audit rate is fairly well studied as a variable. In general, the higher the audit rate, the lower the rate of evasion. A cut-off rule where taxpayers reporting less than a specified threshold would be automatically audited produced the highest degree of theoretical compliance. The reported empirical impact of fines on reducing tax evasion behaviour has been mixed. However, it appears that there was a negligible effect of punishment of evasion behaviour, but a more pronounced effect of detection probability (i.e., getting caught is more effective than the punishment). Empirical studies also found that higher tax rates led to more evasion. Repeated audits of non-compliant taxpayers had different empirical versus actual results. In empirical studies, repeated audits appeared to reduce evasion. In actuality, repeated audits had little effect on the degree or incidence of evasion behaviour. Some explanations included that the audit did not uncover all evasion and that the auditee needed to regain what was lost as a result of the previous audit.

Kirchler (2009) then paid special attention to the self-employment relationship with tax evasion. First, the self-employed simply had more opportunity for evasion as they paid their taxes

directly as opposed to having taxes deducted at source. Second, the self-employed viewed taxes as a loss – this is perhaps a reference point issue since the self-employed were more directly involved in the calculation and payment of taxes out of pocket. Next, taxes were perceived by the self-employed as a limit to their freedom. As a result, the self-employed responded by pursuing actions to regain the perceived loss of freedom (e.g., evasion).

The last major area that Kirchler (2009) examined was the relationship between the tax authority and taxpayers. This also included the messaging between the tax authority and taxpayers, and included the study of framing. Framing was discussed in more detail in the review of Hasseldine and Hite's (2003) research. Kirchler pointed out that perceptions of justice were important to the taxpayer-tax authority relationship. That is, if the procedural and distributive aspects were perceived as fair, the more likely that taxpayers were to comply. Kirchler briefly mentioned audit selection tools including Benford's law as a method of detecting behaviour traces in quantitative data. Last Kirchler suggested that a crime-and-punishment model of tax enforcement was less likely to yield long-term compliance than awareness and education appeals. While framing of communications was mentioned, the psychology of persuasion and attitude change was not. Like Lewis (1982), Kirchler neglected to address Petty and Cacioppo's (1981) seminal work on attitudes and persuasion and their elaboration likelihood model, and the precursor to later framing research.

Eriksen and Fallan (1996) studied the influence of tax knowledge on attitudes towards taxation. Previous research had assumed that the level of knowledge about taxation influences attitudes towards taxation. To test the influence of tax knowledge pre- and post-tests of two groups of student subjects was conducted. The control group was a group of students enrolled in a marketing class. The experimental group was a group of tax law students. The pre-test was used to demonstrate that at the beginning of the academic year, both groups of students had the same level of attitudes.

Cebula and Paul (2000) developed a pedagogical note on tax evasion, its determinants and extent. Cebula and Paul suggested that income tax evasion was a good teaching example of economic concepts. Their paper outlined the basic economic principles of tax evasion, the challenges of not having directly observable behaviour, and the use of various empirical methods to estimate and study the effects of the underground economy and policy initiatives to address it. Cebula (2004) also linked the degree of tax evasion with the interest rate on American bonds. He determined that the higher the yield on tax-free municipal bonds relative to the taxable yield on United States Treasury bonds, the

lower the income tax evasion rate for personal income tax. Cebula suggested that increasing the usage of tax-free municipal bonds was a method for reducing or eliminating income tax evasion. Cebula's rationale for this was that investing in tax-free bonds (tax avoidance) was a substitute for tax evasion. Nevertheless there was no direct evidence that this was indeed the case and no alternative explanations were offered (e.g., this is perhaps an indicator of another phenomenon versus a causal relationship). Cebula and Saadatmand (2005) examined other determinants of tax evasion. In this case it was found that the degree of income tax evasion was negatively related to the rates-thus the higher the audit rates and lower the degree of evasion observed. Further evasion was positively related with the personal income tax rate-thus the higher income tax rate that higher the amount of evasion observed.

Kirchler, Muehlbacher et al. (2009) examined effort and tax evasion. The authors discovered that the lower the amount of effort required producing income lead to overall higher rates of evasion. As a result, the authors suggest that audit efforts be focused on auditing tax returns that demonstrate income from lower-effort sources (e.g., capital gains).

Broadway, Marceau, and Mongrain (2002) examined joint tax evasion. The premise of the paper was that outside of income tax evasion which operates on a principle-agent framework, other forms of tax evasion (e.g., value added tax evasion) required the collaboration of two taxpayers. Broadway et al. made the assumption that the collaborating taxpayers faced an equal probability of detection and sanctions. However, this assumption would only hold true if the two taxpayers were businesses. If the two taxpayers were a business and an individual, the probability of detection may be equal, but the individual in the transaction was unlikely to face sanctions. The next assumption by Broadway et al. was that the collaborating taxpayers form a long-term, repeated trade relationship. Again, this assumption may hold true in some instances, but there are other scenarios that are easily imagined where the trade relationship is on an infrequent or one-time basis.

Broadway, Marceau, and Mongrain (2002) described the options of collaborating taxpayers as a prisoner's dilemma. When the government made a policy decision to increase sanctions, the payoffs decreased in the tax evasion segment, and had varying implications for different taxpayers. For example, Broadway, Marceau, and Mongrain argued that increased sanctions decreased the payoff in the deviation quadrant, but have a lesser effect on the cooperation strategy. Thus, there was potential of an increase in the number of tax evaders that participated in cooperative efforts to avoid detection and sanctions. The key to the model was the ability of the taxpayers to commit (or not) to

cooperatively avoid paying taxes. Those who could not commit transacted in the legal economy. Those who were increasing dishonest would be more and more likely to transact in the underground economy and undertake activities to avoid detection. This study was an economic model and was not tested empirically.

Chang and Lai (2004) examined the effect of deterrence measures on collaborative tax evasion and social norms. Their study undertook to develop a model of collaborative tax evasion, specifically between buyers and sellers and incorporates social norms into this transaction. The authors concluded that their model showed increasing deterrence in fact increased evasion. Chang and Lai's paper built upon the Broadway, Marceau, and Mongrain (2002) paper. Chang and Lai noted that the study of collaborative tax evasion was not well documented despite the widespread nature of collaborative tax evasion. The key difference between this paper and the Broadway paper was that Broadway assumed a lasting repetitive relationship whereas Chang and Lai assumed a random nonrecurring relationship between buyers and sellers. By assuming a random nonrecurring relationship with the variables, social norms were assumed and played a key in the Chang and Lai model. They hypothesized that increasing deterrence measures increased mutual gain for both buyers and sellers. Chang and Lai also believed that their model explained the discrepancies in the empirical evidence on the effects of deterrence vis-à-vis the rate of tax evasion. This is because of the hypothesized deterrence relationship in collaborative evasion was different (positive – the more deterrence, the more evasion) than the deterrence relationships in a single actor model (negative – the more deterrence, the less evasion). Taxpayers can be divided into three groups: 1) non-evaders, 2) collaborative evaders, 3) and non-collaborative evaders.

In Chang and Lai's (2004) study, it was assumed that any of the deterrence measures were imposed on one but not both of the collaborative parties. Typically the fines were imposed on the vendor and not the consumer. As such, other than the lack of warranties or after sales support, the consumer had little to lose in the transaction. In their analysis, Chang and Lai concluded that imposing deterrents on the consumer was a more effective enforcement strategy than deterrence efforts aimed at the vendor. One drawback to the Chang and Lai study was that it is an economic model and was not an empirical test of their assertions.

Murphy (2004) looked at the use of different types of deterrence solutions such as threat and coercion in attempting to improve compliance. Murphy concluded that threat and coercion may not be

effective tools and that trust with the tax authorities was more important in achieving compliance. A questionnaire was administered via mail to 6000 Australian tax scheme investors and resulted in 2,292 useable surveys. The questionnaire consisted of procedural justice, trust, resistance, outcome favourability and demographic variables. The results of Murphy's analysis showed that tax scheme investors were less trusting of tax authorities than taxpayers who were not tax scheme investors. Tax scheme investors were also more likely to have had adjustments made to their returns. The study concluded that the tax scheme investors were less trusting of tax authorities had been impacted by their participation in these tax schemes. Murphy then created a structured equation model, and found that the pathway from trust to resistance was significant. This suggested that evasion could be predicted by lower levels of trust. Murphy concluded that from the policy perspective if sanctions are perceived as unjust, they may also have the effect of undermining the trust between taxpayers and the tax authorities. As such, tax authorities need to be careful in how sanctions are introduced and imposed.

Kirchler and Wahl (2010) developed a tax compliance inventory. This inventory was meant to assess the variability of surveys on tax compliance and their reliance on non-standardized questions and questionnaires. By using a standardized questionnaire the ability to compare self-report research across studies would be increased. The inventory can be used in several ways including its components or entire survey itself. Self-reports of income tax evasion behaviour may have had a social desirability bias in their responses. The lack of standardization and validation does not permit the comparison of results across studies and may explain some of the conflicting results from survey research. Kirchler and Wahl acknowledge previous scales (Pestieau and Possen 1991; Braithwaite 2003; Braithwaite 2009) and included some elements of those scales in their inventory as part of the motivational postures subscale. However, the rationale for using only part of the Braithwaite scale is unclear. The remaining Kirchler and Wahl scales included voluntary tax compliance, enforced tax compliance, tax avoidance, tax evasion and two direct questions on tax cheating. Factor analysis confirmed the groupings. Construct validity was assessed by analyzing the correlations between the scales. Lower correlations should indicate that the scales are measuring different constructs, and this assumption was mostly met. To permit cross-cultural studies the scales need to be translated from English or German. Some tax avoidance questions relate specifically to Austrian law. As a result, those questions would need to be adapted to country-specific scenarios. No discussion of the requirement for further scale validation to ensure that the translations and adaptations did not change the intent of the survey questions was made.

The development of a standardized set of scales to measure the constructs noted makes sense. However, only time will tell if the inventory takes hold as an empirical tool since it is a relatively recent development. Only one peer-reviewed article to date (Wahl et al, 2010) has employed the inventory.

Richardson (2006) looked at the determinants of tax evasion between different countries. In a survey of 45 countries non-economic factors such as complexity have the most impact on tax evasion, followed by education, source of income, fairness and tax morale.

Eriksen and Fallan (1996) chose to have the students respond anonymously to the questions in order to elicit direct and honest answers. However anonymity posed a statistical issue because they could no longer match the subject's answers in a match samples designed the authors needed to use tests for two independent samples where equal variance in the two populations is assumed. However this ensures a more conservative test than in the matched samples scenario. It was hypothesized that differences between the groups at the start of the academic year with respect to the level of tax knowledge would be minimal. The overall score on tax knowledge was slightly higher for the marketing students and was not significantly different from students taking the tax law course. It was also expected that the students who take in the tax law course at the end of the academic year would have better tax knowledge than the students in the marketing class. The authors found a significant increase in tax knowledge for the students taking the tax law course. Nevertheless there is no significant difference between the two classes in the scores for attitudes towards taxation between the pre-and post-test. The tax law student overall perception of fairness in the tax system increased between the pre-and post-test. The authors then concluded that one method of preventing tax evasion was to increase the tax knowledge of larger groups of the population in order to improve their overall tax ethics and perception of fairness of the tax system.

Erard and Feinstein (1994) research honesty and income tax evasion in the so-called tax compliance game. Some models of income tax evasion alleged that all taxpayers will underreport or evade taxes if given the opportunity. Nevertheless research also suggested that some taxpayers are inherently honest and will make an honest declaration of income regardless of other incentives to evade taxes. The authors used a game theory approach to show that including inherently honest taxpayers in the mix is required to improve empirical predictions as well creating more realistic policy options.

The policy options that were discussed included ideology and whether or not disapproval of particular government policies may have triggered tax evasion behaviours. Secondly the link between the interactions between taxpayers and auditors or other representatives of the tax authority specifically taxpayers may report more honestly if they feel are they were being treated courteously and respectively. Other factors influencing honesty in the reporting system included perceptions of fairness of the tax laws themselves and whether the tax burden was distributed fairly amongst different social groups last other influences on honesty may have been the perceptions about whether others are able to defeat taxes and easily or have a reasonable probability of getting caught.

Alm and McKee (2004) studied tax compliance as a coordination game by using experiments to investigate compliance behaviour when tax returns are selected for further audit based on the returns deviation from the average report for all other taxpayers. The simplest method of selecting returns for audit is a random sample in which all taxpayers face a fixed probability of audit regardless of what they reported in their tax declaration. Many tax agencies use random audits as a component of their audit strategy, but not as the sole component of their audit strategy. The most common method for selecting returns for audit is probability based on the information reported by taxpayers on their tax returns. The probability of an audit therefore becomes variable and endogenous, in other words depending both on the behaviour of the tax authorities and the taxpayers themselves.

Endogenous audit selection rules can include the tax authorities knowledge of the taxpayers compliance history. This can apply to both the future and previous tax returns. Another possible rule is based upon the variations from the average for each individual return. This is the basis of the Internal Revenue Service's discriminant index function or DIF that uses the Internal Revenue Service's previous experience with a particular taxpayer and how that taxpayers return compares to all other file returns for a given period. Because one's audit chances depend on the taxpayers behaviour relative to all other taxpayers, the implication is that if taxpayers can communicate with each other they should be able to ensure that their DIF score is lower and thus ensure that they are below the audit threshold. The authors argued whether or not this method audit selection encouraged or discouraged tax compliance and what can tax authorities do to overcome any of the associated noncompliance or policy concerns. Alm and McKee (2004) generated four questions:

1. Can taxpayers coordinate of zero compliance -- equilibrium when audits are based solely on the DIF rule?

2. Can taxpayers coordinate of zero compliance -- equilibrium when audits are based solely on the DIF rule applied with the cut off?
3. An information sharing by taxpayer communication help taxpayers coordinate of the zero compliance Nash equilibrium when audits are based solely on the DIF rule? and
4. Can the tax authority increased tax compliance by combining the DIF audit rule in a random audit rule?(Alm and McKee 2004, pp. 302-304)

Student subjects were used to participate in each session of the experiment each session lasted 25 rounds and used a currency called tokens during the experiment. All of the tokens that they earned during the experiment could be redeemed for cash at the end of experiment at a rate of six tokens per dollar. At the beginning of each round subjects were assigned a random amount of income. This income was the same for all subjects in a given round. Subjects then had to choose what level of income to report and had to pay taxes at the rate of 30% on reported income. After their declaration subjects could be selected for audit in which any unpaid taxes could be discovered. If discovered, the subject paid the unpaid taxes plus the penalty. Alm and McKee examined the four questions that were generated above by varying the audit selection rules. It was found that the ability to coordinate between taxpayers produced compliance. However, when a random audit rule was added compliance increased relative to the coordination treatments alone without the random audit rule in place. In the absence of any coordination, compliance was found to be higher when the random audit rule was used in conjunction with the DIF rule. Subjects were unable to coordinate without some kind of discussion and that these discussions with no random audits enabled coordination between taxpayers. The addition of a random audit rule to the ability to have discussions is able to mitigate this coordination issue to a large degree but still enabled some degree of coordination.

Porcano (1988) studied the effects of eighteen variables that might impact upon tax evasion via discriminant analysis. Porcano found that the significant correlations were dependent on the situation faced by participants in his study. For example, participants were asked a series of questions under one of three scenarios: first, if they were hypothetically evading taxes; second if they had previously underreported income; and last, if they had previously evaded taxes. Discriminant analysis was used to see if the variables could be used to correctly classify evaders and non-evaders. All three scenarios did a reasonably good job of classifying evaders and non-evaders. Only three variables -

honesty, opportunity to evade based on income source, and perceptions of existing evasion contributed significantly to all three scenarios.

| | Dependent Variable | | |
|---|---|---|---|
| Independent Variables | Hypothetical Evasion | Previous Underreporting | Previous Evasion |
| Age | n/s | n/s | n/s |
| Gender | n/s | - | - |
| Marital Status | + | n/s | n/s |
| Occupation | n/s | n/s | + |
| Opportunity to Evade Income source | + | + | + |
| Perceptions of existing evasion | - | - | - |
| Attitudes towards existing evasion | + | n/s | n/s |
| Exchange evasion | n/s | + | + |
| Fair Treatment | n/s | n/s | n/s |
| Risk Attitude | n/s | n/s | n/s |
| Tax Avoidance | n/s | n/s | n/s |
| Honesty | + | + | + |
| Tax Rate | - | n/s | n/s |
| Total income | + | n/s | n/s |
| Procedural justice | n/s | - | - |
| Complexity | n/s | n/s | n/s |
| Taxpayer Experience | n/s | n/s | n/s |
| Previous Evasion | n/s | n/a | n/a |

**Table 4-2 Porcano (1988) Correlations**

Antonides and Robben (1995) correlations included:

| Independent Variables | Evasion |
|---|---|
| Financial strain | + |
| Opportunity (e.g., source of income) | + |
| Deterrence | - |
| Anti-cheating social norms | - |
| Negative Tax Attitudes | + |
| Social comparison (i.e., inequity) | + |
| Social orientation (i.e., free rider problem when maximum benefits and minimum taxes are observed) | + |
| Learning (i.e., deterrence) | - |
| Education (i.e., increasing) | + |

**Table 4-3 Antonides and Robben (1995) Correlations**

Weigel, Hessing and Elffers (1987) argued that individual indicators of evasion needed to be measured and modeled from the social psychological or individual perspective. Weigel, Hessing and

Elffers classified variables from previous research as tax evasion instigators (i.e., those variables that were associated with evasion) or constraints (i.e., those variables that minimize or reduced the proclivity to evade). The model proposed consisted of five social conditions and five psychological conditions, which could lead to tax evasion behaviour. The five social conditions included financial strain and social norms as instigators, and opportunity, legal controls and social controls as constraints. The five psychological conditions included personal financial strain and personal orientation (self versus community) as instigators, and perceived opportunity, perceived risk of punishment, and intolerance of tax evasion as constraints. Tax evasion behaviours were identified via self-reports and behavioural outcome measures. Weigel, Hessing and Elffers theorized that the social conditions would have broad, predictable effects while the psychological conditions would not have uniform effects. Weigel, Hessing and Elffers further theorized that the individual acted as a mediator between the social conditions and tax evasion behaviour. Weigel, Hessing and Elffers argued that the development of objective measures of evasion behaviour needed to be developed in order to assess the validity of self-reports of evasion. Last, other demographic variables such as age, marital status, and gender were not necessary additions to the model as these variables could be mediated by or be analogues to the variables proposed in the model.

Elffers, Weigel and Hessing (1987) then sought to provide experimental evidence for their model (Weigel, Hessing and Elffers 1987). Elffers, Weigel and Elffers first divided a sample of tax returns into those that had demonstrated evasion through audit and those that had no indications of evasion. Both groups were subsequently re-audited to confirm group membership. Anonymous self-reports were used to try to confirm group membership as determined by the audit classification. No significant correlation was found. Elffers, Weigel and Elffers then decided to further subdivide the self-report groups into accurate and inaccurate self-reports of evasion behaviour. This resulted in four groups two for each of evasion and non-evasion as confirmed by the audits. Next, scores on instigations were converted to z-scores and added together to create an instigation index. Higher scores on this index indicated a greater propensity to evade taxes. Similarly, scores for constraints were converted to z-scores, and summed to create a constraints index. Higher scores on this index indicated higher constraints against tax evasion. It was found that there were both accurate and inaccurate self-reports. The inaccurate self-reports included boasting by non-evaders (i.e., they boasted that they evaded taxes when it was shown otherwise) and denial by evaders (i.e., they denied tax evasion when it

was show otherwise). Notwithstanding anonymity, self-presentation or conformity to what is "expected" seemed to dictate whether or not participants honestly self-reported tax evasion behaviour. Elffers, Weigel and Elffers concluded that future research should focus on the interaction of psychological and social variables on the frequency and extent of tax evasion (e.g. (Hessing, Elffers and Weigel 1988)).

Wenzel (2004a) examined the effect of social norms on tax compliance and specifically how taxpayers incorporated some social norms and rejected others in making a compliance decision. In some respects, this described the process by which social norms are internalized by individuals and become part of their internal norms. Wenzel discussed self-categorization theory and the impacts on tax compliance research. First, taxpayers would be more likely to be influenced by social norms when the reference group is part of the same as the taxpayer's self-categorization. Second, the norms and values of the group were internalized as the part of the taxpayer's norms and values.

Wenzel (2005) further examined the causal relationship between ethics, norms and tax compliance, and specifically whether or not tax ethics and social norms were true predictors of tax compliance behaviours. The alternative explanation was that tax ethics and social norms were rationalizations of one's own behaviour. Wenzel's results indicated that tax ethics caused tax compliance. The taxpayers' perceptions of social norms affected their own personal tax ethics only if the taxpayer had a strong identification with the comparison group.

Wenzel (2004b) also studied the effect of personal and social norms as moderators of deterrence. In this particular study he determined that personal norms moderated the effects of deterrence such as sanctions. Wenzel interpreted this finding as meaning that deterrence was only effective when individual ethics were weaker. Wenzel also determined that the perception of social norms also moderated the effects of deterrence. However this finding only held when respondents in Wenzel study did not have a strong national identity, in this case, Australians. If however there were strong tax honesty social norms, the social norms increased the effects of sanctions.

Slemrod (1989) examined the costs of compliance when filing income tax returns. Some types of income such as self-employment income and capital gains/losses had higher costs associated with compliance. As the tax rate increased, the more professional tax advice sought and the greater the number of hours invested in preparing tax returns for those with both self-employment and capital

gains income. Slemrod argued that lowering the tax rate would reduce the compliance burden and perhaps increase compliance.

Sandmo (2005) wrote a retrospective of tax evasion theory from the seminal Allingham and Sandmo (1972) paper. From the original paper, Sandmo suggested that the model of tax evasion was unrealistic in many respects since it looked at the tax evasion choice in isolation from other economic choices. Further the decision to evade taxes was not likely to be spontaneous at tax filing time but made at some point much earlier in the tax year. Extensions to the original model included labour supply, source of income, corporate income tax, and social norms. From the policy perspective, if tax evasion was not rampant, lower tax rates or other measures may not be efficient. This suggested as well that a certain amount of evasion should be expected. Nevertheless, social norms played an important role in the evasion decision, so having too much evasion would lead to the perception that it was socially acceptable. From the research and theoretical perspective, theory has not looked at the impact on consumer prices.

Dubin, Graetz and Wilde (1987) completed an econometric analysis of non-compliance in the United States. The premise behind their analysis was that there was uncertainty over whether or not the tax gap in the United States was growing, shrinking or staying about the same due to conflicting reports from the Internal Revenue Service (IRS). Dubin, Graetz and Wilde also classified previous research into four groups. First, the economics of crime approach focused on the portfolio-risk decision of the taxpayer (Mossin 1968; Dubin and Wilde 1988) in which the taxpayer allocated their taxation portfolio between declared and undeclared income according to their risk tolerance. Second, the model developed by Allingham and Sandmo (1972) and subsequent extensions to that model were classified as decision theory models of tax evasion. The third group was based on principal-agent theories of tax evasion. The last group was based on game theory. Dubin, Graetz et al. suggest that the principal-agent (Reinganum and Wilde 1985; Border and Sobel 1987) and game theoretic models of tax evasion (Graetz, Reinganum and Wilde 1986) allow the tax authorities to adjust their audit strategy based on information collected from taxpayers. For example, this is what the IRS does with their Taxpayer Compliance Monitoring Program (TCMP). The IRS develops the Discriminant Index Function to help better target their audit resources. In Dubin, Graetz and Wilde's analysis, they found that there was a negative trend in both audit rate and compliance, and theorized that perhaps audits were more efficient and were uncovering greater recoveries in each audit than previously thought.

Graetz and Wilde (1985) took a further look at the myths and facts of tax compliance. The first myth Graetz and Wilde examined was "we know how much noncompliance there is and have a clear sense of its causes" (Graetz and Wilde 1985, p. 356). Estimating the degree of noncompliance was a challenge and had various challenges both at the macroeconomic and individual levels. Due to the hidden nature of the economy, the ability to accurately forecast the results based on these data sources is difficult. The Internal Revenue Service's Taxpayer Compliance Monitoring Program was a good example of a country-specific initiative to estimate the degree of non-compliance. Nevertheless, the TCMP cannot assess the extent of non-filer noncompliance.

The second myth examined was "tax noncompliance is an excellent occasion for rather straightforward application of the economics of crime model" (Graetz and Wilde 1985, p. 357). This, of course, referred to Becker's (1968) seminal economics of crime paper. In general, Graetz and Wilde believed that the economics of crime model was too simple and took into account only the taxpayer and not other agents. The model also ignored the rights of the individual and state. There was also a wide variety of definitions of noncompliance. Typically noncompliance was broken down into three categories (tax evasion from illegal sources, tax evasion from legal sources, and tax evasion due to uncertainty or grey areas in the law). The breakdown of noncompliance varied from country to country as did the political, legal and moral issues that surround addressing non-compliance in the three categories. In addition, the use of criminal sanctions required a higher standard of proof (i.e., wilful non-compliance) than did civil sanctions. Graetz and Wilde also noted that unlike other crimes, taxpayers, for the most part (except for non-filers), provided information via their declarations and tax returns.

The third myth was that "the tax compliance problem would disappear if, for example, tax rates were lowered or the income tax were replaced by a consumption tax" (Graetz and Wilde 1985, p. 359). Graetz and Wilde reported that results and evidence were mixed on these policy changes. However, noncompliance would remain high if a policy shift implemented an alternative form of taxation that was not subject to withholding. Graetz and Wilde concluded that tax compliance would not be easily resolved without further research and prudent policy initiatives.

Kesselman (1989) discussed a general equilibrium model of tax evasion with an intersectoral approach. An intersectoral approach was chosen due to the higher occurrence of evasion in specific sectors (e.g., self-employed, rents, farming) and especially those that did not have tax withheld or

information reporting requirements. It was assumed that tax evasion was quite high for illegal income, except where taxpayers wished to reintegrate a portion of their earnings into the legitimate economy. Kesselman's (1989) model made the following assumptions:

- The formal and informal products were imperfect substitutes. Consumers would often prefer goods and services produced via the formal economy due to such considerations as warranty support, quality, and reputation;
- The informal economy had limitations to entry, including psychic costs, risk tolerance, and efficiency of their efforts to conceal their illegal activities;
- Workers in the formal and informal economies participated fully in one or the other, except where the labour force and products were homogeneous and perfect substitutes.

In cases were the labour force and products are homogeneous and perfect substitutes, Kesselman's (1989) model showed that any increases in the tax rate drove all of the production into the informal economy.

## 4.4. Tax Evasion and Non-Compliance

In this section I review various models, approaches and additional variables of interest to the tax evasion and non-compliance issue. I start with Andreoni, Erard and Feinstein's (1998) paper, then move to reviews of signal detection theory models, taxpayer as gambler, measurement of tax evasion, contingency theory, microeconomic tests for evasion, prospect theory and economic and psychological responses. I conclude the section with reviews of additional variables in addition to the correlates discussed in Section 4.3, including, the influence of tax rate, source of income, tax policy, enforcement and audit selection, the impact of information returns, and other variables.

### 4.4.1. Andreoni, Erard and Feinstein

Andreoni, Erard and Feinstein (1998) published a paper on tax compliance and started by stating that tax compliance and the pursuit of reducing tax evasion originated with the implementation of taxes. Tax compliance issues speak to equity, efficiency and incidence. For example, evasion efforts implied that the equity of the tax regime was distorted – the greater the degree of evasion and associated compliance costs, the higher the tax rate must be to compensate. The purpose of Andreoni, Erard and Feinstein's paper was to review the tax compliance and evasion literature to that point. Nevertheless, the scope was restricted to exclude the underground economy, value added versus income tax, and corporate tax evasion. Andreoni, Erard and Feinstein structured their paper in eight principal sections: 1) facts on tax compliance; 2) a model of the compliance decision; 3) interactions between taxpayers and the tax authority; 4) data sources and methodologies; 5) explaining non-compliance; 6) audit regimes; 7) morals and social dynamics; and 8) tax complexity and amnesty. I will summarize each of the sections in turn.

1) Facts on tax compliance – Andreoni, Erard and Feinstein (1998) started by outlining the primary method of measuring tax compliance as the tax gap. The tax gap was defined as "the difference between the federal income taxes households actually owe, and what they report and pay voluntarily on a timely basis" (p. 810). This rudimentary concept introduced a fundamental philosophical question, specifically, how can the tax authority estimate the tax gap, and what was the amount evaded. The Taxpayer Compliance Measurement Program (TCMP) of the Internal Revenue Service (IRS) was one method for estimating the amount of tax evaded by conducting detailed audits on a stratified random sample of tax returns. The TCMP had limitations. For example, the TCMP

cannot estimate the tax evaded by non-filers and it could only effectively estimate the degree of underreporting for items that require information reporting. Nevertheless, the TCMP estimated that 40 percent of households in the United States underpaid their taxes in 1988. Twenty five percent of taxpayers were found to have underreported by $1,500 or more. The IRS used the results of the TCMP to establish a proprietary Discriminant Function that was used to score each tax return on the likelihood that it has indicators of evasion. Other methods of detecting underreporting included matching information provided by taxpayers to information provided by such sources as employers and financial institutions. The IRS estimated that close to 92 percent of income that ought to be reported according to information returns was reported accurately. From this I conclude that the highest risk of tax evasion is on sources of income that are not subject to information returns.

2) A model of the compliance decision -- In this section Andreoni, Erard and Feinstein (1998) discussed the compliance models of Allingham and Sandmo (1972), and Yitzhaki (1974) . In addition, Pestieau and Possen (1991) postulated that tax evasion may influence the choice of occupation (e.g., self-employment may provide greater opportunities for evasion). Andreoni et al catalogued over 25 various extensions to the Allingham and Sandmo model and concluded that it was not possible to derive a model that predicted the effects of all permutations and combinations.

3) Interactions between taxpayers and the tax authority -- Andreoni et al continued to outline the deficiencies of the Allingham and Sandmo model. First, the Allingham and Sandmo model assumed that the probability of audit was constant, when in reality it was not. This had led to the development of a framework that suggested that the probability of audit was a function of reported income and evasion as part of an equilibrium. Remember that the tax authorities can only approximate the true income of an individual via a detailed audit. In general, tax regimes function in two stages: individuals file a declaration of their income and taxes owing; next, the tax authority audits a sample of the filed declarations. Each audit has a cost and the tax authority has a determinate budget for conducting audits. An audit can conclude that either no additional tax is owing, or that additional taxes plus penalties and interest are owed.

Tax authorities can have several strategies for audits. First, the tax authority can set a predetermined strategy such that all tax returns below a threshold are audited. These models are primarily principal-agent models. Next, the tax authority can be assumed to only formulate its audit strategy after the taxpayer files their return. These models fall into the game-theory group of models.

Both strategies assumed that the taxpayer was somewhat risk-averse. In the game theoretic approach there were two kinds of taxpayers: taxpayers who honestly reported and taxpayers who do not honestly report their income. Andreoni, Erard and Feinstein (1998) found that this approach was more realistic. For example it was not usually known by the tax authorities the true income taxpayer before the audit. Andreoni, Erard and Feinstein discussed future directions for the audit models. First, in the principal agent model it was assumed that all taxpayers over the cut off are seem to be honest. However, in reality, the Taxpayer Compliance Monitoring Program had found that approximately 40% of taxpayers did not make a full and honest report of their income. Second, the game theoretic approach generated more realistic predictions then the alternative principal-agent model. In addition both models assumed that the taxpayer had perfect knowledge of the tax legislation and policies governing their tax situation. However in reality it was nearly impossible to have a perfect knowledge and understanding of an individual's tax liability. Thus the uncertainty of actual tax obligations was a potential mitigating factor in the validity of the tax declaration.

4) Data sources and methodologies -- Andreoni, Erard and Feinstein (1998) found that before 1980 most literature focused on theoretical models surveys or small data sets. Further, most recent literature focused on studies that were based on the United States' Taxpayer Compliance Monitoring Program plus state and a small number of other national studies. Andreoni, Erard and Feinstein concluded that more recent studies were not based on the theoretical underpinnings of tax evasion.

Andreoni, Erard and Feinstein (1998) decided to focus on the four alternative sources of data that could be used to measure and study deviation: 1) audit data; 2) survey data; 3) tax amnesty data; and 4) data generated through laboratory experiments. Andreoni, Erard and Feinstein then categorized the reliability of the data with actual tax data being the most reliable data source followed by survey data, tax amnesty data then experimental data. Andreoni, Erard and Feinstein lamented the discontinuation of the Taxpayer Compliance Monitoring Program by the Internal Revenue Service and the lack of analogous sources in other countries that would provide additional sources of research data

5) Explaining non-compliance -- Andreoni, Erard and Feinstein (1998) then explored explanations for individual non-compliance. In the first section Andreoni, Erard and Feinstein explored income tax and tax rates. For example, Friedland, Maital and Rutenberg (1978) found that higher tax rates lead to higher evasion. Slemrod (1985) however clarified that within a tax bracket, evasion was more likely to be found in those declaring at or near the high end of the tax bracket, than

those that were declaring at the lower or middle of the bracket. Various demographic and social factors were correlated with noncompliance. Increased age was associated with greater voluntary compliance. Married individuals were associated with greater non-compliance. Sole proprietors (i.e., self-employed individuals) were associated with higher degrees of non-compliance. Last males were more likely to participate in tax evasion activities than females. Torgler and Valev's (2010) study on gender and attitudes towards evasion and corruption supported this finding by suggesting that females showed a greater aversion to corruption and tax evasion.

Andreoni, Erard and Feinstein (1998) then explored the effects of penalties and the probabilities. In general higher penalties discouraged tax evasion. Tax authorities could minimize the risk of noncompliance by undertaking matching programs (i.e., matching information returns with individual tax declarations). In Andreoni, Erard and Feinstein's review they concluded that penalties and audit probabilities deter tax evasion, but the degree of those effects was still uncertain. Nevertheless, those with more opportunities for noncompliance tended to comply less. Further, the deterrence effect of audits was unclear. For example, if an audit uncovered less tax evasion than actually occurred, what is the effect on compliance? Andreoni, Erard and Feinstein also reported that individuals with more negative perceptions of government and a lower belief in the honesty of their fellow taxpayers. Further, tax evasion was also associated with the use of a lawyer or accountant in the preparation of returns.

6) Audit regimes -- Andreoni, Erard and Feinstein (1998) reported on three issues associated with detection. First, the Internal Revenue Service detected approximately 50 percent of evasion. Second, auditors had a wide variation in the amount of evasion detected. Last, there was a halo effect (i.e., less evasion detected) when a tax return is prepared by a tax professional. As a result, the Taxpayer Compliance Monitoring Program underestimated the tax gap and needs to be adjusted accordingly.

7) Morals and social dynamics -- Andreoni, Erard and Feinstein (1998) reported that moral values played a role in the tax compliance-tax evasion decision. However, it was unclear how such moral values could play a role in formal models. Another factor was the fairness of an individual's tax burden. This may help the taxpayer to rationalize the evasion-compliance decision. Next, satisfaction with the current regime also played a role in the evasion-compliance decision. Those that were less satisfied were more likely to evade taxes. Despite the compelling indications that these factors

influence the evasion-compliance decision, again, there was no research on how to include these factors in an empirical analysis of evasion.

8) Tax complexity and amnesties -- Last, Andreoni, Erard and Feinstein (1998) discussed tax complexity and amnesties. Tax complexity can influence the accuracy of an individual's tax declaration. If the tax legislation and accompanying policies are complex or vague, it can be difficult to complete an accurate tax declaration even if the intent is there. A random audit regime may detect these inaccuracies, but introduces uncertainty as audits may not necessarily differentiate between the unintentionally inaccurate declarations versus the intentionally inaccurate declaration. Andreoni, Erard and Feinstein stated that complexity and uncertainty were not necessarily unwanted from the tax administration perspective as these factors may foster compliance. Tax amnesties were also briefly discussed. While tax amnesties are typically found to increase revenues but the mechanisms that make these amnesties effective and their long term effects on compliance were not well understood.

Andreoni, Erard and Feinstein (1998) concluded with four observations. First, Andreoni, Erard and Feinstein suggested that more integration of theoretical and empirical research is required. Second, the different perspectives of psychological, social, and moral influences on tax evasion behaviour needed to be integrated into the economic frameworks of tax evasion. Third, the interaction between the organizations responsible for tax compliance and taxpayers needed to be better understood. Last, empirical studies needed to be conducted in a broader set of jurisdictions outside of the United States. This included comparative and cross-cultural comparisons, amongst both developed and developing countries.

### 4.4.2. Signal Detection

Antonides and Robben (1995) examined true positives and false positives in the detection of tax evasion. Specifically, whether or not the corrections made by the tax regime were due to income tax evasion (true positives) or errors (false positives). In the study two groups of taxpayers in the Netherlands were outlined. First, taxpayers could have their taxes withheld at source. Those taxpayers required no further investigation by the tax authorities because it was a straightforward process to determine that the tax withheld was appropriate given the associated income. Second, some groups may have requested a further refinement of their tax situation in situations where certain adjustments (either additions or deductions from income) may have been required. Those requesting a refinement

of their tax situation would have been subject to one of five different audit categories. Corrections could be imposed, but sanctions were not typically applied if the corrections were as a result of mistakes. At least one in six returns contained mathematical errors. Errors and subsequent corrections could have been in favour or disfavour of the taxpayer, or the errors could remain undetected. Antonides and Robben asserted that corrections that were not in favour of the taxpayer could not easily be differentiated between intentional and unintentional.

Antonides and Robben (1995) then developed their signal detection model of tax evasion. Information processing by taxpayers may influence the probability of errors such as unawareness or misinterpretation of tax legislation. Errors in math, clerical errors, and unintentional over and under-reporting were also possible. Antonides and Robben included psychological variables presented by Weigel et al. (1987). Further, four categories of errors and corrections were possible. The first category was corrections to the advantage of the taxpayer (and disadvantage of the tax authorities). The second category was where no corrections are required. The third category is where corrections to the disadvantage of the taxpayer (and advantage of the tax authorities) were made due to errors may be the taxpayer. The last category was where corrections to the disadvantage of the taxpayer (and advantage of the tax authorities) were made due to tax evasion. Further complicating the model was that a single declaration can have errors (the third category) and tax evasion (the last category).

Antonides and Robben (1995) categorised the evasion probabilities as follows:

| | P*ev* | 1-P*ev* |
|---|---|---|
| P*er* | D | A ∪ C |
| 1-P*er* | D | B |

**Table 4-4 Evasion Probabilities (Antonides and Robben, 1995)**

Lower probabilities of errors and tax evasion resulted in larger numbers of 'no correction' audit results (category B in the table). Higher probabilities of evasion resulted in large number of corrections in favour of the tax authorities (category D) whether or not the return contained errors. Errors from the taxpayers resulted in both favourable and unfavourable corrections (A ∪ C in the table). Antonides and Robben used a survey of taxpayers from the Netherlands for their study. They found that the proportion of tax evasion was 19.6%. Self-reported evasion in their survey did not predict evasion found during the audit process. There was also evidence of learning since true errors decreased during the timeframes in question. Opportunities to hide income increased the probability of evasion.

However this did not translate into a corresponding observation on the use of deductions. In addition, the tax withholding regime in the Netherlands did not appear to be an effect tool in preventing evasion. Nevertheless, Antonides and Robben suggested that information sharing regimes decreased the opportunity for evasion.

### 4.4.3. Taxpayer as Gambler

Cowell (1992) then outlines what is potentially wrong with the taxpayer as gambler model of noncompliance. He focuses on three particular areas: 1) the nature of the taxpayer's motivation, 2) the nature of the economic interaction and 3) the nature of taxpayer as an economic agent. Cowell argues that the taxpayer as gambler model does not look at an appropriate characterization of risk, the interaction between the taxpayer and the tax authority such as tax amnesties, and assumes that all taxpayers are gamblers and that none are inherently honest. The model also did not account for the firm's behaviours as it focused solely on individual taxpayers.

Cowell (1992) suggested that the taxpayer as gambler model ignored framing which can impact an individual's reference model depending on how information was presented to the taxpayer. For example, the taxpayer's response to incentives such as carrots or sticks, that is positive or negative incentives, differed according to the reference frame in which the information was received. The model also ignored time and assumed that there was no learning or memory in the tax compliance decision. In other words, the compliance decision began anew in each taxation year. There were also social norms and what Cowell called the climate of behaviour. These social norms were external to the individual and/or an indicator of whether or not the individual had taken into account social norms when making their compliance decision. The carrot and stick approach was a useful economic model. However it may have led to misguided policy decisions. If applied rigorously, it would imply that compliance costs would increase to the point where the marginal revenue raised equalled the administrative costs of compliance. This was not realistic from the cost or policy perspective.

Alm, Sanchez and De Juan (1995) examined economic and non-economic factors in tax compliance. This study replicated Alm, Jackson and McKee's (1992) study but added the dimension of social norms. They start by posing the question "why is there so little cheating" (Alm, Sanchez and De Juan 1995, p. 3) when it comes to taxation. Further, when the typical probability of audit was less than one in one hundred, and most economic models suggested that there should be more tax evasion than is

typically observed. Alm, Sanchez and De Juan's paper was to use the major economic and non-economic factors to explore their effects on tax compliance. Alm, Sanchez and De Juan also argued that the laboratory is the more productive route for academic papers since real world data such as the TCMP are rare and methods are not as controlled as a laboratory setting.

Alm, Sanchez and De Juan (1995) suggested that social variables are important in determining attitudes towards tax compliance and the level of compliance and change compliance to various policy initiatives. Alm, Sanchez and De Juan followed the same experimental methodology as other tax evasion laboratory experiments. Typically tax evasion laboratory experiments use students who receive an income and are required to report taxes on the income received on a voluntary basis while other variables are adjusted. The impacts of the various economic and non-economic variables are studied on the student's behaviour. To study the influence of social norms, students from Spain and the United States were used.

In this experiment there are several different audit rates ranging from 5% through 60%. Note that the audit rates exceeded the typical audit rate of less than 1% in the real world. Note that in all of these experiments the tax rate was held constant at 30 percent. In later sections the tax rate varies from 10% to 30% to finish at 50% in each of 18 rounds per session. Fines were also adjusted through the experiment at the low end of the scale of the following rate simply involve the subject pain in the unpaid taxes. The maximum fine during the experiment is four times the unpaid taxes. Alm, Sanchez and De Juan also introduces a public good in later sections.

Alm, Sanchez and De Juan (1995) summarized the results by the average compliance rate which they defined as the ratio declared income to actual income averaged across all of the participants and rounds in the relevant sections. Alm's results indicated that overall compliance increased with increased audit rates and similarly increased for increasing fines. Increasing tax rates also increased compliance. This effect was consistent with economic theories of tax evasion, but contrary to some empirical and experimental evidence.

Alm, Sanchez and De Juan (1995) results for the social norms component of the study found a difference in compliance between the Spanish and American students. The level of compliance was significantly higher for American students holding all other experimental elements equal. Alm, Sanchez and De Juan concluded that this was an indication that social norms such as tax morality may be factors that contributed to the difference in the levels of compliance.

### 4.4.4. Measuring Tax Evasion

Elffers, Robben and Hessing (1992) studied the measures of tax evasion. This study extended a previous study by Elffers, Weigel and Hessing (1987) but addressed some of the limitations of the previous study. Evasion has typically been measured in empirical studies in two ways. First, studies have used self-report of evasion activities. Second, studies have used an auditor's classification of evasion versus non-evasion. Elffers et al (1987) found that there was zero correlation between self-reports of evasion versus auditor's classifications of evasion versus non-evasion. Elffers et al (1992) refined their explanations by suggesting that either:

1) The auditors classifications involved large measurement error; or
2) Self-reports involve large measurement errors such as boasting or self-presentation; or
3) That while the correlation is not zero, it might be relatively small and be influenced by a common variable.

The study used a sample in the Netherlands in 1988/1989. Data on 918 personal income tax returns were provided. For each return there were three measures: the initial or actual assessment, a measure of the reassessment if applicable, and an auditor's assessment. For each tax return it was classified as to the noncompliance status, including unchanged, corrected or correctable but no correction was applied. The corrections were further categorized as to the taxpayers' intent to evade on a three point scale, including no evasion, unsure, or evasion. A stratified subsample of the original sample was reassessed, and again reclassified to the taxpayer's intent. The third assessment was a panel of expert auditors' opinions – the panel had access to the original assessment, and the reassessment. Overall, the agreement on compliance status and evasion status was non-existent. Elffers, Robben and Hessing concluded that the auditor's assessment was not a reliable or valid tool for research purposes. They also concluded that they lacked sufficient data for reaching a conclusion on their self-report techniques. Last, in their third measure, Elffers, Robben and Hessing modified an experimental approach that typically only measures tax evasion behaviour by substituting an approach that measures evasion behaviour but hide the true nature of the experiment by disguising the intended purpose within a business simulation. Two variables were manipulated: tax withholding and opportunities to evade. Both variables have been previously shown to contribute to tax evasion. Support was found for this experimental measure of evasion behaviour.

Elffers, Robben and Hessing (1992) then compared their three measures tax evasion: auditor classification, self-report and experimental. They concluded that there was no correlation amongst these measures. Last, Elffers, Robben and Hessing suggested that perhaps this was an indication that evasion behaviour had aspects with three independent measures.

Elffers and Hessing (1997) examined policy initiatives to influence the propensity to evade taxes. Elffers and Hessing proposed that taxpayers are inherently lazy and will not take risks if the payoff is in their favour. The first technique would be to increase the amount of tax withheld on various transactions. Upon final assessment, any excess would be returned to the taxpayer. The second technique would be to have sufficiently large standard deduction that would reduce the tax payable for most taxpayers to zero. Elffers and Hessing concluded that people were more compliant if they will get a refund than a balance owing.

In Elffers and Hessing's (1997) second scenario, the introduction of an overall standard deduction, taxpayers would be given the option of a preparing an itemized return or claiming an overall standard deduction. The only condition of using the overall standard deduction was that no other deductions could be used. Elffers and Hessing then introduced another psychological element – specifically for taxpayers that are not confident in their ability to prepare an accurate income tax return (which is the majority) would need to face some degree of uncertainty vis-à-vis the outcome of the assessment of that return. As such, the taxpayer would likely opt for the overall deduction for several reasons: to save time; to reduce the requirement to pay for tax advice and reduce the uncertainty in the outcome of the assessment.

Feinstein (1991) conducted an econometric analysis of income tax evasion and its detection. The model used comprised two equations. The first equation was related to the taxpayer's compliance decision. The second equation was related to the Internal Revenue Service's income tax evasion detection process. The compliance equation was based on the premise that taxpayers will make consistent, rational (at least from the economics perspective) compliance decisions. The dependent variable in the compliance equation is evasion, and the independent variables are taxpayer attributes that contribute to the evasion/non-evasion decision.

In contrast, Feinstein's (1991) evasion detection equation is more difficult to elaborate as the detection of income tax evasion is not perfect. For any given income tax return, the probability of detection will vary, for example, due to the capabilities of the auditor examining the return. The

amount of evasion detected will have three levels: 1) all; 2) some; or 3) none. The effectiveness of auditors at detecting evasion is not collected since the overall evasion is not precisely known.

Feinstein (1991) tested his equations using data from the 1982 and 1985 TCMP datasets. One of the drawbacks to the TCMP data is the assumption of the Internal Revenue Service that an auditor has detected all the evasion on a particular income tax return. The most compelling finding of the study was that while conventional wisdom states that overstatement of deductions would be easier to detect than the underreporting of income. However, Feinstein's model demonstrates that the Internal Revenue Service's detection is better for underreporting of income.

### 4.4.5. Contingency Theory

Collins, Milliron et al. (1992) examined the role of contingency on tax compliance. First, the approach involved segmenting noncompliant taxpayers based on a contingency model. Second the study included personality variables, the degree of tax knowledge and the in disputed benefits of tax evasion overall the authors found that the contingency framework added to the overall explanatory power of their model specifically the relationships between their predictor variables and tax evasion behaviour varied across the group's identified by the various contingency factors.

Contingency theory suggested that universal all-encompassing models of behaviour were generally insufficient at explaining the natural variability in outcomes. It was therefore necessary to establish contingency factors that allowed for more precise descriptions of the relationships between the various predictor variables and some outcome. Collins, Milliron et al. suggested that adopting contingency theory to investigate tax evasion behaviour was a logical next step to explain some of the discrepancies found in their literature review.

Collins, Milliron et al. (1992) used two variables in their study to study the usefulness of the contingency theory approach. These variables were taxpayer objective and the use of a tax practitioner. The authors suggested that it was appropriate to use tax preparer utilization in conjunction with the objectives of the taxpayer as contingency factors. First, they argued that tax preparers may have the capability of impacting the tax declaration outcomes to satisfy their clients' tax objectives. The authors then selected the predictor variables for categorizing them based on the frequency of their use in prior empirical studies. The three groups that they formed were demographic factors, situational influences, and tax beliefs and perceptions. The authors also included several variables that had not received much coverage in the literature. Specifically, tax knowledge, the benefits of tax evasion, and the psychological traits of conformity responsibility values and risk propensity.

Collins, Milliron et al. (1992) stated that two methods are typically used to measure tax evasion first the Internal Revenue Service is Taxpayer Compliance Monitoring Program and the results of surveys both these measures have their strengths and weaknesses for example the Taxpayer Compliance Monitoring Program is limited to the variables that can be inferred or deduced from the tax return itself taxpayer surveys can be subject to nonresponse bias, self-presentation bias and concealment behaviour. In the end the authors used a survey of 700 households in the United States dependent variable response for us to indicate whether they had misstated tax return information to

their favour over the last five years. The independent variables included gender age education income conformity responsibility value orthodoxy risk knowledge anticipated benefits of tax evasion unfairness perceptions deterrent system perceptions appears noncompliance and return complexity. The contingency variables included taxpayer objective and preparation method. The contingency variables were measured in the survey by means of a single question.

Collins, Milliron et al. (1992) first tested the dependent and independent variables using a non-contingency method the results of regressing tax evasion on the independent variables showed that 4x14 variables were significant. Specifically, education was negatively correlated with tax evasion while the benefits of tax evasion perceptions of theaters noncompliance behaviour and the complexity of the tax return were positively correlated with tax evasion. Next, the authors included the contingency variables. The differences between the two models included setting up dummy variables for each of the four contingency situations. Each contingency situation was coded as zero or one dummy variable, where one indicated that the situation was present and zero indicated otherwise. After the dummy variables were created, each of the independent variables was multiplied by each dummy variable. This resulted in the generation of 4x14 or 56 contingency interaction variables that were to be included in the model. The explanatory power between the contingency non-contingency models was tested using a partial F test. The results of the partial F test indicated that the contingency added significantly to the explanatory power of the non-contingency model. For example the R squared rose from .39 in the non-contingency model to .59 in the contingency model. Collins et al. also found that in contrast to the non-contingency model where only four of 14 independent variables were significant they found that 12 of the 14 independent variables were significant for at least one of the groups in their contingency framework. To variables that did not significantly correlate with noncompliance for any of the subgroups in the contingency model, the complexity of the tax return was the only predictor that was statistically related to tax evasion across all groups.

Collins, Milliron et al. (1992) concluded that the evasion continuum was not best understood as a single phenomenon. They suggested that further research was required to further refine and identify relevant contingency factors that define subgroups of taxpayers and rather than looking at a single universal model of tax evasion and one that took into account many different variables and factors in the interactions between those is likely a more fruitful path for future research.

### 4.4.6. Microeconomic Tests

Slemrod (1985) proposed a microeconomic test for tax evasion. Slemrod proposed that under certain conditions, households that were evading tax on a portion of their true income would declare their income near the top of an income tax bracket. Conversely, households that were not evading tax would not have an incentive to be near the top of an income tax bracket. Slemrod used this premise as the basis for his analysis. Specifically, the position of a household's income in a particular bracket would be the indicator of tax evasion. If declarations of income were truly random, there would be twenty percent of taxpayers at each level within a bracket. If the declarations at the top of each bracket exceeded twenty percent, the excess was proposed by Slemrod to be indicative of primary tax evasion. The source of income would also impact the degree of evasion. For example, the lowest evasion would be from wages and salaries, somewhat more for interest and dividend income, and highest from small business income.

Spicer (1986) reviewed tax evasion research to that date. Spicer argued that all models of tax evasion based on the Allingham and Sandmo (1972) model viewed tax evasion as gambling, and the appropriate enforcement response was to find the right mix of enforcement activities and penalties. This economic approach dictated that sanctions deter tax evasion. However, economic models did not take into account social and psychological influences on tax evasion behaviour. In other words, evasion was not a purely economic phenomenon. Spicer concluded by suggesting that more research was required to understand the impact on audit probability and penalties on the compliance decision.

### 4.4.7. Prospect Theory and Framing

Robben, Webley et al. (1990) examined decision frame and opportunity as determinants of tax evasion.

| |
|---|
| Non-compliance can mean either unintentional errors or intentional behaviours that result in assessments that are in the favour of the taxpayer. |
| Tax evasion or tax cheating are the intentional underpayment of tax and can come from either underestimating income or overestimating deductions. |

Robben, Webley et al. (1990) based their study on prospect theory. Prospect theory suggested that taxpayers may make different decisions depending on how their choices leading to those decisions are framed. The example of two taxpayers was given by Robben Webley et al. to outline the theory. Two taxpayers were facing either a large refund or a balance owing. The taxpayer with the large refund could attempt to augment that refund but would likely not in order to avoid the risks linked to tax evasion (e.g., fines) since the refund was already a sure thing. The taxpayer facing a balance owing perceived the balance owing as a loss, thus increasing the chance that they will underestimate income or overestimate deductions in order to lower the amount of the loss. Students in six countries were used as subjects in the study. The task of the subjects was to take part in a computer simulation of a small business. Decisions were required in four 6-month periods related to all aspects of running a business. Subjects were also given the option of purchasing additional information in each period that would help them with their business decisions. The authors concluded that prospect theory was supported in that the non-compliance of subjects was significantly greater when there was an additional amount owing versus a refund. Notwithstanding cultural differences, the decision frame appeared to be a determinant of tax evasion behaviour.

Dhami and al-Nowaihi (2007; 2010) examined why people pay taxes from the perspectives of prospect and expected utility theories. Dhami and al-Nowaihi argued that expected utility theory suggested three statements that contradicted experimental evidence: 1) that all taxpayers conceal some income, 2) that taxpayers are risk averse and 3) that increasing the tax rates reduces evasion. Experimental evidence did not support these findings. Prospect theory was comprised of five principles: "reference dependence, declining sensitivity, loss aversion, non-linear weighting of probabilities, and susceptibility to framing effects" (Dhami and al-Nowaihi 2007, p. 173). Through

their analysis Dhami and al-Nowaihi suggested that prospect theory better fit previous experimental evidence and estimated rates of tax evasion. Further, increased tax rates were met with increased evasion.

Hasseldine and Hite (2003) researched framing, gender and tax compliance. Previous research suggested that a decision frame can influence tax reporting behaviours. This previous research is generally known as risky choice of framing. Hasseldine and Hite used a goal framing approach. In general there are three types of framing approaches: risky choice, attribute, and goal framing.

Hasseldine and Hite (2003) hypothesized that subjects who were given a negatively framed persuasive communication would subsequently make different tax reports than subjects who read a positively framed communication. Next, men and women would have made different tax reports after reading either negatively or positively framed communications encouraging tax compliance behaviours.

A mail survey was sent to employees of a large Midwestern United States university. Subjects were given either a positive message or negative message about complying or not complying with tax laws. In response to their survey, Hasseldine and Hite (2003) concluded that males were generally more tolerant of tax evasion than females. An analysis of covariance was used to test the hypotheses for covariates that were included in the model: 1) the noncompliance scale; 2) marital status; 3) education; and 4) the number of times the respondent reported receiving cash income. The noncompliance scale was strongly significant which confirmed that the survey respondents' attitudes to tax noncompliance strongly predicted compliance behaviour. Males were more compliant when a negatively framed message was used in the survey. In contrast, females were more compliant or positively framed message. This suggested that when the information was communicated to taxpayers, two different types of messages, both positive and negative, may be required and may lead to differences in compliance decisions. Nevertheless this posed a problem to tax authorities who in general cannot be seen to discriminate in direct mail campaigns to taxpayers based on their gender. However advertising campaigns could be designed that have two objectively similar messages by broadcast in different target markets.

Hasseldine and Li (1999) discussed the requirement for tax evasion research in the new millennium. Much of the research in the past had been conducted in the United States therefore limiting applicability to other countries. Cross-cultural and multimethod approaches were suggested for both

policy makers and academia interested in understanding tax compliance behaviour. A wide variety of disciplines were involved in the understanding of tax evasion. For example, these disciplines included economics, accounting, decision sciences, criminal justice, psychology, political science, and sociology. In addition most work had not been from an inter-disciplinary perspective. The paper provided the groundwork required for interdisciplinary research on tax evasion.

In defining noncompliance, Hasseldine and Li (1999) showed the differences between the Internal Revenue Service's definition of compliance: all tax returns are completed on time and accurately in compliance with law and policy. In contrast most working definitions of tax compliance within the academic field included the intent behind the taxpayers' motivation in meeting their tax obligations. Further refinement included definitions of tax evasion which usually focused on the deliberate nature of behaviour. Further refinement of groups of noncompliance behaviours was possible. For example: 1) failing to file a return; 2) failing to report a tax liability accurately and 3) failing to make the required payment for taxes owed. Noncompliance also included unreported or under-reported income, overstated deductions and mathematical errors. Noncompliance may be both in favour of the taxpayer and in the favour of the tax authorities. In addition to error, noncompliance can be legal. For example, tax avoidance permitted under law or illegal such as tax evasion.

Hasseldine and Li (1999) then outlined theories of taxation including economic fiscal psychology and social psychological. When discussing economic models the major drawback is they are focused solely on costs and benefits a shift was required to broaden the economic models by including psychological sociological and anthropological considerations. Next psychological models cannot always be empirically tested and often were limited in the number of variables that are tested. Social psychological models included theories of reasoned action (Ajzen & Fishbein 1980) and Prospect theory (Kahneman and Tversky 1979). As previously shown, prospect theory included the concept of framing and this was shown to have an impact on taxpayer compliance when both positive and negative messages were shown to males and females.

Hasseldine and Li (1999) also suggested that tax compliance data did not permit researchers to explore the increasingly complex theories that were being generated. Data was generated in several ways, including self-report, experimental methods (e.g., simulations and auditor assessments) and econometric studies. Notwithstanding the Internal Revenue Service's Taxpayer Compliance Monitoring Program, most jurisdictions have confidentiality requirements that restricted access to data.

Hasseldine and Li (1999) then described some of the policy initiatives that have been explored via research. For example, there is a move away from deterring non-compliance and using incentive based strategies. In addition, tax reform can be used to combat evasion, by reducing tax rates and compliance costs.

Hasseldine, Kaplan and Fuller (1994) examined the characteristics of New Zealand tax evaders. The New Zealand tax system was similar to the Australian tax system but different from the tax regime in the United States. One trend for example was New Zealand's increased usage of income tax withholding regimes. Tax withholding reduced the opportunities for noncompliance. Hasseldine used a questionnaire survey in Christchurch. The survey examined subjects' background, tax beliefs, and self-reports of tax evasion behaviour.

Sixteen independent variables were used in the study as having potential relevance for tax evasion behaviour (Hasseldine and Li 1999). The 16 independent variables were further grouped into five categories: 1) demographic and socioeconomic; 2) financial self-interest; 3) social sanctions; 4) social commitment; and 5) tax preparers. The demographic and socioeconomic independent variables included gender income and education. The financial self-interest variables included perceived severity of sanctions, previous audit experience the portion of income tax withheld at source, and occupation. The informal social sanctions group included the survey respondents knowledge of known evaders as well as their estimation that the percentage of taxpayers who evaded over $500. The social commitment variables included the study participants rating of the fairness of the New Zealand tax system, the fairness of tax amnesty programs, the consequences of tax evasion in New Zealand, and the survey respondent's estimation of the extent to which it was morally acceptable to invade $500 or more in taxes. The last group the tax preparer variable contained only one variable and that was whether or not survey respondents have used a tax preparer or professional during the previous three years. Study had two dependent variables. The first dependent variable was whether or not survey respondents had intentionally underreported their income. Second, the dependent variable was the subjects self-report of whether or not they had intentionally overstated deductions on their income tax return.

Hasseldine, Kaplan and Fuller (1994) used two statistical techniques to evaluate the data. First, univariate tests were used for each variable. Second since the dependent variables were binary in nature, a logistic regression model was used to test the full suite of independent variables. It was found that the predictive signs for the coefficients were in the expected direction for nine of 12 cases. Due to

the large number of independent variables, multicollinearity was a possibility. However, there were no correlations between the 16 independent variables of sufficient magnitude to be of concern. As a precaution, variables with correlations of 0.3 or more were deleted from the analysis for the dependent variable. Variables that were significant in the full model were significant in the reduced model with one exception specifically when morality was dropped from the model the independent variable income dropped to marginal significance.

Hasseldine, Kaplan and Fuller (1994) found that the two types of evasion behaviours, underreporting income and overstating of deductions, occurred in their study with differing frequencies. The notion for this was that respondents in the study had different opportunities to evade income tax under the two different types of evasion behaviour. Further, the social aspects of income tax evasion made the largest contribution to the model for the underreporting of income. Specifically the more that is known to the subjects, the more likely they were to engage in income tax evasion behaviours. Given this finding the policy implications are unclear as it was difficult for a government or tax administration to influence or change these social aspects.

### 4.4.8. Economic and Psychological Responses

Hasseldine and Bebbington (1991) examined the New Zealand experience with the blending of economic deterrence and fiscal psychology models designed responses to tax evasion. There are two potential responses in the role of government in revenue authority to tax evasion was of behaviours. The first was economic oriented responses. These models suggested the taxpayers would continue to evade income taxes if the payoff from tax evasion was greater than the expected value of the penalties assessed if they are caught. If economic approaches were taken by the government to facilitate compliance it would have been difficult for these measures to discriminate between the target group for the economic approaches and the nontarget group. In effect what encouraged compliance in the target group may have encouraged noncompliance in the nontarget group. The second was psychological responses. Psychological responses suggested that attitudes and beliefs were the basis for tax evasion behaviour. In order to reduce income tax evasion behaviours these attitudes and beliefs needed to be modified in some way. Hasseldine had previously shown that the framing of compliance messages in either a positive or negative tone influenced the tax evasion behaviours of male and female subjects differentially.

In the case study of New Zealand (Hasseldine and Bebbington 1991), the New Zealand government had tried economic responses to tax evasion behaviours. For example, the New Zealand government had increased penalties for late payment of taxes, identified tax evasion. In keeping with economic models these changes should reduce tax evasion. A second economic response was the withholding of income tax at source. Withholding should reduce evasion since the party that withholds tax on behalf of the government had no incentive to the taxes. The third economic response was to reduce compliance costs through tax simplification. Tax simplification reduced compliance costs and possibly tax evasion. They last economic response was the New Zealand government audit strategy. For example the inland revenue Department in New Zealand stated its audit program goals and emphasized that all classes of taxpayers in New Zealand would be given some audit coverage every year. Since the probability of detection increased, the incidence of tax evasion should have decreased.

The New Zealand government has also worked on psychological responses to income tax evasion (Hasseldine and Bebbington 1991). First, the government advertised their tax reforms. One of the goals of the advertising program was to increase compliance through awareness of an individual's correct tax liability. The second psychological response was the introduction of a tax amnesty. Tax

amnesties were designed to encourage compliance a portion of outstanding taxes go to the government and permit taxpayers who have previously evaded taxes back into the compliant group. It was not clear whether tax amnesties were effective in encouraging compliance behaviours across the spectrum of tax evaders. The third psychological response was the removal of many of the deductions to taxpayers that were not self-employed. The fourth psychological response was the addition of the tax on benefits such as company cars. This ensured that the total employee compensation package was taxed regardless of whether it took a monetary or nonmonetary form. The fifth psychological response was legislation. This legislation allowed for an assessment of income from various financial instruments as it was accrued under generally accepted accounting practice. Further legislation dealt with international holdings and dividends.

Hasseldine and Bebbington (1991) concluded that there is still a lot to the research in the interactions between economic and noneconomic responses to income tax evasion and their impact on the complex of attitudes and beliefs and social factors that influenced tax evasion behaviours. From a policy perspective this made it difficult for governments and tax administrations to effectively or easily reduce tax evasion behaviours within their jurisdictions.

Hasseldine, Hite, James and Toumi (2007) studied the impact of persuasive communications on sole proprietors and the subsequent impacts on compliance. Compliance activities such as audits were expensive and could only be realistically conducted on a small percentage of taxpayers. Hasseldine, Hite, James and Toumi suggested that the threat of audit could also serve as a compliance tool. The study used a sample of tax returns prepared by the taxpayers themselves and tax preparers. Further, the study was unique because it measures actual tax-reporting behaviour when the taxpayers are exposed to one of five scenarios: "simple offer of assistance, citizenship appeal, threat of audit, threat of audit with possible penalties, and virtual guarantee of forthcoming audit once the return is filed"(Hasseldine, Hite, James et al. 2007, p. 172). A sample of 7,300 sole proprietors in the United Kingdom who reported for two consecutive years sales that were below a £15,000 threshold. This threshold implied that these taxpayers could have used a simplified reporting format and thus reduced their compliance costs. Hasseldine, Hite, James and Toumi suggested that the motivation to reduce sales to fall just below the threshold would be tempting. Hasseldine, Hite, James and Toumi looked at the impacts of the normative and sanction letters, and found that the sanction letters were more effective than normative letters for taxpayers who prepare their own returns (increased reported sales

and degree of change in sales). These results were consistent with previous research on framing (e.g., Hasseldine and Hite 2003).

Last, it is not feasible to attempt to collect all evaded tax (Erard 1997). The goal of compliance strategies should be to maintain non-compliance at tolerable levels (Erard 1997).

Segmentation of non-compliance risk has been researched by tax type (direct/indirect) (Brou and Collins 2001), and source of income (Erard 1997). Segmentation by commodity (i.e., Harmonized Commodity Description and Coding System) or industry (e.g., lobster fishery) does not appear to have been researched by academia (Giles 1998). This suggests that a commodity or industry approach may be an alternative research approach to studying noncompliance.

### 4.4.9. Tax Rate

Clotfelter (1983) examined the effects of the marginal tax rate on tax evasion. Clotfelter used data from the 1969 Internal Revenue Service's Taxpayer Compliance Monitoring Program (TCMP). In defining evasion, Clotfelter acknowledged the difficulty in distinguishing between true evasion and errors. Relatively few taxpayers were subject to fines or penalties. For example, in the 1969 sample, five returns in every 10,000 were determined to be fraudulent and 8 returns in every 10,000 were negligent. Further, the TCMP did not have information on nonfilers and personal and attitudinal measures of evasion. Clotfelter found that evasion varied with source of income (personal, business, and farm) and the deductions available to taxpayers. It was also demonstrated that modest tax cuts had corresponding reductions in tax evasion behaviour while increasing the overall tax base. Clotfelter's paper was significant in that it was the first major empirical test for tax evasion and as such was a departure from the early theoretical work started by Becker (1968) and Allingham and Sandmo (1972).

Torgler (2003) used Canadian data from the World Values Survey to examine the effects of trust in government, pride and religiosity on tax morale. Torgler found positive, significant effects of these variables on tax morale. These variables included trust in government, pride and religiosity as well as other control variables including age and gender family setting education income and satisfaction with their personal financial situation. Torgler's study showed that subjects between ages 30 and 54 had higher tax morale than people between the ages of 16 and 29. In addition females showed significantly higher tax morale than males. No impact on tax morale was detected for education. However students have lower tax morale than full-time employees. The variables trust in

government and pride have a positive effect on tax morale. In the full regression model trust in government impact were reduced when all other variables were included in the model. Trust in government, pride and religiosity had a positive significant influence on an individual's tax morale after controlling for age income education gender and marital status and employment status. Torgler indicated that the study's primary limitation was the use of a single indicator for tax morale and that future research should perhaps develop a scale for evaluating this variable.

### 4.4.10. Source of Income

Madeo, Schepanski and Uecker (1987) modeled judgment of taxpayer compliance based on the evaluation of tax experts ability to predict compliance behaviour. The primary finding was that income source was almost three times more important than the next variable in predicting taxpayer compliance. This study developed a judgment model from accountants specializing in taxation and used the judgment to predict compliance from result identified in the Internal Revenue Service's Taxpayer Compliance Monitoring Program. Four independent variables were used to determine source of income, amount of income, tax rate structure, and penalties. These variables were all variables that could be validated using the Internal Revenue Service's Taxpayer Compliance Monitoring Program data. The subjects in the study were presented a number of cases that described taxpayers using the four factors or variables identified. Subjects were then asked to identify that the percentage liability that would need to be reported by the taxpayer in each case. A judgment model was then used to estimate compliance based on income (high and medium and low), and source of income (self-employment, mixed self-employment and salaried income, and mostly salaried income). Compliance rates for each of the nine cells were provided by the Internal Revenue Service. Next, the Taxpayer Compliance Monitoring Program predictions and the model predictions were correlated, resulting in a correlation of 0.92. The authors concluded that using tax professionals to test the compliance implications of policy changes might be a valuable tool.

Cowell (2002) examined the taxpayer as gambler model of noncompliance with taxation. In general the taxpayer as gambler model supported four propositions: 1) if the rate of return on evasion behaviours is positive then people in general evade tax; 2) more risk-averse people tended to evade taxes less; 3) as income increased evasion increased; and 4) Increased compliance activities such as the probability of audits the tax rate or penalties reduced the amount of tax evaded.

Hite (1988) examined the impact of subject selection on both hypothetical and self-reported non-compliance in a taxation context. Hite argued that both government data and self-report studies are subject to bias. Hite's study attempted to reconcile government –reported compliance data, self-report data and hypothetical reporting data. While overall the relationships were positively correlated, the results were influenced by the subjects selected in the empirical studies.

The Taxpayer Compliance Monitoring Program estimated noncompliance at approximately 10%. When comparing the results of the Taxpayer Compliance Monitoring Program to self-report data, the TCMP data was more conservative. However the TCMP data may not be a non-random sample because the Internal Revenue Service selected their sample on a proprietary basis. However, the TCMP data reported compliance based on dollar amounts. Noncompliance may not be visible to the auditors in the TCMP data.

Notwithstanding the issues in the TCMP data self-reports may also have been subject to bias. For example past behaviour may have influenced self-reports as well as using students as a convenience sample may have impacted on the validity of self-reports. Even the validity of student subjects is questionable as the generalizability to the general population was questionable (e.g., in terms of representativeness, income, diversity, etc.).

Hite (1988) had three hypotheses:

1) Is there a significant correlation between self-reports past compliance and government reporting compliance rates?

2) What is the significance of the correlation between supplement levels of actual noncompliance and hypothetical?

3) Were the relationships between self-reports compliance hypothetical compliance in reported compliance data affected by sample selection? (Hite 1988 p. 453 ).

The dependent variables in the study were hypothetical reporting decisions, as well as self-reports and past tax reporting behaviour. To answer the first hypotheses of whether or not significant correlation between self-reports of tax compliance and government reporting compliance rate, 46% of respondents admitted that they had noncompliance in a tax return within the last five years.

When comparing hypothetical data and TCMP data, Hite (1988) asked participants to estimate the amount of non-compliance on hypothetical income. A Spearman's rank order correlation was used

to compare the hypothetical reporting decisions versus the TCMP data on similar categories. The two sets of data were correlated significantly at 0.857. Thus, hypothetical evasion closely reflected the estimates from the TCMP data. Next, the types of samples were correlated with the TCMP data. The samples that were more representative (e.g., surveys of jurors) were not correlated with the TCMP data. Specialized groups that included students, entrepreneurs and taxpayers were significantly correlated with the TCMP data.

The second hypothesis tested the relationship between self-reported past compliance behaviour and hypothetical compliance. Self-reported non-compliance was significantly correlated with hypothetical non-compliance. This differed between the non-specialized and specialized groups, with the most consistency showing up in the non-specialized samples.

Hite (1988) concluded that the use of accounting students, tax preparers and entrepreneurs are significantly correlated with TCMP data. The other conclusion was that hypothetical questions and simulations were consistent with self-reports on past behaviour, thus validating these tools as research methodologies.

The taxpayer as gambler model was one of the original models of noncompliance. The model depended on five conditions. The first condition was that the taxpayer had a fixed income which was subject to taxation. Second this income was taxable at a fixed rate. Third there was a fixed probability that the tax evasion would be discovered and subjected to fines and penalties. Four, the expected utility curve for the taxpayer assumed that everyone was either risk-averse or risk neutral. Last, risk aversion was a decreasing function of consumption. The Taxpayer Compliance Monitoring Program showed that compliance varied according to type and source of income as well as socioeconomic group. Income and enforcement also have the expected effects on evasion behaviour.

### 4.4.11. Tax Policy

Spiro (2005) examined the relationship between tax policy and the underground economy. The underground economy adds a layer of complexity to tax policy once people decide that they can opt in or out of the tax system to varying degrees. Spiro outlined three main policy issues that result from the growth of an underground economy:

1. Higher tax rates may fuel tax evasion. In turn this forces an ever increasing tax rate to compensate for lost revenue. The higher tax rates are typically required in areas where evasion is more difficult, for example, in areas where income is subject to income tax withholding.

2. Participation in the underground economy may also work as a form of subsidy to economic activities where overall productivity is low.

3. The overall difficulty in measuring the impact of the underground economy, its size, and its impacts make government estimates of economic activity unreliable, and possibly leading to erroneous policy decisions.

Spiro (2005) argued that in some respects the underground economy has its supporters in the world economics. The underground economy can be construed as a form of protest against government spending when democratic process is not sufficient. The underground economy could also be construed as a form of protest again various economic regulations. However, this applies only if economic activity is underground not solely for the purposes of evading income tax. It can be argued that if the sole purpose of going underground is to evade tax there are welfare costs and the activity may be more inefficient than if it was in the legitimate economy.

Spiro (2005) indicated that there are a number of choices when looking at the underground economy and tax policy. The first place to consider was the tax mix between consumption taxes and income taxes. Some consider that income tax being a tax on work was less desirable than a tax on spending. Further the tax on spending may encourage saving in lieu of expenditures. It could also be argued that consumption taxes may encourage underground activity by making it easier to evade taxes. This would negate the argument that consumption taxes are more desirable.

Spiro (2005) also reported that since underground economy transactions were typically cash does not mean that the earnings will be re-spent necessarily in the underground economy cents cash is an acceptable method of payment in the legitimate economy as well. Further some taxpayers specifically those who earn their income from corporations or governments where income taxes withheld by their employer have limited opportunities to participate in the underground economy. Corporations as well have limited opportunities to participate in income tax evasion as opposed to tax avoidance. The exception that Spiro noted was corporations that were privately held and run by families. Spiro also notes that higher income tax rates may encourage more people to become self-

employed as higher after-tax incomes may be enjoyed as well as opportunities to participate in the underground economy.

Spiro (2005) suggested that a value added tax might be harder to evade than a retail sales tax since the value added tax is a multistage tax since purchases may be required from the legitimate economy and these purchases would incur the value added tax. The consequence of not charging the value added tax to end consumers was that the seller would not receive an input tax credit for their purchases from the legitimate economy. The tax authorities then only would lose a portion of the revenue as opposed to the entire portion if the tax was the retail sales tax only on the final sale to the end consumer. Nevertheless a value added tax typically has a broader tax base of goods and services and as such there may be increased participation in the underground economy in the services sector since the input tax credits would be minimal. As the tax base increases for the value added tax consumers may also become much more cognizant of the impacts of the tax and drive demand for services in the underground economy. The other consideration is that consumers may also be forced to choose between purchasing a service and providing services to themselves. From an economic perspective this choice may be inefficient as there are economies in specialization. The other choice is to hire a service provider participates in the underground economy and consumer will derive some benefit by saving the tax portion of the transaction.

Spiro (2005) also argued that there might be some goods and services for which there is no benefit to procuring those goods or services in the underground economy. One example would be the provision of utilities such as telephone or power generation. Consumers may be equal to reduce their consumption of such services by becoming more efficient however they do not have the option of procuring those services in the underground economy. The other consideration in tax policy is having accurate information on the size and scope of the underground economy. Only with this information can more accurate policy decisions be made.

The approaches used to estimate the size of the underground economy are prone to issues. First, the micro- and macro-economic approaches are both subject to incorrect assumptions. Nevertheless, it is important to have a good overall knowledge of what sectors might contribute to the underground economy and generate better microeconomic models. Statistics Canada uses a microeconomic approach to estimating the underground economy. The size of the underground economy is estimated for each sector. The accuracy of the overall estimation is dependent on the

assumptions. Other estimates such as the Taxpayer Compliance Monitoring Program cannot identify all forms of evasion. Specifically, if an underground economy participant is a non-filer, then the TCMP cannot estimate the quantum of evasion for that non-filer group.

Spiro (2005) noted that an understanding of the participants. The three principal groups of participants include family run businesses, self-employed individuals especially in the service industry, and criminals. Tax evasion by family-run businesses is typically under-reporting of income. Thus, some of the income is declared. Tax evasion by self-employed individuals can vary from total participation (i.e., non-filers) to partial (i.e., underreporting). In either case, input tax credits cannot be claimed against cash sales.

Spiro (2005) asserted that Canadian economic growth is lower than the United States, and that the underground economy grew more in Canada in the 1990s. Spiro concluded by stating that the underground economy cannot be eliminated, however with careful policy decisions, its growth can be slowed or discouraged.

### 4.4.12. Enforcement and Audit Selection

Spicer and Thomas (1982) used a laboratory setting to study the effects of tax audit probabilities on the tax evasion decision. University students were recruited to play a three-round tax game. Each round lasted for 8 pay-periods. For each pay-period participants were given an income amount, and had to then decide how much of that income to declare for tax purposes. Audits were conducted on a random selection of the participants and penalties were imposed that were equivalent to seven times the amount evaded. Participants were given an award at the end of the simulation that took into account their total income less any fines. One third of participants were given accurate information on audit probabilities (e.g., 1/20, 5/20, 3/20), one third were given general information on audit probabilities (e.g., low, high and medium) and the last third were given no information on audit probability for the three rounds. Spicer and Thomas found that the percentage of taxes evaded was negatively correlated with audit probabilities. This finding only held true for participants that received accurate information on audit probabilities. This lead to the conclusion that conformance with economic theories of tax evasion would only hold under conditions of accurate information. Further, changing the audit probabilities changed the probability of evasion, but not the quantum of the evasion.

Last, those participants who received no information on audit probability showed no significant probability of evasion and also evaded the least amount of tax.

Boyd (1986) examined the enforcement of tax compliance. He estimates that tax evasion costs between 5% and 20% of potential revenue. Evasion can be combatted either through behavioural (e.g., attitudes, actions) or deterrence mechanisms. Boyd then looked at the elasticity of compliance for different inspection rates. Inspection rates were defined in five levels: 1) zero inspection, 2) profit maximizing inspection rate, 3) quota setting inspection rate, 4) revenue maximizing inspection rate, and 5) full compliance inspection rate. For zero inspection rates, some taxpayers will pay regardless of the level of enforcement. The elasticity of evasion may not be constant across the spectrum of inspection rates. For full compliance (i.e., 100% inspection), the assumed compliance rate between near 100% inspection and 100% inspection would be nearly identical. Again, this suggested that the elasticity of evasion may be different at the ends of the spectrum versus the middle. Boyd further suggested that there would be a time lag between policy decisions on new inspection rates and changes in taxpayer behaviour. For increased inspection rates, the compliance effects may not be immediately observed. Likewise for reduced inspection rates, the potential increases in evasion behaviour may not be immediately evident. Boyd does suggest that reduced inspection rates may lead to irrevocable increases in evasion as suggested by catastrophe theory. Boyd's essay did not involve an empirical test of these ideas. Nevertheless, the salient point was that policy makers must be prudent in setting the inspection rate and be aware of the potential impacts of increasing or decreasing the inspection rates. I note that most inspection rates reported in literature are greatly above real-world inspection rates. Boyd did not address this in his essay, but I would argue that setting artificially high inspection rates in empirical research may distort the results.

Murray (1995) explored sales tax audit selection. Murray noted that most studies on audit selection focused on the individual taxpayer or business tax returns. Murray notes that the decline in sales tax audit coverage that he noted in his introduction reflected the declining budgets, the increased overall number of sales tax registrants and the allocation of audit resources to more complex files. Murray concluded that guidance on which sales tax audits may be the most productive was required and noted that statistically-based audit selection systems have been slow to emerge. As in the individual taxpayer compliance literature, two results were evident. First, noncompliance was linked to the taxpayers' opportunities for noncompliance. The opportunities for noncompliance could be

addressed partly through changes in reporting requirements and information matching programs. The second result from his analysis of sales tax audit selection criteria found that the application of ordinary least squares techniques provided greater predictive power over more complex audit selection techniques.

Murray's (1995) sample consisted of records from a state of Tennessee's sales tax records. He found that the audit selection techniques from the data set provided were somewhat limited because the audited returns themselves could not be used to develop the audit selection procedure. While the data showed the audited counts there was no record provided of the specific audit selection rule that generated these audits. In his results, he found that companies with greater gross sales had lower overall odds of being audited, while firms with greater variability in reported sales had a higher probability of audit. Murray also found that firms that habitually submitted late sales tax returns face lower probabilities of audit. It was also discovered that older companies faced a higher probability of audit and this may have been indicative of the use of established compliance patterns to support the audit selection decision.

Alm and McKee (2006) studied the influence of uncertainty and the productivity of audits on taxpayer compliance. The study was based on the principle that strategies for reducing income tax evasion included enforcement strategies including audits. In this study the authors defined audit productivity as the probability of an audit being successful in finding evaded taxes. The audit certainty was defined as the probability of an audit. If the assumption was made that audit are not 100% successful in finding evaded taxes this was considered to be the same as decreasing the probability of an audit. The experiment designed by the authors was set up to investigate the effects of providing information taxpayers for their tax declaration that their tax return would be audited and also to examine the effects of differing levels of audit productivity.

Subjects were in a controlled laboratory environment where income through the performance of tasks and their income were determined by their relative performance on completing these tasks. The subjects were then asked to determine a tax declaration and pay taxes on any reported income. As expected no taxes were paid on unreported income however this unreported income could be discovered by way of a random audit and then the subjects would have to pay the fines and penalties the unpaid income tax.

Alm and McKee (2006) suggested that the concept of parallelism in which an experiment captured the essence of the naturally occurring phenomenon was satisfied by their design. Additional elements to increase the degree of parallelism included the fact that any nonfilers were automatically audited and used language similar to the language used by tax authorities such as the Internal Revenue Service. In various treatments, the authors varied the information about audit probability provided to subjects and information regarding the productivity of the audits.

The primary approach consisted of a generalized least squares regression model that was used to explain the tax compliance as a function of the various parameters used in the study. The model stated that the compliance rate is a function of some constant plus income, audit rate, and a lagged penalty. Announcing who would be audited while holding audit productivity as a constant decreased overall compliance. However subjects who know that they would be audited would increase their overall compliance and those that know that they would not be audited decreased their compliance. When audit productivity was lower than 100%, compliance declined for subjects that were aware that they will be audited. When the effects of a lagged penalty on compliance was negative, it suggested that a gambler's fallacy type of behaviour was in effect. One interesting fact was that the subjects responded to with increased compliance and increased audit effectiveness or productivity only when they were expecting to be audited. More productive audits were not sufficient by themselves to increase compliance. Increased compliance required a greater expectation on the part of the taxpayer of being audited. The authors noted that sending taxpayers letters that indicated that they are preselected for audit would require that all those taxpayers receiving a letter be in fact audited. If it became known or suspected that the threat or promise of audit was not in fact 100% likely, then the overall compliance in the real world would likely decrease. Conversely, informing selected taxpayers of their likelihood of audit would therefore imply that taxpayers who were not informed of their likelihood of audit would not be audited and overall compliance may decrease from that effect as well.

Alm, Jackson and McKee (1992) continued their study on enforcement information dissemination and compliance behaviour. In this study the question for the tax authority was how taxpayers became aware of audits and other compliance initiatives. For compliance initiatives to be effective taxpayers must be aware of those initiatives. Alm et al. used a laboratory experiment to determine the effects of official information versus unofficial information on taxpayer behaviour. One factor that may influence the overall compliance decision was the concept of social norms in

compliance decisions. This meant that taxpayers will be more likely to comply if they believed that compliance with tax laws was the social norm. The authors contended that official and unofficial communications may affect this social norm. Inherent in the social norm impacts on taxpayer behaviour was knowledge of audit probabilities and compliance initiatives when making a compliance decision. In keeping with Alm's previous research, audit probabilities needed to be credibly announced.

Three hypotheses were generated in the study. First "official announcements of audit results (the number of individuals audited and/for the fines collected) in the previous period will, ceteris parabis increase compliance."(Alm, Jackson and McKee 1992, p. 398). Second "reports of low audit frequency in the previous period will lead to reduced compliance. Reports of high audit frequency will increase compliance, and this effect will increase as the number of audits increases". Third "reports that others are compliance the tax rules lead to higher compliance on the part of individuals receiving this information. Similarly, reports that others do not comply will lead to lower compliance."

The policy perspective the resulted from this study suggested that tax authorities should support the announcement of audit rates and reinforce this information with the results of audits in the previous periods. Informal communication will generally lower compliance unless audit frequencies are much higher than current levels. Of note the impact of audits was not limited to those subjects that were audited. This suggested that the social norms in tax compliance existed and were demonstrated by the experiment.

### 4.4.13. Information Returns

Kamdar (1995) explored the relationship between information reporting and tax compliance using tax payer compliance monitoring program data from the Internal Revenue Service. The Taxpayer Compliance Monitoring Program consistently revealed differences in voluntary reporting behaviour across different types of income. Kamdar suggested that these differences may be linked to differing information reporting requirements. He suggested that different compliance models were required for income subject to third-party information reporting requirements.

Information reporting served two objectives. First it increased the taxpayers' perceptions of detection. Second, information reporting requirements also potentially reduced the taxpayers' administrative burden. The model of reported income is as follows: "Reported income = (true income, marginal tax rate, perceived probability of detection, penalties for noncompliance, socioeconomic and

demographic characteristics)" (Kamdar 1995, p. 280). Kamdar used a proxy for the perceived probability of detection. This proxy included a number of variables including the number of sources of income, agricultural income, interest and dividend income.

Kamdar (1995) found an inverse relationship between tax rates and noncompliance, which was consistent with theoretical economic models of taxation and compliance. However this was inconsistent with previous empirical work. The paper also concluded that, as expected, taxpayer behaviour is affected by the opportunities for noncompliance. However this was constrained when third-party information reporting requirements existed. While it was tempting to expand information reporting requirements from a tax policy perspective, the resultant administrative costs of the tax authorities also needed to be considered.

### 4.4.14. Variables influencing Evasion

Increases in the number of self-employed people, and possible the largest growing type of employment in Canada, may make it easier to evade taxes (Brooks 2001; Erard and Ho 2001). Brooks (2001) also argued that the shift to a service-based economy increases, along with increasing disposable income, the number of people willing to provide services for cash. Brooks further suggests demographics, globalization, and declining tax morality may also influence the rise of the UE. Other considerations that may influence tax evasion are culture and personal behavioural characteristics (Mirus, Smith and Karoleff 1994).

Giles (1998) proposed that partitioning data by sector and developing separate models for each SIC classification would be of value, since his data suggested that different sectors may have different compliance issues.

Strategies taken by governments to motivate compliance need to be varied since "taxpayer motivations may differ across groups and that all taxpayers will not respond to the same (compliance) motivating factors" (Ritsema, Thomas and Ferrier 2003 p. 16). A comprehensive compliance approach would lessen the possibility of substitution of alternate modes of evasion (Martinez-Vazquez and Rider 2005). Their research question focused on the effect of enforcement on income tax evasion. Further, Martinez-Vazquez and Rider looked at whether alternative methods of tax evasion are substitutes or complements and the resultant impact of increased enforcement. The two modes of tax evasion were either underreporting income or overstating deductions. In this scenario, possible outcomes were: 1)

that income tax evasion was not detected; 2) evasion was detected; and 3) evasion is detected in one mode of evasion but not the other. The authors used the Internal Revenue Service's 1985 taxpayer compliance data. Further analysis the authors concluded that taxpayers used multiple methods of tax evasion. Approximately 24% of the returns analyzed correctly with income while 63% understated income the remainder overstated their income. Of the 63% that understated income about 50% of those returns used a multi-method tax evasion strategy. The authors also expected that they would see evidence of lower evasion or items subject to withholding or third-party information reporting. To measure the risk of detection in each mode, Martinez-Vazquez used three proxy variables for the scope of evasion that were based on the TCMP differences observed from auditor and third party information for wages, interest and dividend income and deductions. Each of the proxy variables was weighted by the approximate proportion of the income adjustments that each accounted for (67 percent, 15.4 percent, and 23 percent respectively). Further, dummy variables were used for taxpayer provided information that was not subject to third party reporting (e.g., rental income) since there was greater opportunity to evade on that type of income. From their analysis, Martinez-Vazquez and Rider showed that the two possible modes of evasion are substitutes. Thus, from a policy perspective, enforcement methods that target one of the modes will see corresponding decreases in compliance in the other mode. The authors then studied the effect of changing the reporting requirements for certain types of income (e.g., increasing the scope of third party information reporting). The finding was interesting – if 10 percent more income was subject to third party information reporting, there was a 1.1 percent increase in compliance for income reporting and a 0.1 percent decrease in compliance for deductions. Changing the strategy for deductions from itemized deductions to a standard deduction eliminated the deductions gap and a net increase of 40 percent in income reporting compliance. From a policy perspective, eliminating itemized deductions in favour of standard deduction appears to be an effective strategy.

Ahmed and Braithwaite (2005) investigated how self-employed individuals and they are taxation issues were related to each other and whether or not this group of taxpayers engages in taxation in different ways than other taxpayer groups. Overall there were four domains that were examined: 1) perceived deterrence, 2) tax morale, 3) perceptions of fairness, and 4) work practices. Traditionally the self-employed are viewed as being less compliant with income tax requirements than

other segments of the population. This noncompliance can take the form of either exaggerated deductions or underreported income.

Ahmed and Braithwaite (2005) used a sample of Australian taxpayers using a survey to examine the or domains above. 2040 usable surveys or return code of 7754 questionnaires distributed for a response rate of 29%. Self-employed individuals comprised of 244 in the 2040 usable surveys. The studies definition of self-employed was fairly broad and included sole proprietorships partnerships small businesses and family-owned businesses of up to the 200 or more employees. The four domains were subject to three to eight questions on the student survey. The assumption in the current study as in previous research has been that the small business sector is more likely to participate in tax evasion than other sectors.

The findings indicated that from a tax morale perspective small businesses were comparable in their tax morale two other segments in the sample (Ahmed and Braithwaite 2005). With respect to the fairness hypothesis the small business owners in the sample were more likely to admit paying less than their fair share. This result was in the opposite erection hypothesis. With respect to work practices small businesses admitted to greater tax evasion but at comparable levels to those employed in the private sector. From the deterrence perspective there was only limited Support for the deterrence variables. Overall there were 13 variables in the survey that discriminated small business taxpayers from other sectors these 13 variables were used in a discriminant function analysis in an effort to identify a combination of variables that would differentiate the small business taxpayers from their counterparts. One discriminant function emerged accounting for 14% of the variance. The discriminant function correctly classified 66% of small business taxpayers and 70% of the other taxpayers into their respective groups. The six variables that contributed significantly to the discriminant function were:

- likelihood of getting a tax refund
- Fair share compared to Australians
- tax competence and independence
- perceived power of tax office or small business, self-employed and ordinary people
- small government and minimum interference
- support for health welfare education (redistribution) spending

Overall the results (Ahmed and Braithwaite 2005) suggest that these variables give moderate discriminatory power in separating small business taxpayers from other taxpayers. Finally, Ahmed and

Braithwaite suggest that a combination of persuasion tax reform and deterrence are required for increasing compliance in the small business sector. One method methodological issue comes to mind when reviewing this particular study is the broad definition of self-employed. Since the broad definition of self-employed netted only 10% of the sample the reliability of these results while interesting is questionable given the relatively small sub-sample size.

Dell'Anno (2009) also examined tax morale and tax evasion. This study found that tax compliance increases within the social norms disfavouring evasion are prevalent. One of the outcomes of this paper was that there might exist to different equilibrium states. The first equilibrium is one with low tax evasion and the second way is highly dishonest taxpayers. Cule and Fulton (2009) also demonstrated multiple equilibrium solutions to be tax evasion question or example ladies stated that increasing deterrence may have an adverse effect, namely increasing evasion. One potential cause of this effect is on the social acceptability of income tax evasion become more and more acceptable in the cost of participating in the underground economy is lower. An alternative explanation is that as more businesses participate in tax evasion this participation is good for corrupt officials. This last explanation is of more concern than countries that have a higher degree of overall corruption in their civil service.

Different motivations for evasion and compliance existed for individuals and firms (Cowell 2003). Cowell (1992) examined tax evasion and inequity. Inequity in this case meant that the evasion decision may be driven by the taxpayers' perception of inequity in the taxation or political system. Cowell provided two reasons for examining inequity. First, the literature seemed to provide evidence that societal values play a role in the compliance decision. These societal values formed part of a social climate in which an individual made their compliance decision. This climate included the concepts of social justice, fairness and equity. Thus inequity could form part of those societal values. Second, tax perceptions were a determinant of evasion behaviour.

Cowell (1992) then introduced his mode of inequity and the evasion decision. With four components: 1) the taxpayer's opportunities; 2) the tax-enforcement system, 3) social factors, and 4) taxpayer motivation. Cowell concludes by suggesting that the individual believes that they can correct social inequities through individual action.

## 4.5. Modelling and Estimating the Underground Economy

Slemrod (2001) outlined a general model of the behavioural response to taxation. First, the legal responses to changes in the tax rate involved one of two strategies. First, taxpayers might be induced to change the bundle of goods and services that they consume (i.e., their consumption bundle). Second, taxpayers might pursue tax avoidance strategies such as tax planning. Slemrod suggested that the second strategy (avoidance) was much more common than the first (changes in consumption).

Slemrod (2007) also reviewed the economics of tax evasion. Slemrod noted that while some taxpayers will pay their taxes, others will not. The "tax gap" was defined as the "tax (that) should be paid, but is not paid voluntarily in a timely way" (Slemrod 2007, p. 26). The tax gap was quantified, in part, but the Internal Revenue Services' Taxpayer Compliance Monitoring Program. The Taxpayer Compliance Monitoring Program was cancelled in 1995 due to budget constraints, complaints that the TCMP was unfairly targeting selected taxpayers, and that it was diverted resources from operational audits. The TCMP was replaced by the National Research Program. The National Research Program (NRP) followed a more streamlined approach. In lieu of detailed audits, auditors in the 46,000 return NRP classified returns into one of three categories. First, the return could be accepted due to third party information or other corroborating information. Second, the tax filer could be contacted via letter to provide further information on up to three items from their return. Last, the return could be selected for an in-depth audit. In either case, to use the TCMP and NRP to estimate the tax gap, estimates still must be made on undetected non-compliance as well as the degree of non-compliance. Of the estimated 2001 United States tax gap of $345 billion, the Internal Revenue Service recovers $55 billion, leaving a net tax gap of $290 billion. Also of note was that understated income accounts for 80 percent of the individual underreporting of taxes, as well as an estimated 57 percent of non-farm self-employed income was evaded. Slemrod reported that noncompliance by large corporations was around 14 percent versus 29 percent noncompliance by corporations smaller than $10 million in assets. However, noncompliance in corporate tax was more difficult to evaluate due to the overall complexity of the tax regime, opportunities for tax avoidance and tax planning.

Slemrod (2007) stated that "good tax policy should be designed with the realities of evasion in mind" (p. 41). For example, if a tax regime knew that an average of 20 percent of tax was evaded, then the tax regime should gross up the tax liability by the amount of tax normally evaded. Thus, taxpayers think that they are getting away with tax evasion, and the tax regime gets the amount of tax revenue

required. However, not all taxpayers evade or evade in the same proportion. Evasion also created inequity: taxpayers with equal income could thus have different tax burdens. The key, according to Slemrod was not to eliminate evasion, but to balance the social benefits of reduced evasion to the costs of pursuing the reduced evasion.

Wahlund (1992) addressed the impact of tax policy changes on economic behaviour. For example, did a reduction in tax rate reduce tax evasion? Wahlund used a combination of economic data, telephone interviews of Swedish males and survey data of the respondents to the telephone interviews. The first round of interviews was in 1982 and the second in 1984. Self-reports of tax evasion were used, and consisted of four questions. No change in the self-reports of tax evasion were noted between the two surveys. Despite a tax reform initiative between the surveys, no change in evasion behaviour was noted. Wahlund constructed a structural model to explain the evasion and found that five of twenty three variables had a direct influence on evasion behaviour:

1) Opportunity to evade
2) Perceived opportunities to evade
3) Lower tax morale
4) More risk tolerant; and
5) The greater the rate of tax avoidance, the more tax evasion.

Nevertheless, the model left 70% of the variance in the dependent variable unexplained.

There are several main methodologies that may be used to estimate the size of the UE. These main groups of methodologies include indirect methods such as the currency/demand approach, the electricity method, models/indicators, and direct methods such as survey and audit data.

Berger (1986) discussed the unreported economies concepts approach and estimates in the Canadian context for 1981. He argued that the existence of an unknown reported economy had important economic and social policy implications. As noted previously the principle difficulty with the unreported economy was measurement and the fact that individuals who were involved in the unreported economy wished to remain undetected.

Berger (1986) outlined monetary and national accounts and survey and inferential approaches for estimating the unreported economy. He then outlined some activities commonly linked to the unreported economy:

- Employees working off the books to avoid taxes

- earnings from tips
- rentals
- skimming of cash income from legitimate businesses to avoid taxes
- activities carried out without proper permissions or licenses especially in the construction industry
- the sale of personal services
- barter
- illegal activities such as gambling trading in illegal drugs prostitution and theft

In the Canadian context the definition of economic production excluded all criminal activities. The unreported economy was therefore defined in Canada as that portion of production which was missing from the gross national product because activities are misreported or not reported. When it came to misreporting it was impossible to distinguish between error and intentional misreporting.

Unreported wages were calculated as the number of individuals working in the underreported economy times the hours worked per week times the average are really unreported wage times the number of weeks worked per year. Berger (1986) estimated the total unreported wages in 1981 based on that formula as $7.851 billion. Berger also estimated that income of unincorporated businesses that was unreported may have represented 0.5% of person national product in the same year. Additionally concealed corporation profits were estimated to account for 0.1% of person national product and negligible rental income was not reported. Overall, Berger estimated that the unrecorded components represented approximately 2.9% of gross national product in 1981 including unreported wages concealment of income from unincorporated businesses and the concealment of corporation profits. Note that 2.9% of gross national product translated into $10.134 billion.

Berger (1986) suggested that there is a large degree of variability in the estimates and the assumptions underlying is calculations. Nevertheless it would be unwise to suggest that Canada's unreported economy is no less of a problem than it is in other developed countries. Berger also stated that the estimates are the same general order of magnitude as estimates for the United States and the United Kingdom.

Schuetze (2002) studied non-compliance amongst self-employed taxpayers in Canada from 1969 to 1992 using the Statistics Canada Canadian Family Expenditure Surveys. The key assumption was that families with undeclared income would have higher household food consumption. Income

could then be imputed from the consumption patterns and would take into account both unreported income and overstated deductions. Overall estimates for households deriving over 30 percent of their income from self-employment were between 11 and 23 percent over the period examined. There was no overall increase in non-compliance between 1969 and 1992. However, occupational group (e.g., trades and construction) provided greater opportunities for evasion. Schuetze recommended that enforcement strategies that target households with the greatest opportunity to conceal income (e.g., construction and service industries) would be more effective.

Frey and Weck (1983) posed the question "what produces a hidden economy?" Their paper focused on the factors that cause and increase the underground economy. The likely determinants of the underground economy in 17 OECD countries from 1960-1978 were subjected to a sensitivity analysis to identify crucial variables. Two groupings of variables emerged: 1) the tax burden imposed; and 2) labour market opportunities to participate in the underground economy. The tax burden imposed had two components: the change in the tax share and the change in regulation. Labour market opportunities included changes in the participation rate, unemployment rate, and working hours. Overall, the analysis suggested that the change expected in the Canadian underground economy was going to be negligible based on the analysis. The overall relationship was that a decreasing participation rate decreasing working hours and increasing unemployment were potential indicators of growth in the underground economy.

Spiro (2005) examined the relationship between tax policy and the underground economy. The underground economy added a layer of complexity to tax policy once people decided that they can opt in of the tax system to varying degrees. Spiro outlined three main policy issues that result from the growth of an underground economy:

1. Higher tax rates may fuel tax evasion. In turn this forced an ever increasing tax rate to compensate for lost revenue. The higher tax rates were typically required in areas where evasion is more difficult, for example, in areas where income was subject to income tax withholding. Evasion required a mix of tax rates and sanctions.

2. Participation in the underground economy may also work as a form of subsidy to economic activities where overall productivity was low.

3. The overall difficulty in measuring the impact of the underground economy, its size, and its impacts made government estimates of economic activity unreliable, and possibly leading to erroneous policy decisions.

Spiro (2005) argued that in some respects the underground economy had its supporters in the world economics. The underground economy could be construed as a form of protest against government spending when democratic process was not sufficient. The underground economy could also be construed as a form of protest again various economic regulations. However, this applied only if economic activity was underground, not solely for the purposes of evading income tax. It could be argued that if the sole purpose of going underground was to evade tax there were welfare costs and the activity may be more inefficient than if it was in the legitimate economy.

### 4.5.1. Currency/Demand Approach

The currency/demand approach is likely the oldest approach and is based on the assumption that, as the size of the UE increase/decreases, so too will the demand for currency. The assumption is that all transactions in the underground economy use cash in lieu of credit or cheques or debit cards. In addition, there is an assumption that there is a base period in which the underground economy did not exist. Therefore, any positive changes would be the result of underground activity. There is also an equal income velocity assumption. That is, that a dollar earned in the underground economy is equivalent to a dollar earned in the formal economy. There are numerous theoretical issues with the assumptions underlying this approach, as well as numerous adaptations (Giles and Tedds 2002) such as Tanzi and regression estimates (Spiro 1996).

Gutmann (1977) pioneered the currency demand approach to measuring the underground economy. Gutmann's premise was that cash was the only acceptable form of payment for transactions in the underground economy. The next premise is that cash stocks in an economy are made up of two components: currency and demand deposits. Gutmann assumed that there was no demand for illegal transactions in the period 1937 to 1941, and that currency demand for legal transactions remained the same percentage of demand deposits in later years. Gutmann's justification for the 1937 to 1941 period is not clear. The percentage of demand for currency was believed to be constant at 21.7%. Thus, Gutmann concluded that the amount of currency required for the underground economy was obtained by subtracting the legal (static) and demand deposits from the stock of money. From this, the size of

the underground economy as a percentage of the Gross National Product could be calculated (i.e., percentage of stock of money for illegal transactions is the same percentage of Gross National Product). Gutmann concluded that national statistics should be revised to take into account the underground economy estimates, and this should help to guide subsequent policy decisions.

### 4.5.2. The Electricity Method

Some assume that the consumption of electricity (the Kaufmann-Kaliberda Method and the Lacko Method) is the best indicator of aggregate economic activity in a country (Schneider 2002). Official GDP estimates are then backed out of the picture and leave an estimate of unofficial GDP. Nonetheless, UE activities are not always dependent upon electricity, there is no acknowledgement of efficiency (both in production and use), and consumption is highly variable country-to-country, seasonally, and over time (Schneider 2002).

### 4.5.3. Models/Indicators

There are many models of the UE in existence. Some of these models are specific to the Canadian or Commonwealth experience, and include nonparametric models (Giles and Johnson 1999), fuzzy logic (Draeseke and Giles 2002), and MIMIC (multiple indicators, multiple causes) (Tedds and Giles 2000).

Indicators that infer the direction (growth/shrinkage) and size of the UE include:

(i) Development of monetary indicators: if activities in the shadow economy rise, additional monetary transactions are required.

(ii) Development of the labour market: increasing participation of workers in the hidden sector results in a decrease in the participation in the official economy. Similarly, increased activities in the hidden sector may be expected to be reflected in shorter working hours in the official economy.

(iii) Development of the production market: an increase in the shadow economy means that inputs (especially labour) move out of the official economy (at least partly); this displacement might have a

depressing effect on the official growth rate of the economy. (Schneider 2002 p. 42).

### 4.5.4. Survey

Surveys are used by a number of countries to estimate the size of the UE, but are subject to concerns regarding integrity of response, and difficulty in relating survey results to an estimate of the size of the underground economy (Schneider 2002).

### 4.5.5. Audit

Erard and Ho (2002)developed an econometric model for measuring tax noncompliance using operational audit data. Traditionally the taxpayer compliance measurement program developed by the Internal Revenue Service has been a primary data source or researching the tax gap especially in the United States. The authors wanted to illustrate how operational audit data could be used to develop an estimate of the individual income tax gap. They used one example for the earned income tax credit (EITC).

Erard and Ho (2002) developed two equations. The first equation is a probit model where the likelihood that an individual right return with serve characteristics with the audit and includes an error term. From the tax data the authors can conclude whether the likelihood of audit is greater than zero a observing whether or not an audit has been performed. The second equation is a TOBIT equation based on the size of earned income tax credit claimed above what was allowable individual taxpayer's particular circumstances. The equation represents the degree to which a taxpayer with specific characteristics will overstate their claim. From these two equations three cases are possible: 1) there is no audit; 2) there is an audit but no earned income tax credit or claim; and 3) there is audit with the earned income tax credit overclaim. The authors compare the mean predicted the earned income tax credit overclaim amounts of audit and on the audited income tax returns. The difference between the audited and the on audited returns was less than 5% and was lower than anticipated. However the authors believe that with a better specification of variables in their equation that this difference might become significant.

Estimates of the size of the underground economy may be made by comparing declared income for taxation purposes and income as measured by audits (Schneider 2002). This methodology

is likely to be biased towards largely compliant taxpayers and may underestimate the overall size of the UE.

Feige (1979) posed the question "how big is the irregular economy?". Feige also believed that the underground economy is of such magnitude and not considered in the national accounts that macroeconomic and associated policy directions may be incorrect. Feige then examined the way that the macroeconomic estimates are calculated. Feige also uses the term "irregular economy" as a more neutral term than the underground economy. The irregular economy is defined as the economic activity that is unreported or not measured. By definition, gross national product (GNP) excludes illegal activity such as drug trafficking. Original estimates of the United States irregular economy were in the range of $200 Billion in 1976, which equates to the size of the Canadian regular economy at the time.

Feige (1979) then reviewed the "Gutmann" method which lead to the $200 billion estimate of the United States irregular economy. The Gutmann method started with four assumptions. First, the method of payment in the irregular economy is cash. Second, the irregular economy did not exist in the time period 1937-1941 and was used at the benchmark for the estimates. No rationale is provided as to why the irregular economy was purported not to exist at that time. Third, the ratio of currency to demand deposits during the benchmark period would only change due to the irregular economy. Last, the amount of income produced in the irregular economy per dollar is the same as in the regular economy. Given these assumptions, the currency/demand-deposit ratio for the benchmark period was 0.217. Gutmann then calculated the 1976 demand as the benchmark times the 1976 demand deposit figure. The resulting calculation was an estimate of $177 billion.

Feige (1979) then evaluated the reasonableness of the model and assumptions. First, the laundering of money overseas, and subsequently back into the United States, can create demand deposits. This could alter the currency/demand deposit ratio. Further, the payment for services in the irregular economy could conceivably include cheques and credit cards. Second, Feige had no issue with the benchmark. Nevertheless, as long as human history and taxation has existed, the irregular economy has existed. Feige suggested that the third assumption ignores other influences on the currency/demand-deposit ration. Last, the equality of the income produced in the irregular economy versus the regular economy would more than likely underestimate the irregular economy notwithstanding any inefficiencies that it may have.

Feige (1979) then attempted to re-estimate the irregular economy in the United States. Beige's estimates show that the irregular economy is, by his calculation, underestimated. Given the variability in estimates, it is difficult to determine the appropriate response from the policy perspective.

Feige (1990) outlined an approach to defining and estimating the underground and informal economies. Feige had three objectives for the paper: First, to outline a taxonomy of underground economies; Second, to enumerate the issues in quantifying the size, growth and characteristics of the underground economy; Third, to evaluate the strengths and weaknesses of the various approaches to measuring the underground economy; and last, to outline the impact of measurement of the underground economy on policy.

Feige (1990) identified four types of underground economies in his taxonomy: the illegal economy; the unreported economy; the unrecorded economy; and the informal economy. These economies were defined by Feige as follows:

| |
|---|
| **The illegal economy** is defined as the economic activity that results in income from activities that violate legislation. These activities typically include theft, the drug trade and prostitution. |
| **The unreported economy** is defined as the economic activity that evade tax legislation. In other words, the amount of income that should be declared to the tax authorities but is not. This is sometimes referred to as the tax gap. |
| **The unrecorded economy** is defined as the economic activity that must be reported to statistical agencies for inclusion in national accounts, such as gross national product, but is not reported. |
| **The informal economy** is not consistently defined in the literature. Feinstein proposes that the informal economy is not as severe as the illegal economy, but is economic activity that general evades property law, labour law, torts and licensing regimes. |

Feige (1990) then described various measurement scenarios. Measurement of the underground and informal economies is somewhat challenging ""any attempt to measure a social phenomenon whose raison d'etre is to defy observation is fraught with empirical difficulties."(Feige 1979, p. 393)

Feige (1990) then examined the strengths and weaknesses of various measurement methodologies. Feige first observed that the measurement of any activity whose primary goal is to evade detection will be necessarily difficult. He then sets out to establish some criteria that could be

used to determine whether or not the estimates are within acceptable limits. First, a measurement strategy must be sufficiently wide ranging and use different sources of data using multiple methodologies and may include qualitative, quantitative and anecdotal data. Anecdotal data provides context that may guide research questions. Next, Feige termed microdata as information that could be derived from such sources as surveys, and tax returns and may be used to derive characteristics of individuals or businesses. Last, macroeconomic data may provide impartial data from published sources. Such macroeconomic data for studying the underground economy usually includes aggregated monetary measures.

Feige (1990) then described the various methods that can be used to detect unreported, unrecorded income and transactions. For example, discrepancies in national accounts (e.g., income versus expenditures, payments-transactions) can be used to identify sectors with unreported income. Expenditures are less likely to be misrepresented and discrepancies can give indications but not definitive proof of unreported activities. Other methods including currency ratios provide estimates of currency demand. Since cash is the primary method for transactions in the unrecorded economy, this method give gross estimates of the size of the unrecorded economy. Feige (1990) suggests that time series analysis of Internal Revenue Service data shows that the size of the unrecorded economy in the United States has been increasing since the 1940s. Census data can also be used to identify unpaid work. Feige concluded that the ability to measure the unreported and unrecorded industries is key to being able make policy decisions.

## 4.6. Estimates of the Size of the Canadian UE

Official Government of Canada estimates of the UE (Office of the Auditor General of Canada 1999) vary somewhat according to the methodology used (e.g., model vs. currency/demand) and the definition of the UE used.

The Office of the Auditor General of Canada (OAG) reported in 1999 that estimates of the size of the Canadian UE have ranged from 3 percent to more than 20 percent of GDP. The OAG estimated the UE at between 4.2 and 4.5 percent of GDP in 1993, while Statistics Canada estimated the UE at 4.2 percent of GDP for 1993. The OAG (Office of the Auditor General of Canada 1999) further estimated that at 4.5 percent of GDP in 1997, the UE's value would have been $38 billion.

Erard (1997 p. 7) summarized the UE estimates for Canada as follows:

**Selective Review of Indirect Attempts to measure Unrecorded GDP**

| Study | General Approach | Year(s) Measured | Findings |
|---|---|---|---|
| Mirus and Smith (1981) | Currency Ratio | 1976 | 16.3% of GNP unrecorded |
| Spiro (1993) | Currency Ratio | beg. 1991 - mid. 1992 | 0.8% growth in unrecorded GDP over period |
| Spiro (1994, 1997) | Currency Ratio | beg. 1991 - end 1993 | 2.0% growth in unrecorded GDP over period |
| Mirus, Smith and Karoleff (1994) | Currency Ratio | 1990 | 30.0% of GNP unrecorded |
| Mirus and Smith (1981) | Tanzi | 1976 | Between 4.9% and 7.2% of GDP unrecorded |
| Ng and Karolyi (1984) | Tanzi | 1982 | Between 12% and 16% of GDP unrecorded |
| Éthier (1985) | Tanzi | 1973-1981 | Unrecorded GDP grew from 6% in 1973 to 8.4% in 1977 and then fell to 5.9% in 1981 |
| Pouftis (1993) | Tanzi | 1946-1990 | Upward trend in unrecorded GNP since 1960s, with exception of brief dip in the early 1970s; represented 2.44% of GDP in 1960 and 12.98% in 1990 |
| Mirus, Smith and Karoleff (1994) | Tanzi | 1990 | 5.1% of GDP unrecorded in 1990 |
| Hill and Kabir (1996) | Tanzi | 1964-1995 | Unrecorded GDP growth between 1964 and 1995 of 3 to 11 percent |
| Mirus and Smith (1981) | Transaction Method | 1976 | 28% of GDP unrecorded |
| Mirus (1984) | Transaction Method | 1976 | 10% of GDP unrecorded |
| Mirus, Smith and Karoleff (1994) | Transaction Method | 1990 | 23.9% of GDP unrecorded |
| Gervais (1994) | Judgment | 1992 | A maximum of 2.7% of *legal sector* GDP unrecorded |
| Smith (1994) | Judgment | 1992 | A maximum of 3.7% of GDP unrecorded, counting the illegal sector |

**Table 4-5 Estimates of the Size of the Canadian Underground Economy**

Growth in the UE has been estimated at about 10 percent per annum between 1990 and 1993 (Drummond, Ethier, Fougere et al. 1994). Not coincidentally, Canada introduced a value added tax (the Goods and Services Tax or GST) in 1991. Spiro (1993) concluded that the introduction of the GST increased UE activity starting in 1991.

Mirus, Smith and Karoleff (1994) examined Canada's irregular economy. From their perspective, the relative size of the irregular economy can lead to misleading gross national product

(GNP), GNP growth, unemployment and inflation rates. The resulting policy decisions may also then be misinformed. Mirus, Smith and Karoleff revisited the Canadian underground economy over the 15 years period from 1976 to 1990. During this timeframe, personal income tax increased from 15.2 to 19.7 percent. Self-employment rose from 11 percent to 14.5 percent.

Mirus, Smith and Karoleff (1994) first address the question regarding why they care about the size of the underground economy. The first reason that they care was that the existence and uncertainty of the size of the underground economy biases the calculation of macroeconomic information for use by policy makers. In turn, this could lead to incorrect policy assumptions and directions. The second reason that Mirus, Smith and Karoleff gave was the foregone tax revenue attributed to the underground economy. In their estimation this could be as high as $6 billion in tax revenue in the mid-1980s. This lost revenue also has implications on the honest taxpayer as their tax burden may be increased as a result. The third reason that the authors give for caring about the size of the underground was the microeconomic consequences. For example, if the tax base was reduced, labour may be reallocated from the legitimate, tax economy to the irregular economy as there are cost advantages for businesses and individuals participating in the underground economy. Not all of the reasons are negative. For example, the underground economy may have social welfare implications by reducing income disparities in the market. Further, the growth of the underground economy may indicate policy challenges (and changes) are required to allow the regular economy to become more globally competitive. Last, the irregular economy may allow price discrimination in that some consumers would be able to pay less for some goods and services in the irregular economy than they would normally have to pay.

The next question that Mirus, Smith and Karoleff. (1994) addressed was how big the underground economy was. The estimation of the size of the underground economy was difficult since it is underground. Surveys may be useful in providing data on the scope of consumer usage of the underground economy, but are also subject to nonresponse and social response biases. Labour market studies are a subset of surveys that look at the participation in the labour force. The differences between independent studies and government studies may use to determine the degree and nature of the participation in the underground economy. Currency demand methods were less reliable as financial services product offerings changed, and the growth of electronic funds transfers increased. Nevertheless, the estimates from the currency demand approach provided rough estimates that may be

worthy of further refinement. The income-expenditure discrepancy method presumed that income at the national level must equal expenditures. Thus, if there was a discrepancy between income and expenditures, the difference could be construed as a measure of irregular activity.

Next Mirus, Smith and Karoleff (1994) looked at the estimates of the Canadian irregular economy. These estimates updated the earlier work by Mirus and Smith (1981). Mirus, Smith and Karoleff (1994) found that the currency/demand approach showed a steady increase over 25 years. However, Mirus, Smith and Karoleff also concluded that demand deposits dropped as a percentage of GDP decreased quicker than currency. When comparing the previous study's estimates with current estimates the following was shown:

| Method | Previous Estimates | Current Estimates (% of total economic activity) |
|---|---|---|
| Gutmann | 14.0 (1976) | 21.6 (1990) |
| Feige | 21.9 (") | 19.3 (1984) |
| Tanzi | 4.8-7.2 (") | 14.6 (1990) |

**Table 4-6 Estimates of the Size of the Canadian Underground Economy**
(Mirus, Smith and Karoleff 1994, p. 243)

The accuracy of the Canadian estimates remained questionable and continued availability of data (e.g., the Feige method cannot be used past 1984 as cheque clearing data is no longer available) was a concern. Further, data similar to the Internal Revenue Service's Taxpayer Compliance Monitoring Program had not been made available for Canada. The lack of accurate estimates limited effective policy approaches in controlling the Canadian irregular economy.

From the policy perspective Mirus, Smith and Karoleff (1994) had five suggestions. First, they suggested increasing the tax base and lowering tax rates. Second, the government should make a better link between taxes and the benefits services provided in return. Third, compliance with the tax regime must be as straightforward as possible. Fourth, increasing enforcement may not have the desired effects if it increases the number of non-filers. Last, Mirus, Smith and Karoleff point to the need for international cooperation and information sharing arrangements to ensure that offshore income is tax appropriately.

Mirus, Smith and Karoleff (1994) also argued that the use of the currency demand approach had limited ongoing validity for several reasons. First, the irregular economy was not limited to cash

for transactions. Next, financial institutions introduced products other than demand deposits which were used by businesses. For example, businesses have been encouraged to centralize deposits and make sort-term investments. Last, the Canadian currency ratio had been larger than the United States ratio due to fewer demand deposits.

Mirus, Smith and Karoleff (1994) gave indicators of irregular activity. First, tax prosecution cases tripled from 1974 to 1979 while the value of these cases doubled. Next, the illegal trade in jewellery was uncovered in Montreal in 1977. The scheme involved the creation and sale of false invoices for $50 million in transactions. The $50 million would have generated roughly half, or $25 million, in tax revenue. The false invoices were taken as an indicator of a much larger illegal trade in jewellery created by high excise tax rates. Last, the growth rate in the circulation of larger denomination bank notes far exceeded GNP growth of 226 percent between 1969 and 1979.

Using a variety of methods including Gutmann, Feige and Tanzi, the estimates of the irregular economy for 1976 ranged from 5 to 20 percent of total economic activity. By not including this activity in statistical measures of productivity, governments may make misinformed policy decisions. Mirus, Smith and Karoleff (1994) also encouraged the Canadian government to undertake similar studies to the Internal Revenue Service to increase understanding of the degree and nature of the irregular economy.

Hill and Kabir (2000) examined currency demand in the growth of the underground economy in Canada during the time period 19 91 through 1995. The authors also examined the impact of the introduction of the goods and services tax which is a value added tax into the Canadian economy and its impact on the growth of the underground economy. Overall their findings indicated that there was an increase in the underground economy of between .01 and .3% of gross domestic product after the introduction of the goods and services tax. This in turn translated into a decrease in tax revenues of between 1.2 and 5.1 percent.

Unlike in the United States where a large amount of American currency circulated outside of the United States, Canadian currency typically only circulated within Canada. As such the authors believed that it was easier to estimate the direct impact of the introduction of the new value added tax into the Canadian company with a greater degree of accuracy. As seen before, the difference between actual and forecast currency demand may be used as an indicator of how much excess currency is in the system. This excess currency is used as an indicator of growth of the underground economy. The

Hill and Kabir (2000) study differed from previous estimates using currency demand due to the use of a vector regression model that incorporated an error correction mechanism. The authors also incorporated tax rates and after-tax interest rates into their currency demand. Hill and Kabir used 1968 as the comparison here for their model as the 1960s saw the introduction of higher direct tax rates and the beginnings of automation in banking services.

Overall, Hill and Kabir (2000) concluded that the introduction of the goods and services tax in Canada had a negligible effect on and the increase in the underground economy. While they concluded that the underground economy grew was their belief that direct tax increases had more of a causal influence on the underground economy growth and did the introduction of goods and services tax.

Hill (2002) examined the underground economy in Canada. Hill stated that the underground economy emerged as a major issue in Canada in 1993. One of the issues that gave rise to public attention in the underground economy in the year was tobacco smuggling. At that time as well there were large fiscal deficits, and the government faced the prospect of spending cuts and tax increases to deal with those deficits. In the late 1990s fiscal surpluses started to appear and the government was urged to consider tax in lieu of additional spending.

Hill (2002) stated that the underground economy, since it was not directly observable, was best defined as a latent variable. This meant that the underground economy must be measured indirectly via observable variables. Such observable variables included the opportunity to evade taxes such as self-employment and changes in tax morality. In addition to observable variables were also indirect indicators of the underground economy. Examples of indicators have included demand for cash and the demand for cash had been linked to changes in the tax rate. One statistical method for dealing with latent variable issues was the multiple indicators multiples causes or MIMIC model. The model worked by estimating the relationships between the observable causes and the observable indicators of a latent variable.

Hill (2002) then critiqued Giles and Tedds (2002) model of the underground economy using a MIMIC model. Hill agreed that the underground economy could be considered a latent variable. However, he argued that there was no definitive model that specified the causal and indirect variables. As such, Hill believed the inclusion of variables was ad hoc. Hill also argued that the causal variables could have been more direct. For example a causal variable in Giles and Tedds (2002) model was males with multiple sources of employment. Hill suggested that a more direct causal variable might be

the number of self-employed individuals. The choices for the remaining causal variables also suffered from a similar degree of ambiguity and misspecification (e.g., using the nominal United States-Canada exchange rate versus the real exchange rate). Hill also pointed out that a measure related to the personal income tax rate was missing.

Hill (2002) pointed out that the latent variable was the underground economy. In this case, the model defined the latent variable as the output of the underground economy as a percentage of measured gross domestic product (GDP). Hill stated that it was unclear whether the latent variable as defined was a measure of the whole underground economy or a portion thereof. In any case, it was not possible to define the results as a more than an estimate. Compared to the Statistics Canada approach, Hill reported that the Statistics Canada approach was more conservative than the Giles and Tedds approach (one percent of GDP versus ten or more percent of GDP). Nevertheless, the Giles and Tedds approach was more consistent with international estimates (e.g., OECD). Hill then walked through an example of the currency-demand approach. First the general equation for the currency demand approach was:

> "tax-induced" currency x income velocity of currency = "tax induced" hidden economy income

**Equation 4-1 General Equation for the Currency Demand Approach**
(Hill 2002, p. 1649)

The tax induced currency was the estimated amount of additional currency held that was attributable to tax rate changes. The income velocity was defined as the income generated per dollar of currency. Thus the impact of changes in tax rates on the size of the underground economy could be measured. Using this estimation method, Hill estimated the Canadian underground economy at 5.2 percent of GDP, less than the Giles and Tedds estimate.

Hill (2002) concluded by stating that the MIMIC model was an important advancement in the attempt to measure that underground economy. Nevertheless, the MIMIC model needed work in the specification and justification of the variables included.

## 4.7. Statistical Fraud Detection

Depending on the type of data, and the amount known about the dataset, there are a variety of statistical methodologies to detect fraud (Bolton and Hand 2002). Such computer-assisted audit

techniques (CAATs) are attractive antecedents to better focus labour-intensive (and expensive) audits and investigations. Statistical fraud detection methodologies can be divided into supervised and unsupervised methods (Bolton and Hand 2002). In supervised techniques such as neural networks (Krishnaswarmy, Gilbert and Pashley 2000; Bolton and Hand 2002; Hodge and Austin 2004), both fraud and non-fraud data are used to devise models which can classify new cases as either fraud or non-fraud. Supervised techniques typically require good *a priori* knowledge of the characteristics of fraud and non-fraud cases. Unsupervised techniques identify data which are outliers (e.g., machine learning (Hodge and Austin 2004), pattern detection (Hand 2002), Benford's Law (Nigrini 1996), and reinforcement learning (Lu, Boritz and Covvey 2006), and are most useful when there is no *a priori* knowledge of the characteristics of fraud and non-fraud cases, while machine learning and pattern detection require such *a priori* knowledge. Unsupervised techniques do not distinguish between errors and fraud, but rather seek to define "a baseline distribution that represents normal behaviour and then attempt to detect observations that show the greatest departure from this norm" (Bolton and Hand 2002; Hodge and Austin 2004). Hodge and Austin (2004) also outline a third technique, semi-supervised, which also needs *a priori* definition of normal (but not fraudulent) data to classify normal and outlier cases.

The challenge from both the tax and fisheries management perspective vis-à-vis the underground economy in the Atlantic Canadian lobster fishery is that no *a priori* characteristics of fraud and non-fraud cases, in either underreported or unreported catches, are currently documented. (See Bodiguel (2002) for a discussion of the illegal trade in lobster licences). I will discuss the two most suitable techniques for such situations, Benford's Law and reinforcement learning. I will then critique two papers using these techniques, specifically Nigrini's (1996) application of Benford's Law and Lu, Boritz et al.'s reinforcement learning technique (2006) based on Benford's Law, and discuss future applications of these techniques to the data available on the lobster fishery.

### 4.7.1. Benford's Law

Benford's article (1938) was a rediscovery of a phenomenon observed by Newcomb (Newcomb 1881). Both Benford and Newcomb observed that tables of logarithms were more worn at the beginning than at the end. Contrary to conventional belief that the first significant digit of a

number has an equal probability of occurring (1 in 9), Benford found that the frequency of first digits conforms to the following formula:

$$F_a = \log\left(\frac{a+1}{a}\right).$$

**Equation 4-2 Frequency of First Digits**

Similarly, the second significant digit of a number is also a logarithmic frequency. The further away from the start of the number, the more equal the frequency of occurrence (e.g., the third and fourth significant digit have a roughly 1 in 10 frequency). These frequencies result in the following table (Newcomb 1881, p. 40; Benford 1938, p. 556):

| Digit | First Digit frequency | Second Digit frequency |
|---|---|---|
| 0 | - | 0.1197 |
| 1 | 0.3010 | 0.1139 |
| 2 | 0.1761 | 0.1088 |
| 3 | 0.1249 | 0.1043 |
| 4 | 0.0969 | 0.1003 |
| 5 | 0.0792 | 0.0967 |
| 6 | 0.0669 | 0.0934 |
| 7 | 0.0580 | 0.0904 |
| 8 | 0.0512 | 0.0876 |
| 9 | 0.0458 | 0.0850 |

**Table 4-7 First and Second Digit Frequencies**

Other characteristics of the Benford distribution are scale and base invariance, and that the product of two data sets is more likely to exhibit the Benford distribution (Rodriguez 2004). Scale invariance means that a Benford distribution multiplied by a non-zero number will also produce a Benford distribution (e.g., inventory quantities multiplied by dollar value). Base invariance means that the data can be in base 10, or base 8 (Hill 1995; Geyer and Williamson 2004).

Newcomb (1881) observed that "this law would enable us to decide whether a large collection of independent numerical results were composed of natural numbers". This observation was much later applied to the possible identification of human manipulation of accounting data (e.g., (Nigrini 1996)).

In general, the use of Benford's Law is subject to the following constraints (e.g., (Busta and Weinberg 1998; Durtschi, Hillison and Pacini 2004)):

1. The data should measure the same thing (e.g., all weights, all dollar amounts, etc.);
2. there should be no built-in floors or ceilings (e.g., income);
3. the data should not be comprised of allocated numbers (e.g., licence numbers, cheque numbers);
4. the data set should be skewed to the left (i.e., more smaller numbers than larger numbers, i.e., mean > median); and
5. The population is tested as opposed to a sample.

Note that non-conformance with Benford's Law does not mean that there is certainty of fraud or human manipulation (Durtschi, Hillison and Pacini 2004; Geyer and Williamson 2004). For an interesting discussion on guessed numbers and Benford's Law, including the creation of the Hill distribution, see Hill (1988).

### 4.7.2. Nigrini

## Methodology

Nigrini (1996) analyzed a dataset based on the U.S. Internal Revenue Service (IRS) Individual Tax Model File (ITMF). Nigrini used his "Distortion Factor Model," (DF), where:

$$DF = \frac{(AM - EM)}{EM}$$ (AM = actual mean, and EM = expected mean),

**Equation 4-3 Nigrini's Distortion Factor Model**

on numbers transformed to a range from 10 to 100. Thus 3.14 would be expanded to 31.4, and 1968, would be collapsed to 19.68. This would permit the calculation of a mean for both the test and Benford distributions. Nigrini dropped any observations less than 10 from the analysis, and divided numbers greater than 100 by an appropriate factor to bring them to within the 10-100 range. Nigrini argued that an excess of lower digits in comparison to a Benford distribution would indicate downward manipulations (e.g., lowering income) and would result in a negative DF, but the degree of manipulation would not be known. Conversely, deductions would be more likely to be subjected to upward manipulations, thus lowering income. The type of evasion (planned, unplanned or error) would

not be known. In other words, the DF model is an indicator, but not a definitive tool for the identification of manipulation in tax data.

Nigrini (1996) then separated the sample into observations with a higher or lower incentive for unplanned evasion based on factors that would impact on audit probability. In this study, the higher income group is more likely to be audited and was classed as the lower incentive group, while the lower income group is less likely to be audited and was classed as the higher incentive group. The DF model was then applied to determine if the fields in question were either over- or understated and correctly signed to indicate a level of unplanned evasion.

## Statistics and Critique

Nigrini (1996) used the z-score test for population proportions to show the significance level of each digit's probability compared to the Benford probability, and has shown the direction (or bias) of the results. The formula used was:

$$z = \frac{\left| p_1 - \pi_1 \right| - \frac{1}{2n}}{\sqrt{\frac{\pi_1 \pi_2}{n}}},$$

**Equation 4-4 Nigrini's (1996) Z-test**

where $p_1$ is the observed population proportion, $\pi_1$ is the expected population proportion, $\pi_2$ is $(1-\pi_1)$, and the term 1/2n is a continuity correction term for use only when it is smaller than the first term in the numerator (Nigrini 1996; Sheskin 2004). Note that the z-test calculated in this manner will yield similar results to the chi-square goodness of fit test, and has the relationship $z^2 = \chi^2$ (Sheskin 2004).

The main issue with the z-test as used by Nigrini (1996) is that if there are a large number of transactions (as suggested earlier as a pre-requisite for applying Benford's Law), it will take a lower proportion of inconsistent transactions to generate a significant difference (Durtschi, Hillison and Pacini 2004). As a result, it is generally recommended to use both a digit-by-digit analysis (e.g., z-test) and a chi-square goodness of fit test to compare the expected and observed proportion distributions (Durtschi, Hillison and Pacini 2004; Cleary and Thibodeau 2005), with the chi-square test being used as an overall indicator of whether or not further tests of individual significant digits are warranted. Nigrini (1996, p. 81) completed the test on a digit-by-digit basis, but did not complete tests on the overall distribution versus the Benford distribution, for example:

| | | 1985 ITMF | | |
|---|---|---|---|---|
| First Digit | Expected Distribution | Actual | Bias | Z-Stat |
| 1 | .3010 | .2963 | - | 2.737* |
| 2 | .1761 | .1729 | - | 2.197* |
| 3 | .1249 | .1280 | + | 2.436* |
| 4 | .0969 | .0973 | + | 0.325 |
| 5 | .0792 | .0821 | + | 2.916* |
| 6 | .0669 | .0674 | + | 0.447 |
| 7 | .0580 | .0577 | - | 0.289 |
| 8 | .0512 | .0523 | + | 1.429 |
| 9 | .0458 | .0459 | + | 0.185 |

***significant at .05 level**

**Table 4-8 Nigrini's (1996) ITMF Distribution**

In testing the DF model between lower and higher incentive groups, Nigrini used the chi-square test for independence. This test requires a minimum of two rows (r) and two columns (c), representing two variables. The chi-square test of independence tests the hypothesis that the variables are independent subject to the conditions that the data is categorical/nominal, the data is a random sample of independent observations, and the minimum frequency in each cell is 5 (Sheskin 2004). The chi-square test of independence is calculated using the formula:

$$\chi^2 = \sum_{i=1}^{r} \sum_{j=1}^{c} \left[ \frac{(O_{ij} - E_{ij})^2}{E_{ij}} \right]$$

**Equation 4-5 Chi-Square Test**

Nigrini (1996, p. 85) then used Fisher's exact test which "shows the probability of observing a table that gives at least as much evidence of association as the one actually observed." The Fisher's test was not significant either. Sheshkin (2004) observed there is conflicting opinion on whether or not a Yates' correction for continuity needs to be applied for 2 by 2 tables regardless of sample size, or only of sample sizes less than 20 or not at all since it results in an overly conservative test. The Yates' correction reduces the probability of a Type I error by subtracting 0.5 from the absolute value of each

set in a chi-square calculation, based on the premise that "if a continuous distribution is employed to estimate a discrete distribution, such an approximation will inflate the Type I error rate. By employing the correction for continuity, the Type I error rate is ostensibly adjusted to be more compatible with the prespecified alpha level designated by the researcher" (Sheskin 2004). Nigrini (1996) does not address the use of the Yates' correction in his use of Fisher's exact test, nor did he address the potential impact of removing data points between 0 and 10 on the computation of his statistics.

Nigrini demonstrated how he calculated a standard deviation for the distortion factor model. He argued that this was to be used to determine the statistical test of significance of the DF model. However, it is not evident from the article or accompanying tables what test was used to determine the significance of the DF (it was reported as being significant at the 0.05 level). It was not until a later article (Geyer and Williamson 2004) that the test statistic is specified as z = DF/SD. The error or distortion in the standard deviation and means used to calculate the DF by dropping observations less than 10 was not reported.

Nigrini also did not explain why he did not use chi-square goodness of fit test in lieu of the distortion factor, which would have prevented the loss of data caused by removing observations less than 10 from the analysis. Other studies since the Nigrini study have used the z-test ((Busta and Weinberg 1998; Durtschi, Hillison and Pacini 2004)) Kolmogorov-Smirnov Goodness-of-Fit Test (e.g.,(Hill 1988)), or chi-square (e.g.,(Hill 1988; Bhattacharya 2002; Durtschi, Hillison and Pacini 2004; Zhipeng, Lin and Huajia 2004; Cleary and Thibodeau 2005)) either alone or in combination. Most studies use chi-square as the statistic of choice for reporting significance of individual digits or for the comparison of the test and Benford distributions. Sheshkin (2004) provides an excellent discussion on the advantages and disadvantages of the z-test and Kolmogorov-Smirnov tests. Nigrini's DF model has not seen widespread study (e.g., (Geyer and Williamson 2004) propose a Bayesian alternative), however, Nigrini's work is seen as a key paper in the application of Benford's law to accounting data (Ettredge and Srivastava 1999).

In examining Type 1 versus Type II errors, Rodriguez (2004 p. 155) has shown that "a lognormal distribution with a sufficiently high variance parameter is consistent with Benford's Law, and thus produces a false alarm rate commensurate with the significance level of the test." Others indicate that the dangers of Type 1 errors (tests indicate evidence of manipulation when there was none) are more likely to occur if analysis is completed on a digit-by-digit basis (e.g., Nigrini (1996))

versus a test by test (e.g., chi-square goodness of fit) (Cleary and Thibodeau 2005). Cleary and Thibodeau (2005) demonstrated that there is a probability of 0.37 (i.e., 1-(.95)$^9$) of a Type 1 error when using a digit-by-digit analysis. Using both types of tests (digit-by-digit and test by test) increases the chances of uncovering Type 1 errors and examining both the first digit and first two significant digits potentially increases the possibility of finding areas for further audit or examination (Cleary and Thibodeau 2005).

Nigrini argued that the DF model provided evidence of unplanned evasion. However, the possibility of taxpayer error or other alternate explanations were not explored. Nigrini uncovered evidence that would require additional audit work in several areas. However, this evidence could have been achieved via a combination of the chi-square goodness of fit test on the overall probability distribution, plus the z-test or Kolmogorov-Smirnov test on a digit-by-digit basis. In this case, the application of Occam's razor would suggest that Nigrini's approach is overly complex approach to arrive at the conclusion that more audit work is required in certain areas of concern.

Considering the methodology popularized by Nigrini (1996), and the inherent issues discussed, I believe that there is a need to move this non-specific unsupervised technique that does not distinguish between errors and fraud towards an applied methodology that will single out specific cases for further audit without *a priori* knowledge of the characteristics of fraud and non-fraud cases. I will next critique a recent paper by Lu, Boritz et al. (2006) and contrast it with Nigrini's methodology.

### 4.7.3. Lu, Boritz and Covvey

Lu, Boritz et al., (2006) introduced reinforcement learning to an application of Benford's Law. Reinforcement learning is a network of states. Each state has a number of possible actions, and a reward or payoff for each action. A policy is a framework or map of states versus actions. The objective is to find the policy that maximizes the rewards possible by choosing actions. Reinforcement learning is an unsupervised variant of a neural network, but in lieu of training or supervising the network (i.e., with known fraudulent and non-fraudulent cases), the approach is capable of identifying new instances of fraud via the development of policies.

Lu, Boritz et al. (2006) outline an example of their fraud detection algorithm. First, they look at the significant digits of financial transactions – where practicable, the first, second and third digits.

Second, for each transaction, they calculate how much any actual transaction deviates from the expected transaction value by as determined by Benford's Law by calculating:

$$Reward(i) = \frac{f_{1i}}{b_{1i}} + \frac{f_{2i}}{b_{2i}} + \frac{f_{3i}}{b_{3i}},$$

**Equation 4-6 Lu, Boritz et al. (2006) Reward Equation**

where f is the actual frequency of the digit, and b is the expected Benford frequency. The reward value is calculated for each state. Once the rewards are calculated, the reinforcement learning algorithm "explores" the data and an optimal policy is determined that will join the transactions with the greatest rewards into a model of fraudulent or abnormal activity.

Lu, Boritz et al. (2006) then applied this method to a dataset of healthcare reimbursement claims. They eliminated columns that did not conform to the constraints discussed earlier (page 121). Further columns were eliminated that conformed to a 90% confidence interval (defined here as variance information provided by the owner of the dataset and with 2 standard deviations from the expected Benford frequencies). The reinforcement learning algorithm resulted in attributes that were further investigated for fraud. In one example, the algorithm was able to identify a company that was submitting fraudulent claims, not through the company name (since it used different names or variants), but by linking insurance agents who filed claims on behalf of that company.

### 4.7.4. Lu, Boritz and Covey Statistics and Critique

Lu, Boritz and Covey's (2006) paper does not report the calculations used in their confidence intervals to eliminate columns that conform to Benford's Law. It is thus not possible to critique the methodology. Further, standard statistics that describe overall goodness of fit (e.g., chi-squared) or digit-by-digit (e.g., z-test, Kolmogorov-Smirnov) were not used or reported. Last, the overall reward function calculated is not evaluated statistically to show what a significant (or non-significant) reward might look like.

In the field of statistical fraud detection (Bolton and Hand 2002) and outlier detection (e.g., (Hodge and Austin 2004)) there ought to have been a discussion of hit or detection rate (i.e., the percentage of potentially fraudulent cases that, after audit, were correctly identified as fraud), sensitivity (i.e., the minimum number of suspicious cases required before the technique is able to identify a policy), and speed of detection (Bolton and Hand 2002). Such a discussion of the number of

suspect cases that are correctly classified would give a sense of the type I versus type II error potential. For example, Busta and Weinberg (1998) created several distributions that mixed Benford and Hill numbers in varying degrees of contamination, with the Hill numbers representing the contamination. Busta and Weinberg (1998) were thus able to show the ability of their neural network methodology for detecting the contamination of the Benford data with the Hill data. Had Lu, Boritz et al. (2006) provided such analysis, their paper might have provided a common benchmark and been more widely applicable.

The ability to replicate Lu, Boritz et al.'s (2006) work is hindered since the authors do not provide adequate information to be able to replicate the study. For example, while they provide a narrative example of their algorithm, they do not provide details. Next, while they provide suggestions as to optimization policies (e.g., maximum likelihood, temporal differencing, and Monte Carlo matrix inversion) they again do not provide details. Last, Lu, Boritz et al., do not provide details of the software used. Despite these shortcomings, personal communication (Lu 2007) with the authors has provided the additional information (e.g., used Matlab as the software for their research) that would possibly enable replication.

Given the overview of Benford's Law and the associated statistical issues to date, I see this as an opportunity to contribute a more robust statistical analysis as well as to apply a Benford's Law technique to lobster fishery data.

## 4.8. Collusion and the Underground Economy

### 4.8.1. Introduction

It seems likely that there is a social norm of fraud and evasion within the Canadian lobster fishing industry (Bobek et al. 2007). Clearly it is important to differentiate between legitimate or legal efforts to avoid paying taxes (tax avoidance) versus illegal efforts or tax evasion (Wenzel 2002). Similarly for fisheries management, compliance with regulations is acceptable, while non-compliance (non-report of all or part of a catch) is analogous to tax evasion. For the purposes of this paper, I use the term fraud with a meaning that is inclusive of both tax evasion and fisheries non-compliance. This also helps to determine which areas of literature may be relevant to the issues facing both the tax and fisheries administrations in Canada and other countries.

This raises the issue of business ethics within the fishing industry. While economic prosperity is clearly important to both the Canadian government and the Atlantic Canadian lobster fishery, of particular interest to any government is the security of the tax base and the sustainable exploitation of natural resources. However, with indicators of the presence of an underground economy (Graham, Hasseldine and Paton 2007) and the industry's desire to achieve certification as a sustainable fishery (Marine Stewardship Council 2008), the need to identify non-compliance has become increasingly important.

Cowell (1990) argued that one effect of the presence of the underground economy is the creation of market power. In this study I identify and report on indicators of market power in the lobster fishery industry and I extend knowledge in three ways. First, the study provides quantitative support for ethnographic studies of the lobster fishery (Arai, 1994; McMullan and Perrier, 2002). Next, this study extends Abrantes-Metz et al. (2006) by refining procedural aspects of screening for market power. Lastly, I discuss implications of market power and the underground economy for the fishing industry in both Canada and elsewhere.

The remainder of this chapter is structured as follows. First I provide some background on illegal fishing behaviour such as poaching and tax evasion. I then discuss market power, collusion, price behaviour and screening.

### 4.8.2. Illegal activity and ethics

Poaching in the lobster fishery in Atlantic Canada can be classified as communal, outlaw and business poaching (McMullan and Perrier 2002). Communal poaching is tolerated within the community and is usually not for resale (i.e., it is for personal or family use), while outlaw poaching is not tolerated within the community and is typically for profit (McMullan and Perrier 2002). Outlaw poaching differs from business poaching in the degree of illegality; outlaw poaching is completely illegal, while business poaching is an illegal supplement to an otherwise legitimate commercial operation (McMullan and Perrier 2002).

Another distinguishing feature of the three types of poaching is the number of people involved. Communal poaching is small-scale and limited to one or two family members. Outlaw poaching typically involves a larger number of related individuals, and business poaching is more of a community effort involving family, crew, buyers and distributers (McMullan and Perrier 2002).

The illegally caught lobster is soon reintroduced into the legitimate market when the lobster is exported or distributed within Canada. Cowell (1990) believes that that the underground economy's presence can create, as a consequence, market power, and McMullan and Perrier's community-wide nature of business poaching suggests that if there is an element of market power in the lobster fishery at the community level, it should be detectable within the fisheries data.

From an ethical perspective, it would appear that social norms are at play within this industry (Bobek et al. 2007). For example, peer reporting behaviour was experimentally examined by Trivedi et al. (2003) who found that non-compliance by peers negatively influenced compliance behaviour by the subjects in the experiment whereas compliant behaviour by peers did not necessarily increase compliance behaviour of subjects.

Non-compliant populations generally do respond to enforcement through gradually increased compliance (Davis, Hecht and Perkins 2003). However, targeting those enforcement efforts to the appropriate populations may be difficult when only anecdotal evidence exists (McMullan and Perrier 2002), and government auditors must therefore focus on the appropriate aggregation of data.

Illegal poaching activity may also negatively impact on a fishing community itself. There is an increased focus on ethical business practices on fisheries products and eco-labelling initiatives such as the Marine Stewardship Council (Cummins 2004). Growth in this eco-labelled fish segment is predicted to be 224% from 2007 to 2009 (Hartlieb and Jones 2009). It could be difficult to demonstrate

sustainability in a fishery with a history of non-compliance. As such efforts to identify areas of non-compliance not only benefit the relevant government, but the industry itself.

### 4.8.3. Market Power and Screening

*Definitions*

| |
|---|
| Cartels can be defined as "agreements between firms to reduce the level of competition between them with the aim of raising prices and profitability" (Grout and Sonderegger 2005, p. 1). |
| Landes and Posner (1981) define market power as "the ability of a firm (or a group of firms, acting jointly) to raise price above the competitive level" |

This collusion between firms ranges in the degree of organization from unstated cooperation to formal (but often verbal) agreements (Frass and Greer 1977). This form of market behaviour is often illegal (Porter 2005). High profile examples of cartels include sugar (Genesove and Mullin 2001), lysine, vitamin C, Sothebys and Christies auction houses (Ashenfelter and Graddy 2005), and OPEC (Loderer 1985).

Indicators of markets that may be more likely to exhibit market power or collusive behaviour may include: a higher regular price and more homogeneous prices; price declines precede a series of price increases; price increases while imports decline; strong correlations between prices of different firms; highly stable market shares; homogeneous products; a small number of firms in the market; significant barriers to entry; and excess capacity (Asch and Seneca 1975; Grout and Sonderegger 2005; Harrington Jr. 2006). Recalling that Cowell (1990) has asserted that the underground economy can create market power as a consequence, an obvious question then, is whether it is possible to screen data for indicators of collusion and market power and draw conclusions about an industry.

### 4.8.4. Screening for Market Power and Collusion

Collusion detection methods focus on either auction-based (e.g. bid rigging) or price-based collusion (Frass and Greer 1977; Athey, Bagwell and Sanchirico 2004; Connor 2004; Bolotova, Connor and Miller 2005; Connor 2005; Harrington Jr. 2005; Abrantes-Metz, Froeb, Geweke et al. 2006; Harrington Jr. 2006). Some features of the price-based methodologies include decreased variance in price and negative skewness in the presence of collusion (Athey, Bagwell and Sanchirico 2004; Connor 2005). Prices also typically rise during collusion (Bolotova, Connor and Miller 2005). Screening may act as a deterrent along with anti-collusion policies (Friederiszick and Maier-Rigaud 2008), and from an enforcement perspective, screening can be useful in any of the enforcement stages of investigation, case development, litigation, and remedies (Schinkel 2007).

Screening can take place at the industry level or the firm level. At the industry level, Appelbaum (1982) uses economic data such as price and cost data to calculate a degree of oligopoly index. This index is able to differentiate between oligopolistic versus non-oligopolistic industries.

Baker and Rubinfield (1999) reviewed and critiqued several empirical methods used in antitrust litigation. Improvements in information technology have made empirical methods in antitrust litigation more feasible. These improvements have also lead to the development of techniques that have allowed courts to consider statistical methods as evidence of impact, harm and damages. Baker identifies two methodologies in his review. : 1) reduced form methods; and 2) methods that identify supply and demand structures.

Reduced form equations explain price variations by using variables related to costs (Baker and Rubinfield 1999). Dummy variables allow the intercept of the price equation to vary based on subgroups of observations. Reduced form equations are most commonly used in price fixing litigation. Reduced form models can respond to critical criteria in litigation. For example this type of model can identify whether or not prices were higher during the timeframes in question without requiring detailed supply and demand information.

Reduced form equations are also used in litigation to determine the effects of flow-through costs and their impact on and consumers (Baker and Rubinfield 1999). Given a company's costs and the selling price to the consumer it is possible to determine the fluctuations in the flow-through costs that are passed along to the end consumer. The other usage of reduced form equations is to measure the impact of changes in the structure of the market on potential industry the performance. In an example

in Baker's article it was demonstrated that in eight major metropolitan areas where retailers faced no direct competition prices were demonstrated to be higher.

Overall the Baker and Rubinfield (1999) paper concludes that reduced form price equations are effective for several reasons. First reduced form equations are useful in a variety of scenarios. Second because of their relative simplicity they are easiest to explain to non-expert participants in any litigation such as judges or juries members. Next reduced form equations do not have complex data or computational requirements. Despite these strengths reduced form items are not effective when the structure of demand needs to be identified.

Baker and Rubinfield (1999) then outline the methods for identifying the structure of market demand. Baker specifies that for market power to the exercise the firms involved need to have a downward sloping demand curve. Only when facing a downward sloping demand curve is it more profitable for firms to increase prices by reducing their collective. In order to estimate the demand functions there are three methods to identify demand substitution. These three methods are demand elasticity estimation, the use of auction models to learn about the structure of preferences, and last surveys.

In Baker and Rubinfield's (1999)evaluation of identifying structures of market demand is certainty of these are especially useful in antitrust cases. By using these techniques to demonstrate that the shape of the demand curve is downward sloping, courts can identify whether or not market power, monopoly power in the competitive behaviour or unwanted price effects of potential mergers exists. While these techniques can address questions that reduced form methods cannot address they are more complex and harder to explain to the courts.

Baker and Rubinfield (1999) note that the data sets available for use in litigation are often more robust than the data sets available for empirical research. Next, litigation focuses on using methods that are the best for a particular purpose at hand. Typically new techniques or techniques that demonstrate or develop a theory or methodological innovation are not used in the litigation process. Last inaccuracies or variations on that result from the model are often used to question the credibility of expert witnesses' litigation process. Nevertheless antitrust litigation draws heavily on empirical work and is necessarily linked to the body of research.

While these techniques are used in litigation the important criteria for current study is to identify technique that can effectively screening the data set and hand.

In this present study, I focus on firm-level, price-based methodologies. Two studies on price-based methodologies, Bolotova et al. (2005) and Abrantes-Metz et al. (2006), will be reviewed to show how market power is identified. Bolotova et al. (2005) use time series models to simultaneously compare the mean and variance of price and whether they differ between collusive and non-collusive periods. Collusion was demonstrated by this study to increase the mean price and decrease variance in one case, but only an increase in price in another case. Bolotova et al. (2005, p. 19) conclude that their model can "quantify the effect of conspiracy on market price…and they require minimum amount of data, at least price time-series for a cartelized product before, during and after hypothesize or known conspiracy". The model developed is an alternative to screening techniques to detect collusion and as an alternative model in legal proceedings to quantify collusive impacts on prices.

Finally, Abrantes-Metz et al. (2006) outline a more statistically sophisticated screening method to try and identify if groups of retail gasoline stations in and around Louisville, Kentucky were colluding on prices. While no collusion was found, they report that price variations were driven more by the proximity to major streets and brand.

## 4.9.Summary

This literature review has provided an overview of the central issue of the ability to detect underreported and unreported sales of lobster in the Atlantic Canadian lobster fishery. This included an overview of the size and scope and regulatory and policy environment in the lobster fishery and the role of various government departments and agencies in the regulation of the fishery. The value of the fishery is estimated at $805Million (Department of Fisheries and Oceans 2011), and has grown from $516 Million in 2004. The size and growth of the fishery only reinforces the requirement for methodologies to ensure that taxpayers are paying their fair share. Further, the industry's desire to achieve certification as a sustainable fishery (Marine Stewardship Council 2008), the need to identify non-compliance has become increasingly important.

The underground economy research started from an economics of crime approach based on Becker's (1968) essay and elaborated by Allingham and Sandmo's (1972) seminal work. Over the years, it has been demonstrated that a multi-disciplinary approach is required in studying the underground economy and touches on economics, sociology and psychology. The other element that was discussed during the literature review were correlates and characteristics of the underground

economy and its participants. Known correlates and characteristics are useful in determining potential strategies for analyzing a data set. Reviewing empirical tests for evasion also permitted the determination of whether or not the tests could be applied to the current context, modified, or whether new tests or models were required. A number of studies examined the reasons behind the compliance decision (Andreoni, Erard and Feinstein 1998), and others still looked at the nature of the interaction between taxpayer and the tax authorities (Hasseldine and Hite 2003). Next, macro measures and estimates of the underground economy were measured such as the currency/demand approach, the electricity method, and models/indicators.

Next I reviewed the relevant literature on statistical fraud detection, including the application of Benford's Law, and critiqued two approaches from Nigrini and Lu, Boritz and Covvey. Following, the review on statistical fraud detection, I examined collusion and the underground economy.

The literature review has resulted in being able to identify a number of gaps in the literature.

First, Broadway et al (2002) and Chang and Lai (2004) researched collaborative tax evasion. The premise of the Broadway et al paper was that outside of income tax evasion which operates on a principle-agent framework, other forms of tax evasion (e.g., value added tax evasion) required the collaboration of two taxpayers. Broadway et al made the assumption that the collaborating taxpayers faced an equal probability of detection and sanctions. However, this assumption would only hold true if the two taxpayers were businesses. If the two taxpayers were a business and an individual, the probability of detection may be equal, but the individual in the transaction was unlikely to face sanctions. The next assumption by Broadway et al was that the collaborating taxpayers form a long-term, repeated trade relationship. Again, this assumption may hold true in some instances, but there are other scenarios that are easily imagined where the trade relationship is on an infrequent or one-time basis. Broadway et al.'s model was not tested empirically. Chang and Lai (2004) examined the effect of deterrence measures on collaborative tax evasion and social norms. Their study undertook to develop a model of collaborative tax evasion, specifically between buyers and sellers and incorporates social norms into this transaction. The authors concluded that their model showed increasing deterrence in fact increased evasion. Chang and Lai's paper built upon the Broadway et al paper (2002). The authors noted that the study of collaborative tax evasion was not well documented despite the widespread nature of collaborative tax evasion. The key difference between this paper and the Broadway paper was that Broadway assumed a lasting repetitive relationship whereas Chang and Lai

assumed a random nonrecurring relationship between buyers and sellers. By assuming a random nonrecurring relationship with the variables, social norms were assumed and played a key in the Chang and Lai model. They hypothesized that increasing deterrence measures increased mutual gain for both buyers and sellers. Chang and Lai also believed that their model explained the discrepancies in the empirical evidence on the effects of deterrence vis-à-vis the rate of tax evasion. This is because of the hypothesized deterrence relationship in collaborative evasion was different (positive – the more deterrence, the more evasion) than the deterrence relationships in a single actor model (negative – the more deterrence, the less evasion). Taxpayers can be divided into three groups: 1) non-evaders, 2) collaborative evaders, 3) and non-collaborative evaders. These principles can be used to test the allegation that "Fishermen sometimes try to hide their total catch when they exceed their quotas…occasionally working in collusion with processing companies" (Beeby 2006).

Second, McMullan and Perrier's (2002) paper on the community-wide nature of business poaching suggests that this manipulation should be detectable within the fisheries data. Given the overview of Benford's Law and the associated statistical issues to date, I see this as an opportunity to contribute a more robust statistical analysis as well as to apply a Benford's Law technique to lobster fishery data.

Third, Cowell (1990) argued that one effect of the presence of the underground economy is the creation of market power. I see another opportunity to identify and report on indicators of market power in the lobster fishery industry and extend knowledge in three ways: a) providing quantitative support for ethnographic studies of the lobster fishery (Arai, 1994; McMullan and Perrier, 2002); b) extending Abrantes-Metz et al. (2006) by refining procedural aspects of screening for market power; and c) expanding the understanding of the implications of market power and the underground economy for the fishing industry in both Canada and elsewhere.

Next I set the stage for the three studies that comprise the empirical work in this dissertation by outlining the methodology to be used as well as an overview of the data.

# 5. Methodology and Data

## 5.1. Introduction

In this chapter I describe the methodology and data for this dissertation. The previous chapter's literature review provided an overview of the central issue of the ability to detect underreported and unreported sales of lobster in the Atlantic Canadian lobster fishery. This included an overview of the size and scope and regulatory and policy environment in the lobster fishery and the role of various government departments and agencies in the regulation of the fishery.

In the Methodology section I outline the approach taken to the development of the model of the underground economy in the Atlantic Canadian lobster fishery.

In the Data section, I explore the descriptive statistics for the data set (e.g., digit-by-digit analysis and a chi-square goodness of fit test to compare the expected and observed proportion distributions) and explore based on the Nigrini (1996) methodology, taking into account the limitations highlighted in Chapter 4. The data set contains observations on the lobster fishery (Lobster Fishery Area 33 and 34), plus data from the "grey zone" (a highly regulated lobster fishery shared by Canada and the United States) and a fishery with a different regulatory regime (snow crab). This will enable the comparison between the different fisheries and regulatory regimes.

## 5.2. Methodology

Hosmer and Lemeshow (2000) outline model development strategies that will loosely guide the development of the final model of the underground economy in the Atlantic Canadian lobster fishery. First, Hosmer and Lemeshow suggest the following steps:

1) Variable selection;
2) Examine possible interactions;
3) Choose variables with $p<.25$ and of known value to the issue at hand
4) Fit the multivariable model; and
5) Refine and address issues as required.

Following this methodology, variable selection will require an additional step in that the Benford and collusion variables did not yet exist. Thus, it was necessary to create and test these variables before adding them into the pool of potential variables from the data set. After variables were identified, a

general-to-specific modeling approach ( e.g., Hendry 1980; Campos, Ericsson and Hendry 2005) was adopted. A multivariable probit panel data model will be run using Stata 9 to evaluate the models (StataCorp 2005a)

## 5.3. Data

The data set was obtained from the Department of Fisheries and Oceans Canada (Department of Fisheries and Oceans 2007) through my employment with the Department of Fisheries and Oceans. The data set consisted of: "grey zone" (observed, shared United States-Canada) (2002-2006), <3 000 landings; LFA 33 (non-observed) (1997-2006), 109 664 landings; LFA 34 (non-observed) (1997-2006), 220 715 landings; and snowcrab (observed) (1997-2006), 22 939 landings.

Each data group as described above contains licensee, licensee postal code, buyer, buyer postal code, date landed, weight and price information. The snow crab and grey zone are observed fisheries. Each record shows the catch (in kilograms plus the reported value of the catch) reported by a licence holder for each day they land back in port. The data are not continuous since a licence holder may not report a catch on each day of a fishing season.

The data for LFA 33 and LFA 34 are summarized as follows:

| | LFA 33 | | | | | | |
|---|---|---|---|---|---|---|---|
| | Weight | | Value | | Price | | N |
| | Mean | SD | Mean | SD | Mean | SD | (Licensees) |
| 1997 | 2,722.37 | 1,686.57 | $ 29,892.25 | 19,075.66 | $ 10.80 | 1.19 | 697 |
| 1998 | 2,832.02 | 1,696.54 | $ 36,805.57 | 22,173.40 | $ 12.87 | 1.13 | 697 |
| 1999 | 3,318.30 | 1,904.04 | $ 45,685.94 | 26,378.14 | $ 13.61 | 1.22 | 697 |
| 2000 | 3,525.34 | 2,455.51 | $ 45,976.82 | 32,959.96 | $ 12.88 | 1.10 | 669 |
| 2001 | 4,453.73 | 3,699.03 | $ 54,308.52 | 45,610.30 | $ 12.04 | 1.74 | 681 |
| 2002 | 3,272.33 | 2,231.13 | $ 48,430.47 | 33,249.41 | $ 14.66 | 1.53 | 641 |
| 2003 | 3,514.18 | 2,156.25 | $ 53,401.52 | 34,388.50 | $ 14.95 | 1.45 | 639 |
| 2004 | 3,302.68 | 2,113.58 | $ 45,721.00 | 29,602.06 | $ 13.70 | 1.04 | 639 |
| 2005 | 4,123.67 | 2,547.04 | $ 60,398.17 | 38,106.93 | $ 14.48 | 1.27 | 660 |
| 2006 | 4,324.32 | 3,000.22 | $ 52,083.09 | 36,424.33 | $ 12.07 | 1.27 | 635 |

**Table 5-1Summary of LFA 33 Mean Weight, Value and Price by Licensee (1997-2006)**

| | LFA 33 | | | | | | |
|---|---|---|---|---|---|---|---|
| | Weight | | Value | | Price | | N |
| | Mean | SD | Mean | SD | Mean | SD | (Landings) |
| 1997 | 581.70 | 733.89 | 6,387.25 | 7,989.58 | 10.72 | 3.21 | 3,258 |
| 1998 | 697.26 | 798.34 | 9,064.94 | 10,817.78 | 12.08 | 3.95 | 2,790 |
| 1999 | 693.28 | 821.58 | 9,551.76 | 11,761.35 | 12.58 | 4.13 | 3,293 |
| 2000 | 695.71 | 871.72 | 9,061.76 | 11,460.43 | 12.30 | 4.28 | 3,302 |
| 2001 | 892.65 | 1,103.23 | 10,893.40 | 12,536.58 | 12.89 | 5.66 | 3,238 |
| 2002 | 594.38 | 749.11 | 8,796.81 | 11,314.55 | 13.56 | 4.40 | 3,529 |
| 2003 | 185.34 | 365.08 | 2,816.41 | 5,813.01 | 14.92 | 3.09 | 12,116 |
| 2004 | 224.25 | 441.33 | 3,104.39 | 6,210.14 | 13.36 | 2.81 | 9,308 |
| 2005 | 193.24 | 386.76 | 2,830.36 | 5,760.62 | 14.36 | 2.64 | 14,084 |
| 2006 | 222.49 | 465.28 | 2,679.69 | 5,505.19 | 12.08 | 2.82 | 12,342 |

**Table 5-2 Summary of LFA 33 Mean Weight, Value and Price per Landing by Year (1997-2006)**

| | LFA 34 | | | | | | |
|---|---|---|---|---|---|---|---|
| | Weight | | Value | | Price | | N (Licensees) |
| | Mean | SD | Mean | SD | Mean | SD | |
| 1997 | 23,876.19 | 9,748.93 | $ 268,888.10 | 110,014.60 | $ 11.27 | 0.52 | 974 |
| 1998 | 23,476.14 | 8,756.33 | $ 308,839.60 | 115,622.10 | $ 13.15 | 0.54 | 968 |
| 1999 | 30,143.83 | 11,599.79 | $ 416,355.10 | 162,405.90 | $ 13.78 | 0.60 | 969 |
| 2000 | 29,624.47 | 13,176.57 | $ 395,769.40 | 176,834.70 | $ 13.40 | 0.69 | 975 |
| 2001 | 39,111.20 | 15,079.60 | $ 501,294.00 | 193,304.30 | $ 12.95 | 1.25 | 969 |
| 2002 | 37,199.62 | 16,119.01 | $ 534,987.10 | 233,956.30 | $ 14.37 | 0.71 | 945 |
| 2003 | 19,160.56 | 7,111.81 | $ 285,753.90 | 107,658.40 | $ 14.93 | 0.80 | 933 |
| 2004 | 17,226.21 | 6,178.64 | $ 235,410.80 | 85,978.64 | $ 13.65 | 0.63 | 968 |
| 2005 | 18,771.01 | 6,794.97 | $ 271,939.20 | 99,043.75 | $ 14.49 | 0.53 | 978 |
| 2006 | 16,783.07 | 8,295.64 | $ 202,208.80 | 96,396.95 | $ 12.27 | 1.09 | 962 |

**Table 5-3 Summary of LFA 34 Mean Weight, Value and Price by Licensee (1997-2006)**

| | LFA 34 | | | | | | |
|---|---|---|---|---|---|---|---|
| | Weight | | Value | | Price | | |
| | Mean | SD | Mean | SD | Mean | SD | N (Landings) |
| 1997 | 1,648.84 | 1,773.83 | 18,568.94 | 18,910.96 | 11.69 | 2.50 | 14,102 |
| 1998 | 1,796.81 | 2,228.37 | 23,637.90 | 28,945.35 | 13.87 | 2.98 | 12,644 |
| 1999 | 2,284.22 | 2,487.49 | 31,550.38 | 34,856.98 | 13.96 | 2.72 | 12,782 |
| 2000 | 1,988.19 | 2,599.53 | 26,561.67 | 33,167.40 | 14.18 | 2.93 | 14,516 |
| 2001 | 2,930.00 | 3,208.37 | 37,553.94 | 34,750.44 | 14.98 | 4.88 | 12,926 |
| 2002 | 1,970.72 | 2,433.97 | 28,341.90 | 35,853.43 | 14.26 | 2.61 | 17,838 |
| 2003 | 413.22 | 706.28 | 6,162.65 | 10,322.37 | 15.98 | 2.83 | 43,262 |
| 2004 | 406.35 | 711.30 | 5,553.12 | 9,608.11 | 14.12 | 1.70 | 41,036 |
| 2005 | 362.74 | 621.08 | 5,255.12 | 8,845.04 | 15.04 | 2.06 | 50,609 |
| 2006 | 371.98 | 682.43 | 4,481.73 | 7,922.86 | 12.80 | 1.93 | 43,404 |

**Table 5-4 Summary of LFA34 Mean Weight, Value and Price per Landing by Year (1997-2006)**

For LFA 33 and LFA 34 I note that between 2002 and 2003 it appears that the overall strategy of the fishermen appeared to have changed, notably that the number of landings increased. The price of lobster also peaked in 2003 so fishermen were likely trying to take advantage of the higher prices by landing smaller, more frequent catches, and thus minimizing the risk of price decreases or increases.

| | Snowcrab | | | | | | |
|---|---|---|---|---|---|---|---|
| | Weight | | Value | | Price | | |
| | Mean | SD | Mean | SD | Mean | SD | N |
| 1997 | 8,000.46 | 6,569.99 | $ 41,429.45 | 34,057.08 | $ 5.16 | 0.17 | 1,744 |
| 1998 | 9,059.98 | 6,945.60 | $ 27,190.89 | 21,158.45 | $ 2.99 | 0.18 | 1,367 |
| 1999 | 13,441.11 | 10,875.18 | $ 46,457.93 | 37,613.94 | $ 3.46 | 0.08 | 2,070 |
| 2000 | 26,635.17 | 23,499.49 | $ 139,671.40 | 124,139.10 | $ 5.29 | 0.42 | 3,038 |
| 2001 | 28,588.87 | 23,755.82 | $ 117,932.10 | 98,859.00 | $ 4.11 | 0.24 | 2,778 |
| 2002 | 28,030.21 | 27,329.10 | $ 158,541.40 | 159,441.70 | $ 5.61 | 0.62 | 2,700 |
| 2003 | 27,668.33 | 26,757.39 | $ 184,074.20 | 178,939.20 | $ 6.72 | 0.46 | 3,119 |
| 2004 | 24,636.41 | 24,286.06 | $ 162,945.20 | 160,628.00 | $ 6.61 | 0.00 | 2,764 |
| 2005 | 21,437.61 | 21,925.35 | $ 91,445.49 | 93,693.27 | $ 4.23 | 0.21 | 2,249 |

**Table 5-5 Summary of Snowcrab Mean Overall Weigh, Value and Price by Year (1997-2006)**

I note that snowcrab catch values increased until 2003 and then declined by over 50% in 2005. As a comparison, there is a small observed lobster fishery that is shared between Canada and the United States. This data will be used as a comparison group, where possible, with LFA 33 and LFA 34.

| | Grey Zone | | | | | | |
|---|---|---|---|---|---|---|---|
| | Weight | | Value | | Price | | |
| | Mean | SD | Mean | SD | Mean | SD | N |
| 2002 | 2,086.36 | 2,036.56 | $ 30,674.30 | 30,334.98 | $ 14.57 | 0.40 | 262 |
| 2003 | 1,100.29 | 1,122.04 | $ 13,813.87 | 14,074.98 | $ 12.55 | 0.30 | 442 |
| 2004 | 721.68 | 642.47 | $ 10,342.48 | 9,206.76 | $ 14.32 | 0.11 | 249 |
| 2005 | 1,552.77 | 1,821.65 | $ 21,089.97 | 24,314.31 | $ 13.76 | 0.90 | 124 |
| 2006 | 5,288.10 | 4,962.61 | $ 59,193.88 | 55,428.02 | $ 11.04 | 1.26 | 250 |

**Table 5-6 Summary of Greyzone Mean Overall Weight, Value and Price by Year (2002-2006)**

The greyzone is a much smaller fishery and experienced a price decrease in 2003 unlike LFA 33 and LFA 34. The number of landings increased sharply for both LFA 33 and LFA 34 in 2003. The relative value of landings has increased for LFA 33 and LFA 34 from 1997 to 2006. The corresponding purchase of lobster by buyers has also logically increased.

Geographic (e.g., sorted by the first 3 of 6 digits of postal codes) data also shows a marked increase in the value of the lobster fishery from 1997 to 2006. Table 5-7 LFA 33 Value by Postal Code 1997 versus 2006and Table 5-8 LFA 34 Value by Postal Code 1997 versus 2006 highlight the disparity between postal code locales and between LFA 33 and LFA 34. Last, Table 5-9 Value of Buyer Purchases 1997 versus 2006 highlights the differences between buyer locales. Buyers are not restricted from buying lobster from a particular LFA.

| Short Postal Code | 1997 Total Value | 2006 Total Value |
|---|---|---|
| B0T | $ 10,256,352.65 | $ 17,696,134.28 |
| B0J | $ 5,816,879.61 | $ 8,711,997.25 |
| B0W | $ 1,914,731.02 | $ 3,386,858.22 |
| B0R | $ 1,138,250.73 | $ 1,445,875.81 |
| B3Z | $ 852.24 | $ 1,293,406.67 |
| B3V | $ 614,743.41 | $ 902,387.07 |
| B3T | $ 592,631.95 | $ 763,241.27 |
| B3G | $ 121,840.41 | $ 341,481.18 |
| B4V | $ 144,722.90 | $ 277,255.68 |
| B0V | $ - | $ 138,926.00 |
| B2N | $ 56,071.10 | $ 138,727.60 |
| B1A | $ 9,027.00 | $ 138,467.25 |
| B5A | $ - | $ 122,195.34 |
| B0E | $ - | $ 105,163.10 |
| B0N | 0 | $ 84,642.79 |
| B3J | $ 32,554.00 | $ 61,564.91 |
| B1B | | $ 51,335.26 |
| B2W | $ 35,149.74 | $ 48,430.26 |
| B4B | 0 | $ 41,612.07 |
| B3P | $ 13,850.05 | $ 29,013.05 |
| B0P | $ 27,861.00 | $ 15,395.79 |
| B3M | $ - | $ 7,681.10 |
| B3K | $ 1,663.35 | $ 7,529.32 |
| B3B | $ 18,152.01 | $ - |
| B4C | $ 13,570.00 | $ - |
| B0A | $ 7,441.30 | $ - |
| Total | $ 20,816,344.47 | $ 35,809,321.27 |

**Table 5-7 LFA 33 Value by Postal Code 1997 versus 2006**

| Short PC | 1997 Value | 2006 Value |
|---|---|---|
| B0J | $ 12,619 | $ 56,699 |
| B0N | 0 | $ 40,686 |
| B0P | $ 314,644 | $ 629,194 |
| B0S | 0 | $ 488,569 |
| B0T | $ 107,423 | $ 329,138 |
| B0V | $ 10,116,304 | $ 18,090,863 |
| B0W | $ 103,370,858 | $ 174,071,512 |
| B1R | $ - | $ 258,919 |
| B2N | $ - | $ 667,382 |
| B2Y | $ - | $ 178,338 |
| B3V | $ - | $ 91,864 |
| B3Z | $ - | $ 175,329 |
| B5A | $ 17,028,362 | $ 24,678,458 |
| Total | $ 130,950,211 | $ 219,756,951 |

**Table 5-8 LFA 34 Value by Postal Code 1997 versus 2006**

| Short PC | Sum of 1997 value | Sum of 2006 value |
|---|---|---|
| B0W | $ 94,117,122.80 | $ 169,067,413.08 |
| B5A | $ 15,331,818.30 | $ 25,297,796.13 |
| B0V | $ 11,271,229.28 | $ 14,575,437.90 |
| B0J | $ 9,974,825.10 | $ 15,888,628.85 |
| B0T | $ 8,264,620.00 | $ 11,844,905.00 |
| E0A | $ 1,925,487.00 | $ 4,159,418.80 |
| B0K | $ 1,523,364.28 | $ 1,630,555.00 |
| B0N | $ 1,220,757.00 | $ 2,041,469.83 |
| B0H | $ 640,481.80 | $ 36,724.50 |
| B3M | $ 527,470.10 | $ 4,640,438.00 |
| B0R | $ 267,096.40 | $ 16,584.07 |
| BOJ | $ 197,367.60 | $ - |
| B5M | $ 179,536.90 | $ - |
| B3G | $ 156,794.77 | $ 748,017.63 |
| E0B | $ 150,065.00 | $ 280,991.76 |
| B3R | $ 136,242.00 | $ 263,324.30 |
| B2Y | $ 72,838.00 | $ - |
| B3K | $ 68,962.56 | $ - |
| B3L | $ 64,135.87 | $ - |
| B0S | $ 58,233.00 | $ 399,257.90 |
| B3A | $ 25,394.00 | $ - |
| B0A | $ 8,500.00 | |
| E2K | $ 733.50 | $ - |
| E2J | $ 113.64 | $ - |
| B2T | $ - | $ 1,247,424.00 |
| B3B | $ - | $ 457,680.50 |
| B1P | $ - | $ 380,609.00 |
| B0E | $ - | $ 243,855.30 |
| E0G | $ - | $ 158,227.98 |
| B3J | $ - | $ 127,593.30 |
| C0B | $ - | $ 87,031.37 |
| A1N | $ - | $ 73,566.10 |
| B4A | $ - | $ 38,667.01 |
| A2H | $ - | $ 31,510.72 |
| B3V | $ - | $ 6,273.29 |
| B0C | $ - | $ 1,182.07 |
| Total | $ 146,183,188.90 | $ 253,744,583.39 |

**Table 5-9 Value of Buyer Purchases 1997 versus 2006**

Data was also provided on fishermen that had license sanctions imposed as a result of various violations. Violations can include illegal, underreported or unreported catches. In total there were 243

violations between 1999 and 2006. LFA 34 had 124 violations and LFA 33 had 119 violations. The license sanctions ranged from 1 day to 10 years.

Data was also compared with the mean weight, value and price for LFA 33 and LFA as shown in Table 5-10 and Table 5-11. Generally those licensees with sanctions in LFA 33 had a generally higher mean price than licensees without sanctions. In contrast, licensees with sanction in LFA 34 had a generally lower mean price than licensees without sanctions.

| | LFA 33 | | | | | |
|---|---|---|---|---|---|---|
| | Weight | | Value | | Price | |
| | Mean - All | Mean - Sanctions | Mean - All | Mean - Sanctions | Mean - All | Mean - Sanctions |
| 1997 | 581.7 | 545.4070684 | $ 6,387.25 | $ 5,920.16 | $ 10.72 | $ 10.98 |
| 1998 | 697.26 | 722.4741887 | $ 9,064.94 | $ 9,413.50 | $ 12.08 | $ 13.00 |
| 1999 | 693.28 | 683.6668363 | $ 9,551.76 | $ 9,448.28 | $ 12.58 | $ 13.78 |
| 2000 | 695.71 | 723.2854091 | $ 9,061.76 | $ 9,461.50 | $ 12.30 | $ 13.03 |
| 2001 | 892.65 | 922.0828143 | $ 10,893.40 | $ 11,381.67 | $ 12.89 | $ 12.20 |
| 2002 | 594.38 | 575.017217 | $ 8,796.81 | $ 8,542.89 | $ 13.56 | $ 14.80 |
| 2003 | 185.34 | 181.4308886 | $ 2,816.41 | $ 2,768.50 | $ 14.92 | $ 15.20 |
| 2004 | 224.25 | 207.366105 | $ 3,104.39 | $ 2,833.94 | $ 13.36 | $ 13.84 |
| 2005 | 193.24 | 205.8149862 | $ 2,830.36 | $ 3,024.85 | $ 14.36 | $ 14.65 |
| 2006 | 222.49 | 230.1889561 | $ 2,679.69 | $ 2,764.56 | $ 12.08 | $ 12.04 |
| | 498.03 | 499.673447 | $ 6,518.68 | $ 6,555.98 | $ 12.89 | $ 13.35 |

**Table 5-10 LFA 33 Mean weight, value and price for population versus fishermen with sanctions**

| | LFA 34 | | | | | |
|---|---|---|---|---|---|---|
| | Weight | | Value | | Price | |
| | Mean - All | Mean - Sanctions | Mean - All | Mean - Sanctions | Mean - All | Mean - Sanctions |
| 1997 | 1,648.84 | 1,606.78 | 18,568.94 | 18,076.31 | 11.69 | 11.25003 |
| 1998 | 1,796.81 | 1,878.20 | 23,637.90 | 24,703.34 | 13.87 | 13.15268 |
| 1999 | 2,284.22 | 2,342.39 | 31,550.38 | 32,412.24 | 13.96 | 13.83723 |
| 2000 | 1,988.19 | 2,008.60 | 26,561.67 | 26,707.11 | 14.18 | 13.29636 |
| 2001 | 2,930.00 | 2,904.89 | 37,553.94 | 36,598.12 | 14.98 | 12.59878 |
| 2002 | 1,970.72 | 1,937.19 | 28,341.90 | 27,790.76 | 14.26 | 14.34588 |
| 2003 | 413.22 | 440.72 | 6,162.65 | 6,523.74 | 15.98 | 14.8025 |
| 2004 | 406.35 | 412.25 | 5,553.12 | 5,595.02 | 14.12 | 13.57199 |
| 2005 | 362.74 | 357.63 | 5,255.12 | 5,126.85 | 15.04 | 14.33557 |
| 2006 | 371.98 | 434.52 | 4,481.73 | 5,118.50 | 12.8 | 11.77978 |
| | 1,417.31 | 1,432.32 | 18,766.74 | 18,865.20 | 14.09 | 13.30 |

**Table 5-11 LFA 34 Mean weight, value and price for population versus fishermen with sanctions**

The data in its original format was transactional. For each landing on a given data, lobster fishing area, date, the licensee, licensee postal code, buyer, buyer postal code, weight, value and price data were captured. A given licensee may have multiple catches in one day. The transactional models were based on the landings and data available for each landing. The licensee models were based on the annual summary of landings and data available for each landing

For transactional models, the weight in kilograms for each landing, the value of each landing and the price per kilogram for each landing were recorded. Weight, value and price are related in that weight x price = value. Value is the best available indicator of gross income (before expenses or other deductions).

For licensee models, the data was collapsed so that there was one record for each licensee per year that recorded the total weight in kilograms for each licensee per year, the total value of landed for each licensee per year and the mean price per kilogram for each licencee per year,

## 5.4. Summary

There are two variables that require additional development before proceeding with variable selection for the model. First, Nigrini's (1996) methodology is a good descriptor of a data set's compliance with Benford's Law and the identification of broad categories for further investigation. However, this methodology does not provide the characteristics of tax fraud, or definitively indicate tax fraud without additional audit work or additional variables in a fraud detection technique. Next I explore the presence of collusive indicators in the lobster fishery. Cowell (1990) has asserted that the underground economy can create market power as a consequence. It follows that screening for collusion may help identify areas of participation in the underground economy. Finally, Benford's law, collusion and other indicators will be tested to determine if there is predictive value in the variations discovered via applying the methodologies noted above to current enforcement actions in the lobster fishery. Before launching into the development of the variables and model, I outline the general hypotheses for the remainder of the dissertation.

# 6. Hypotheses

## 6.1. Introduction

After having described the data, the first step is to look back at the literature to see if there are possible correlates or relationships that could be explored with the data set. The next step is to develop the model and hypotheses that will guide the next three chapters using the Hosmer and Lemeshow methodology (2000).

## 6.2. Correlates

Known correlates and characteristics are useful in determining potential strategies for analyzing a data set. Reviewing empirical tests for evasion also permitted the determination of whether or not the tests could be applied to the current context, modified, or whether new tests or models were required. As discussed, the data set consisted of licensee, licensee postal code, buyer, buyer postal code, date landed, weight, price, and compliance information.

Of the variables in the data set, compliance history should be included in a model, as Alm and McKee (2004) note that compliance history is an important factor used by tax authorities in audit selection rules. Weight and price/value information could be used to calculate the deviation from the norm for a particular fisherman. Slemrod (1985) proposed a microeconomic test for tax evasion. Slemrod proposed that under certain conditions, households that were evading tax on a portion of their true income would declare their income near the top of an income tax bracket. Conversely, households that were not evading tax would not have an incentive to be near the top of an income tax bracket. However, the data set does not contain the actual income of the fishermen, rather it is the gross income before operating expenses and other deductions are made (e.g., fuel, crew, bait, repairs). A proxy might be available since similar deductions would be available to all.

Other variables such as age, gender, occupation, and withholding status from Jackson and Milliron's (1986) literature review examined, are not available in the data set. Further, even if some were (e.g., occupation), they would be of limited value since the data set is homogenous data of self-employed fishermen.

While there have been qualitative reviews of compliance issues in the lobster fishery (Arai 1994; Bodiguel 2002), the literature review demonstrates that there is little quantitative research on the

lobster fishery. To address this gap, I will use also use a Benford's Law and collusion screening technique to further knowledge in the lobster fishery vis-à-vis indicators of compliance and collusion.

## 6.3. Benford's Law Hypothesis

As shown, Nigrini's (1996) methodology is a good descriptor of a data set's compliance with Benford's Law and the identification of broad categories for further investigation. However, this methodology does not provide the characteristics of tax fraud, or definitively indicate tax fraud without additional work on broad areas of concern (i.e., audits).

In general, the use of Benford's Law is subject to the following constraints (e.g., Busta & Weinberg 1998; Durtschi et al. 2004): (1) The data should measure the same concept (e.g., all weights, all dollar amounts, etc.); (2) there should be no built-in "floors" or "ceilings" (e.g., income); (3) the data should not comprise allocated numbers (e.g., license numbers, cheque numbers); (4) the data set should be skewed to the left (i.e., more smaller numbers than larger numbers, i.e., mean > median); and (5) the population is tested as opposed to a sample. Non-conformance with Benford's Law does not mean that there is certainty of fraud or human manipulation (Durtschi et al. 2004; Geyer & Williamson 2004), but has been taken as an indicator that further audit or review is required.

McMullan and Perrier's (2002) paper on the community-wide nature of business poaching suggests that this manipulation should be detectable within the fisheries data. Given the overview of Benford's Law and the associated statistical issues to date, I see this as an opportunity to contribute a more robust statistical analysis as well as to apply a Benford's Law technique to lobster fishery data.

I expected that the data would conform to Benford's Law, and that the observed fisheries (snow crab and grey zone) have greater conformity than non-observed fisheries. The weight and price information was expected to conform to Benford's Law as it conformed to the previously noted constraints (Busta & Weinberg 1998; Durtschi et al. 2004) and is consistent with previous applications (e.g., Nigrini 1996). I expected to see indications of non-conformity with Benford's Law in both LFA33 and 34.

## 6.4. Market Power Hypothesis

Harrington (2006) and Grout and Sonderegger (2005) outline some indicators of markets that may be more likely to exhibit collusive behaviour. These include:

1. A higher regular price and more homogeneous prices;
2. Price declines precede a series of price increases;
3. Price increases while imports decline;
4. Strong correlation between prices of different firms;
5. Highly stable market shares;
6. Homogeneous products;
7. A small number of firms in the market;
8. Significant barriers to entry; and
9. Excess capacity

Broadway et al. (2002) and Chang and Lai (2004) researched collaborative tax evasion. The premise of the Broadway et al. paper was that outside of income tax evasion which operates on a principle-agent framework, other forms of tax evasion (e.g., value added tax evasion) required the collaboration of two taxpayers. Broadway et al. made the assumption that the collaborating taxpayers faced an equal probability of detection and sanctions. However, this assumption would only hold true if the two taxpayers were businesses. If the two taxpayers were a business and an individual, the probability of detection may be equal, but the individual in the transaction was unlikely to face sanctions as the onus is on the business to collect and remit the value added tax on the transaction. The next assumption by Broadway et al. was that the collaborating taxpayers form a long-term, repeated trade relationship. Again, this assumption may hold true in some instances, but there are other scenarios that are easily imagined where the trade relationship is on an infrequent or one-time basis. Broadway et al.'s model was not tested empirically. Chang and Lai (2004) examined the effect of deterrence measures on collaborative tax evasion and social norms. Their study undertook to develop a model of collaborative tax evasion, specifically between buyers and sellers and incorporates social norms into this transaction. The authors concluded that their model showed increasing deterrence in fact increased evasion. Chang and Lai's paper built upon the Broadway et al. paper (2002). The authors noted that the study of collaborative tax evasion was not well documented despite the widespread nature of collaborative tax evasion. The key difference between this paper and the

Broadway paper was that Broadway assumed a lasting repetitive relationship whereas Chang and Lai assumed a random nonrecurring relationship between buyers and sellers. By assuming a random nonrecurring relationship with the variables, social norms were assumed and played a key in the Chang and Lai model. They hypothesized that increasing deterrence measures increased mutual gain for both buyers and sellers. Chang and Lai also believed that their model explained the discrepancies in the empirical evidence on the effects of deterrence vis-à-vis the rate of tax evasion. This is because of the hypothesized deterrence relationship in collaborative evasion was different (positive – the more deterrence, the more evasion) than the deterrence relationships in a single actor model (negative – the more deterrence, the less evasion). Taxpayers can be divided into three groups: 1) non-evaders, 2) collaborative evaders, 3) and non-collaborative evaders. These principles can be used to test the allegation that "Fishermen sometimes try to hide their total catch when they exceed their quotas…occasionally working in collusion with processing companies" (Beeby 2006).

Cowell (1990) argued that one effect of the presence of the underground economy is the creation of market power. I see another opportunity to identify and report on indicators of market power in the lobster fishery industry and extend knowledge in three ways: a) providing quantitative support for ethnographic studies of the lobster fishery (Arai, 1994; McMullan and Perrier, 2002); b) extending Abrantes-Metz et al. (2006) by refining procedural aspects of screening for market power; and c) expanding the understanding of the implications of market power and the underground economy for the fishing industry in both Canada and elsewhere.

Abrantes-Metz et al. (2006) outline an alternative screening method that is based on a Markov chain Monte Carlo with Gibbs sampling combined with data augmentation methodology to fill in missing observations. The method was used to try and identify if groups of retail gasoline stations in and around Louisville Kentucky were colluding on prices. While no collusion was found, they report that price variations were driven more by the proximity to major streets and brand. The technique first computes values for missing values for stations with missing daily price information. Next, the mean, standard deviation, and the coefficient of variation were calculated. Various methods were used to identify outliers (e.g., scatter plots, and histograms overlaid with cut-off points) that would suggest collusion. Applying this methodology to the Atlantic Canadian lobster fishery will show evidence of collusion.

## 6.5. Underground Economy Model Development

Recall from Chapter 5 that the general flow of the model development was to be guided by Hosmer and Lemeshow's (2000) outline of a model development strategy that suggested the following steps:

1) Variable selection;
2) Examine possible interactions;
3) Choose variables with p<.25 and of known value to the issue at hand
4) Fit the multivariable model; and
5) Refine and address issues as required.

Also, as previously noted, variable selection will require an additional step in that the Benford and collusion variables did not yet exist. Thus, it was necessary to create and test these Benford and collusion variables in Chapters 7 and 9. Once these variables are validated, they will be added to the suite of potential variables to be considered for inclusion in the model in Chapter 9:

| Compliance | Correlates | Benford's Law | Collusion Screen |
|---|---|---|---|
| Compliance will be a function of: | • Compliance history<br>• Income level*<br>• Weight of Landings<br>• Price | Non-compliance with Benford's Law | • Higher than average mean price<br>• Lower than average standard deviation<br>• Lower than average standard deviation.<br>• Community/ geographic location<br>• Broker/ licensee relationship |

**Table 6-1 Underground Economy Model Variables**

*income less operating expenses is not directly available in the data. However, the total value of each landing (and thus annual value landed for each licensee) is available.

# 7. Study 1: Benford's Law

## 7.1. Introduction

This study is based on a paper published on "Statistical fraud detection in a commercial lobster fishery" (Graham, Hasseldine and Paton 2007).

Recall that Nigrini (1996) analyzed a dataset based on the U.S. Internal Revenue Service (IRS) Individual Tax Model File (ITMF). Nigrini used his "Distortion Factor Model," (DF), where $DF = \frac{(AM - EM)}{EM}$ (AM = actual mean, and EM = expected mean), on numbers transformed to a range from 10 to 100. Thus 3.14 would be expanded to 31.4, and 1968 would be collapsed to 19.68. This would permit the calculation of a mean for both the test and Benford distributions. Nigrini dropped any observations less than 10 from the analysis, and divided numbers greater than 100 by an appropriate factor to bring them to within the 10-100 range. Nigrini argued that an excess of lower digits in comparison to a Benford distribution would indicate downward manipulations (e.g., lowering income) and would result in a negative DF, but the degree of manipulation would not be known. Conversely, deductions would be more likely to be subjected to upward manipulations, thus lowering income. The type of evasion (planned, unplanned or error) would not be known. In other words, the DF model is an indicator, but not a definitive tool for the identification of manipulation in tax data. Further, by dropping data from the analysis, Nigrini skewed the data set and quite possible ensured that the data would not conform to the Benford distribution.

Newcomb and Benford (1881, p. 40; 1938, p. 556) exhibited the following distribution:

| Digit | First Digit frequency | Second Digit frequency |
|---|---|---|
| 0 | - | 0.1197 |
| 1 | 0.3010 | 0.1139 |
| 2 | 0.1761 | 0.1088 |
| 3 | 0.1249 | 0.1043 |
| 4 | 0.0969 | 0.1003 |
| 5 | 0.0792 | 0.0967 |
| 6 | 0.0669 | 0.0934 |
| 7 | 0.0580 | 0.0904 |
| 8 | 0.0512 | 0.0876 |
| 9 | 0.0458 | 0.0850 |

**Table 7-1 First and Second Digit Frequencies**

Nigrini argued that the DF model provided evidence of unplanned evasion. However, the possibility of taxpayer error or other alternate explanations were not explored. Nigrini uncovered evidence that would require additional audit work in several areas. However, this evidence could have been achieved via a combination of the chi-square goodness of fit test on the overall probability distribution, plus the z-test or Kolmogorov-Smirnov test on a digit-by-digit basis. In this case, the application of Occam's razor would suggest that Nigrini's approach is overly complex approach to arrive at the conclusion that more audit work is required in certain areas of concern.

Considering the methodology popularized by Nigrini (1996), and the inherent issues discussed, I believe that there is a need to move this non-specific unsupervised technique that does not distinguish between errors and fraud towards an applied methodology that will single out specific cases for further audit without a priori knowledge of the characteristics of fraud and non-fraud cases.

The intent of this study was to further Nigrini's research by increasing the rigor of the resultant statistical analysis of an application of Benford's law to a dataset. Second, if significant non-conformance with Benford distribution is uncovered, this would provide satisfactory evidence to justify the inclusion of a Benford-based variable in a subsequent model. A significant Benford-based variable would provide quantitative evidence of human manipulation of data.

## 7.2. Hypotheses

Hypothesis B1: I will observe an overall deviation for the first significant digits (i.e., all digits from 1 to 9) from the expected Benford distribution for LFA 33 and LFA 34, but no deviation (or at least a lesser deviation) for the two observed areas (Benford, 1938, Bodiguel, 2002; Nigrini, 1996; Seed 1996).

. Hypothesis B2: I will observe an overall deviation for the second significant digits (i.e., from 0 to 9) from the expected Benford distribution for LFA 33 and LFA 34, but no deviation (or at least a lesser deviation) for the two observed areas.

Hypothesis B3: The distribution of each first significant digit observed will be more likely to not equal the expected distribution as per Benford's Law for LFA 33 and LFA 34 versus the observed fisheries.

Hypothesis B4: The distribution of each second significant digit observed will be more likely to not equal the expected distribution as per Benford's Law for LFA 33 and LFA 34 versus the observed fisheries.

Hypothesis B5: The distribution of first two significant digits observed will be more likely to not equal the expected distribution as per Benford's Law for LFA 33 and LFA 34 versus the observed fisheries.

## 7.3. Materials and Methods

The data set was obtained from the Department of Fisheries and Oceans Canada (Department of Fisheries and Oceans 2007). The data set consisted of: "grey zone" (observed, shared United States-Canada) (2002-2006), <3 000 landings; LFA 33 (non-observed) (1997-2006), 109 664 landings; LFA 34 (non-observed) (1997-2006), 220 715 landings; and snowcrab (observed) (1997-2006), 22 939 landings.

Each data group as described above contains licensee, licensee postal code, buyer, buyer postal code, date landed, weight and price information. The snow crab and grey zone are observed fisheries. Each record shows the catch (in kilograms plus the reported value of the catch) reported by a licence holder for each day they land back in port. The data are not continuous since a licence holder may not report a catch on each day of a fishing season.

The observed data sets are used as controls for the areas in which I were interest, LFA33 and LFA34. Both LFA33 and 34 data were used since combined they account for 74% of the lobster landed in the Maritimes Region of DFO and 77% of the Maritimes Region value (and half of the overall Canadian value) (Department of Fisheries and Oceans 2005). Descriptive statistics for the data set (mean and median catch in kilograms) are contained in Table 8.2:

| | LFA 33 (kg) | LFA 34 (kg) | Snowcrab (*chionoecetes opilio*) | Grey zone (kg) |
|---|---|---|---|---|
| Mean | 1018.9 | 713.9645 | 3111.833 | 215.451 |
| Median | 240.3985 | 214.098 | 2152.771 | 125.000 |
| Standard deviation | 1844.97 | 1433.23 | 2977.97 | 240.93 |

**Table 7-2 Descriptive Statistics for Data Set**

The overall goodness of fit of the data versus the Benford frequencies was evaluated using a chi-square test as calculated using Equation 8.2 (Sheskin 2004):

$$\chi^2 = \sum_{i=1}^{k} \left[ \frac{(O_i - E_i)^2}{E_i} \right],$$

**Equation 7-1 Sheskin's Chi-Square Test**

where for each cell, the expected frequency (E) is subtracted from the observed frequency (O), squared, and divided by the expected frequency. These results are then summed to arrive at the chi-square. The goodness of fit tests the overall statistical deviation from an expected distribution of numbers, in this case Benford's Law, compared to an observed distribution. In the current study, the frequency for the first digit of each weight reported was calculated and compared to the expected frequency from Benford's Law.

Following the overall chi-square test, a digit-by-digit test was completed for the first and second digits for each of the populations using a z-test:

$$z = \frac{\left| p_1 - \pi_1 \right| - \frac{1}{2n}}{\sqrt{\frac{\pi_1 \pi_2}{n}}}$$

**Equation 7-2 z-test**

where $p_1$ is the observed population proportion, $\pi_1$ is the expected population proportion, $\pi_2$ is $(1-\pi_1)$, and the term 1/2n (where n is the sample size) is a continuity correction term for use only when it is smaller than the first term in the numerator or when a more conservative test is desired (Nigrini 1996; Sheskin 2004). The z-test calculated in this manner will yield similar results to the chi-square goodness of fit test (Sheskin 2004). For both tests, the expected proportions from Benford's Law (Table 1) were used to derive the expected values for the calculations. Both calculations were programmed as formulae in Microsoft Excel (Microsoft 2002).

The issue with the z-test as used by Nigrini (1996) is that if there are a large number of transactions (as suggested earlier as a pre-requisite for applying Benford's Law), it will take a lower proportion of inconsistent transactions to generate a significant difference (Durtschi et al. 2004). As a result, it is generally recommended to use both a digit-by-digit analysis (e.g., z-test) and a chi-square goodness of fit test to compare the expected and observed proportion distributions (Durtschi et al. 2004; Cleary & Thibodeau 2005), with the chi-square test as an overall indicator of whether or not further tests of individual significant digits are warranted.

Controlling the family-wise error rate is a concern when evaluating a number of significant variances. The use of a Bonferroni adjustment may result in a more conservative evaluation (Knoke 1976). For example, in the first digit comparisons, there are 9 tests (and for second digit comparisons there are 10), and a Bonferroni adjustment was made to maintain the family-wise error rate at 0.01 (i.e., $0.01/9 \approx 0.001$), the critical value of z at 0.0005 for a two-tailed test was 3.27 (Sheskin 2004).

I expected that the data would conform to Benford's Law, and that the observed fisheries (snow crab and grey zone) have greater conformity than non-observed fisheries. The weight and price information was expected to conform to Benford's Law as it conformed to the previously noted constraints (Busta & Weinberg 1998; Durtschi et al. 2004) and is consistent with previous applications (e.g., Nigrini 1996). I expected to see indications of non-conformity with Benford's Law in both LFA33 and 34.

## 7.4. Results

Overall, a conservative approach was used for determining significance. Specifically, all tests were completed using a 99% confidence level for the family-wise error rate. At the 99% confidence level, the null hypotheses was not rejected for the grey zone, but was rejected for snow crab, LFA 33 and LFA 34.

The strongest conformity was in the observed fisheries and the weakest in the non-observed fisheries, LFA 33 and LFA 34. Importantly, the time period available for the grey zone was 2002-06 compared with 1997-2006 for snow crab, LFA 33 and LFA 34, and there are large differences in the size of the populations (i.e., the grey zone may not have the population size required for a Benford's Law analysis). There is no clear line of demarcation in the literature as to what constitutes a population.

On a first two digits basis, the results show a large degree of conformity to Benford's Law in the grey zone, and non-conformity in the snow crab fishery, LFA 33 and LFA 34.

| | $\chi^2$ critical value | Grey zone[1] | Snow crab[2] | LFA 33 | LFA 34 |
|---|---|---|---|---|---|
| First Digit | d.f.=8, 0.01, 20.09 | 18.77 | 145.34* | 219.15* | 6328.70* |
| Second Digit | d.f.=9, 0.01, 21.67 | 17.68 | 34.36* | 180.30* | 267.30* |

**Table 7-3 Degree of Conformity with Benford's Law**

| | Grey zone | | Snow crab | | LFA 33 | | LFA34 | |
|---|---|---|---|---|---|---|---|---|
| | First digit frequency | Second digit frequency | First digit frequency | Second digit frequency | First digit frequency | Second Digit frequency | First digit frequency | Second digit frequency |
| | | | | | | | | |
| 0 | n/a | | n/a | | n/a | | n/a | * (+) |
| 1 | | | * (-) | | | | * (+) | |
| 2 | | | | * (-) | * (-) | | | |
| 3 | | | * (+) | | * (-) | * (+) | * (-) | * (+) |
| 4 | | | * (+) | | * (+) | | * (-) | |
| 5 | | | | | | * (+) | * (-) | |
| 6 | | | | | | * (-) | * (-) | * (-) |
| 7 | | | | | * (-) | * (-) | * (-) | |
| 8 | | | | * (+) | * (-) | * (+) | | * (+) |

**Table 7-4 Significant Variations from Benford's Law**

[1] Time period is 2002-2006
[2] Time period is 1997-2006

## 7.5. Discussion

Overall, the greyzone, as a highly regulated and observed fishery, showed no indication of non-conformity with Benford's Law. It was expected that the snow crab fishery results would be close to the grey zone results, but the snow crab fishery, an observed fishery, showed indications of non-conformity. LFA 33 and LFA 34 also showed signs of non-conformity. While Benford's Law cannot uncover specific cases of non-conformity, it does show that further study and development of techniques to better determine the level of underreporting/manipulation is required. The non-conformity in the snow crab fishery was unexpected. Although there is a possibility of a Type I error, the use of a conservative chi-square and z-test, in addition to a conservative confidence level of 99% with a family-wise error rate reduces the probability of a Type I error to 0.01 (Sheskin 2004). More likely is that the participants of the snowcrab fishery have devised a way to circumvent the observers. The form of regulation or the presence of observers does not guarantee the reliability of the reported numbers.

Nigrini's (1996) methodology and the above application of Benford's Law are a good descriptor of a data set's compliance with Benford's Law and serves as a screening tool to identify broad categories for further investigation. However, an analysis using Benford's Law alone does not provide a model, characteristics of, or definitively indicate fraud. Lu et al. (2006) advance the Benford's Law research by applying a reinforcement learning (a technique where a computer application discovers the best strategy to maximise or minimise a reward) methodology that may be better at developing a model or policy that describes the nature of fraud.

Although care has been taken to ensure that a conservative estimate of the conformity with Benford's Law has been performed, there is still arbitrariness to the significance levels chosen in this study. In addition, the lack of significant results in a given fishery does not necessarily mean that there is no fraud or manipulation. For example, if entire catches are not reported, Benford's Law would not be able to identify that there were missing data. Nevertheless, conservative significance levels plus consideration of family-wise error rates result in a fair indication of whether or not there is conformity with Benford's Law.

Future research in this area should apply Lu et al.'s (2006) reinforcement learning methodology to the current data sets to demonstrate that their technique was effective and by reporting some requisite detection, sensitivity and timeliness data. Alternatively, Paton & Williams (2002) use a

univariate probit model to examine possible pricing irregularities in a betting market. Future research should explore the application of Paton & Williams' (2002) methodology, as it could identify possible seller-buyer collusion. As more information is gathered on the nature and characteristics of fraud in the lobster fishery a semi-supervised fraud detection technique may also become a viable research direction.

## 7.6. Policy Implications

This study alone provides an indication of the level of human manipulation, whether intentional or unintentional, on a specific data set. This knowledge could be applied in corporate social responsibility, ecolabelling, tax and fisheries contexts. I will explore each of these policy implications in turn, and then lead into the next chapter.

### 7.6.1. Corporate Social Responsibility

Another interesting implication of the evidence of potential human manipulation of data in the lobster fisher is the link between tax avoidance, tax evasion and corporate social responsibility. First, I need to restate the definition of tax avoidance and tax evasion. Tax avoidance is legitimate or legal efforts to avoid paying taxes while tax evasion is the illegal effort to avoid paying taxes. Second I would like to examine the implications of the current research on tax evasion and corporate social responsibility.

Chen, Chen et al. (2010) examined the aggressiveness of family versus non-family firms on tax issues. The first premise in Chen, Chen et al.'s paper was that most shareholders prefer a certain degree of tax aggressiveness as shareholders are supportive of any measures that provide value to them. Nevertheless, there are also non-tax costs to tax aggressiveness. Interestingly, Chen, Chet et al. found that tax aggressiveness was more prevalent in non-family firms than family firms. Interestingly, illegal activity such as collusion has been found anecdotally in family firms (McMullan and Perrier 2002).

Sikka (2010) asserts that taxation provides an indicator of corporate social responsibility as the avoidance of taxation cannot be reconciled with social responsibility. All of the corporate social responsibility literature to date examines the linkage between tax avoidance-corporate social responsibility. Sikka further argues that despite a growing number of corporate social responsibility claims, tax avoidance activities by firms continue. These divergent philosophies show a level of

hypocrisy and underscore the strong motivation of firms to provide value to shareholders, thus creating a gap between stated corporate philosophy and action (Sikka 2010).

Since the participants in the lobster fishery are largely self-employed individuals that operate as sole-proprietorships, what then is the relationship to corporate social responsibility? Notwithstanding the literature (e.g., (Chen, Chen, Cheng et al. 2010)) there are significant indicators of human manipulation of numerical data in a predominantly family-firm industry. Why are these family-firms behaving more like Sikka's corporations than Chen, Chen et al.'s family-firms? I believe that I need to return to the introduction to the lobster fishery from section 2.5. Recall that input controls such as the effort required to catch lobster produce a response that maximizes effort in an attempt to maximize income. This also creates a common resource management issue similar to the "Tragedy of the Commons" (Hardin 1968). This response also parallels the corporate imperative to provide value to shareholders and is consistent with news reports that news reports in December 2006 that "Fishermen sometimes try to hide their total catch when they exceed their quotas…occasionally working in collusion with processing companies" (Beeby 2006). Policy considerations that reduce the incentives to maximize income might encourage corporate social responsibility responses of family firms more typical to that found by Chen, Chen et al. (2010).

### 7.6.2. Ecolabelling

Ecolabelling of fisheries products is becoming more common and is an overt point-of-purchase indicator of the sustainability of the fisheries practices used in a given fishery (Roheim 2003). As an indicator it could also be considered an overt sign of corporate social responsibility and the fisheries' adherence to a commonly understood set of social responsibility criteria. One of the major ecolabelling certification authorities, the Marine Stewardship Council, reported that by the end of 2009-2010, 187 fisheries producing 7 million tonnes or 12 percent of the wild fisheries production were certified or in the certification process (Marine Stewardship Council 2010). The Marine Stewardship council was founded by the World Wildlife Federation and the consumer goods conglomerate Unilever (Roheim 2003). The Marine Stewardship Council is now funded via charitable organizations (Potts and Haward 2006).

| |
|---|
| **Certification:** declaration that "focus on the legal permissibility of the harvest and that the fish have been caught within an agreed regulatory framework" (Potts and Haward 2006 p. 95) |
| **Ecolabelling:** moves beyond certification and "tends to be granted on the basis of investigation into the ecological integrity of the harvest, including ecosystem considerations within the fishery" (Potts and Haward 2006 p. 95). Further refinements are possible with respect to the type of label. For example, some labels address a specific issue (e.g., tuna is caught via a dolphin-friendly harvesting method) whereas others cover the entire life cycle of the product from ocean to consumer and may include strict chain of custody requirements (Potts and Haward 2006). |

**Table 7-5 Definition of Certification and Ecolabelling**

Certification of the sustainability and ecolabelling of how various seafood is also emerging as an important non-government fisheries management mechanism especially in the areas of illegal, unreported and unregulated fishing (Potts and Haward 2006). The presence of an ecolabel also attempts to persuade consumers at the point of purchase to purchase a product with more sustainable fishing practices than an otherwise identical, directly substitutable product (Potts and Haward 2006).

As more and more markets move towards ecolabelling requirements such as the European Union (Potts and Haward 2006), the Atlantic Canadian lobster fishery will be faced with some challenges. For example, if the lobster fishery wished to participate in an ecolabelling initiative, the chain of custody would be difficult for some fishermen to substantiate if their sales were cash and unreported. As a market-driven initiative, ecolabelling then becomes a non-government mechanism to

persuade fishery participants to adopt more sustainable practices including perhaps the cessation of illegal, unreported, and unregulated fishing.

Further, the presence of research outlining illegal activities (Bodiguel 2002) and issues reported in Arai (1994) and McMullan et al. (2002) that some communities are more prone to compliance issues than others would be potentially problematic for a bid to certify the lobster fishery or pursue an eco-label. For example, poaching in the lobster fishery in Atlantic Canada can be classified as communal, outlaw and business poaching (McMullan and Perrier 2002). Communal poaching is tolerated within the community and is usually not for resale (i.e., it is for personal or family use), while outlaw poaching is not tolerated within the community and is typically for profit (McMullan and Perrier 2002). Outlaw poaching differs from business poaching in the degree of illegality; outlaw poaching is completely illegal, while business poaching is an illegal supplement to an otherwise legitimate commercial operation (McMullan and Perrier 2002).

Another distinguishing feature of the three types of poaching is the number of people involved. Communal poaching is small-scale and limited to one or two family members. Outlaw poaching typically involves a larger number of related individuals, and business poaching is more of a community effort involving family, crew, buyers and distributers (McMullan and Perrier 2002).

The illegally caught lobster is soon reintroduced into the legitimate market when the lobster is exported or distributed within Canada. McMullan and Perrier's (2002) paper on the community-wide nature of business poaching suggests that this manipulation should be detectable within the fisheries data. From the certification perspective, my quantitative finding that there are indicators of manipulation could negatively impact certification efforts. This should not deter the lobster fishery from pursuing certification as the fishery can still choose an advantageous unit of certification (Marine Stewardship Council 2009). The unit of certification is defined as "the entire fishery, a smaller group of vessels within the fishery, or specific gears or fishing methods. Once defined, only fish from that particular unit will later be able to carry the MSC ecolabel in the marketplace" (Marine Stewardship Council 2009 p. 5). Thus if the lobster fishery chose an appropriate unit of certification that excluded fishermen that were participating in illegal, unreported or unregulated lobster fishing. This non-governmental approach could have market access (e.g., provide a barrier to entry to markets wishing to purchase eco-labelled lobster to non-participating fishermen), and subsequent market share and profitability implications.

### 7.6.3. Tax and Fisheries Policy

In this section I will outline some of the policy implications for the Government of Canada from the tax and fisheries policy perspectives.

## Tax Policy

The tax policy implications start with a summary of what I have learned from the first study on statistical fraud detection in the lobster fishery. First, the greyzone, as a highly regulated and observed fishery, showed no indication of non-conformity with Benford's Law. Next, it was expected that the snow crab fishery results would be close to the grey zone results, but the snow crab fishery, an observed fishery, showed indications of non-conformity. Last, LFA 33 and LFA 34 also showed signs of non-conformity. While Benford's Law cannot uncover specific cases of non-conformity, it does show that further study and development of techniques to better determine the level of underreporting/ manipulation is required. From this, the Canada Revenue Agency could use a risk-based approach to further audit both snowcrab and lobster fishermen. For example, chi-squared scores for individual licence holders could be compared with the expected distribution for the year under review. However, recall that the constraints for Benford's Law included (e.g., (Busta and Weinberg 1998; Durtschi, Hillison and Pacini 2004)) a constraint that the population is tested as opposed to a sample. Further note that non-conformance with Benford's Law does not mean that there is certainty of fraud or human manipulation (Durtschi, Hillison and Pacini 2004; Geyer and Williamson 2004). Thus an audit selection tool based solely on non-conformance with Benford's Law would be in itself risky and open the Government to challenges about the rationale for audit selection. As part of an audit selection strategy, an auditor would need to have additional information, tools, and techniques to select fishermen for audit. Additional tax policy considerations to reduce the incentives to maximize income might encourage corporate social responsibility responses of family firms more typical to that found by Chen, Chen et al. (2010).

## Fisheries Policy

The fisheries policy implications have an interesting dichotomy. I have shown that there are indications of non-conformity with Benford's Law. As with tax policy, this does not mean that there is certainty of fraud or human manipulation (Durtschi, Hillison and Pacini 2004; Geyer and Williamson 2004). Thus an enforcement actions based solely on non-conformance with Benford's

Law would be risky and open the Government to challenges about the rationale for enforcement. As part of an enforcement strategy, a fisheries officer would need to have additional information, tools, and techniques to select fishermen for investigation. For fisheries policy, the dichotomy comes from deciding whether a government or non-government response may be more appropriate. For example, a government response would imply that regulations or policies should be changed in an effort to modify the illegal, unreported or unregulated behaviour of the lobster and snowcrab fishermen. Given the longstanding history of non-compliance in the lobster fishery including the illegal trading or transfer of licenses, subsequent tax implications, and the illegal use of licenses as collateral (Bodiguel 2002), a government-based policy approach may not be practical or effective.

The second approach the Government could take is to encourage a non-government approach. For example, from the eco-labelling perspective, my quantitative finding that there are indicators of non-conformance with Benford's Law could negatively impact certification efforts. Nevertheless, this should not deter the lobster fishery from pursuing certification as the fishery can still choose an advantageous unit of certification (Marine Stewardship Council 2009). The unit of certification is defined as "the entire fishery, a smaller group of vessels within the fishery, or specific gears or fishing methods. Once defined, only fish from that particular unit will later be able to carry the MSC ecolabel in the marketplace" (Marine Stewardship Council 2009 p. 5). Thus if the lobster fishery chose an appropriate unit of certification that excluded fishermen that were participating in illegal, unreported or unregulated lobster fishing. This non-governmental approach could have market access (e.g., provide a barrier to entry to markets wishing to purchase eco-labelled lobster to non-participating fishermen), and subsequent market share and profitability implications. This could be a very effective approach to change illegal and underreporting behaviours in the lobster fishery.

## 7.7. Summary

This study of Benford's Law in the lobster fishery has shown that:

1. The statistical methods used in previous research were not robust enough;
2. Non-conformity with Benford's Law was observed in both the lobster fishery in LFA33 and LFA34 plus the snowcrab fishery.
3. Benford's Law alone should not be used as an effective tool for isolating specific fishermen for audit or investigation. Specifically, non-conformance with Benford's Law does not mean

that there is certainty of fraud or human manipulation (Durtschi, Hillison and Pacini 2004; Geyer and Williamson 2004). The constraints for Benford's Law included (e.g., (Busta and Weinberg 1998; Durtschi, Hillison and Pacini 2004)) a constraint that the population is tested as opposed to a sample.

4. Non-government options such as eco-labeling regimes may be an alternative to direct government policy interventions.

From this conclusion, I believe that further variables are required for inclusion in a model that may help to predict non-compliance in the lobster fishery. For example, I believe that a measure of the presence or absence of collusion in the lobster fishery may have merit as a variable for further study. First, news reports in December 2006 reported that "Fishermen sometimes try to hide their total catch when they exceed their quotas…occasionally working in collusion with processing companies" (Beeby 2006). Next, Cowell (1990) argues that one effect of the presence of the underground economy is the creation of market power. Last, as the next study I will look into whether or not there are indications of market power or collusion in the lobster fishery and determine the value of including such a variable in the overall model.

# 8. Study 2: Collusion in the Lobster Fishery

## 8.1. Introduction

Recall from the previous study that there are indicators of non-conformance Benford's Law (Graham, Hasseldine and Paton 2007) and the need to identify non-compliance has become increasingly important to facilitate eco-labeling initiatives. Further, Cowell (1990) argues that one effect of the presence of the underground economy is the creation of market power. In this study I identify and report on indicators of market power in the lobster fishery industry and I extend knowledge in three ways. First, the study provides quantitative support for ethnographic studies of the lobster fishery (Arai, 1994; McMullan and Perrier, 2002). Next, this study extends Abrantes-Metz et al. (2006) by refining procedural aspects of screening for market power. Lastly, I discuss implications of market power and the underground economy for the fishing industry in both Canada and elsewhere.

| |
|---|
| **Market Power:** Landes and Posner (1981) define market power as "the ability of a firm (or a group of firms, acting jointly) to raise price above the competitive level" |
| **Collusion:** is the "intent to restrict output and/or to control market price" amongst a group of companies that would normally be in competition (Stigler 1964; Bolotova, Connor and Miller 2008 p. 1291). Indicators of markets that may be more likely to exhibit market power or collusive behaviour may include: a higher regular price and more homogeneous prices; price declines precede a series of price increases; price increases while imports decline; strong correlations between prices of different firms; highly stable market shares; homogeneous products; a small number of firms in the market; significant barriers to entry; and excess capacity (Stigler 1964; Asch and Seneca 1975; Grout and Sonderegger 2005; Harrington Jr. 2006). |

## 8.2. Hypotheses

H1: Based on previous qualitative (Arai (1994) and McMullan and Perrier (2002) and quantitative research (Graham, Hasseldine and Paton 2007), we will observe prima facie evidence of market power by lobster fishermen when using a screen for market power (Cowell 1990; Abrantes-Metz, Froeb, Geweke et al. 2006).

H2: Based on previous qualitative (Arai (1994) and McMullan and Perrier (2002)) and quantitative research (Graham, Hasseldine and Paton 2007), we will observe prima facie evidence of market power by lobster brokers when using a screen for market power (Cowell 1990; Abrantes-Metz, Froeb, Geweke et al. 2006).

## 8.3. Data and Methods

The dataset was obtained from the Canadian Department of Fisheries and Oceans. It consisted of daily time series data between 1997 through 2006 for two Lobster Fishery Areas (LFAs). Specifically LFA 33 contains 109,664 data points and LFA 34 contains 220, 715 data points.

Each data group contained details of licensee, buyer, date catch landed, weight and price information. Both LFA 33 and 34 data are used for several reasons. First, when combined these regions account for 74% of the lobster landed in the Maritimes Region of DFO and 77% of the Maritimes value and over half of the overall Canadian value (Department of Fisheries and Oceans 2005). Information on the quality or grade of the lobster is not collected.

Indicator variables were calculated for each licensee operating in a postal code. The indicator variables calculated were mean price (0<= mean, 1> mean), standard deviation (1<standard deviation, 0>=mean), and coefficient of variation (1<coefficient of variation, 0>=coefficient of variation).

I followed the Abrantes-Metz et al. (2006) approach to screening. Specifically I classify any observation as being a possible case of market power if each of the indicator variables (i.e. for mean, standard deviation, and coefficient of variation) is equal to one.

Overall indicator variables were calculated for each year in the entire time period (1997-2006) and for each licence holder.

An important issue in my data is whether or not it is appropriate to impute missing data. Abrantes-Metz et al. (2006) do not discuss the conditions under which imputation of missing data

needs to be undertaken. In their study, prices were observed daily, unless no fleet credit cards are scanned during a twenty-four hour period, in which case, data were recoded as missing for the day in question. According to Rubin (1976), the manner in which the data becomes missing is key to its statistical treatment as most statistical procedures are not designed to handle missing data (Schafer and Graham 2002). Specifically, data that was missing at random need not be imputed. Random missing data also implies that there is no underlying value that has simply not been observed (Schafer and Graham, 2002). In the case of Abrantes-Metz et al. (2006), there was an expectation that the data would be continuous, and there should be a daily data point, and thus supporting their use of an imputation technique.

In my study, I did not impute data as there is no expectation that a lobster fisherman will have a sale every day during lobster season. For example, lobster traps require a period of time underwater (soak time) to increase the probability of trapping a lobster. Even with a landing, a sale may or may not occur. The fisherman can choose to warehouse the lobster and await more favourable market conditions. Nevertheless, it is the landings that are recorded by DFO. Since data in this case is missing at random, imputation is not appropriate. This is a necessary addition to the Abrantes-Metz et al. (2006) market power screen.

I extend the Abrantes-Metz et al. (2006) approach through the addition of an appropriate parametric statistical tests. Abrantes-Metz et al used observation of outliers to determine the presence or absence of collusion. The indicators of reduced variance (lower than mean variance), reduced coefficient of variance (lower than mean coefficient of variation) and higher prices (higher than mean price) under market power have a probability of 0.125 of occurring by chance if each indicator is categorized as a binary (0,1) occurrence and is independently distributed with a probability of 0.5 (0 or 1). Further, if a market power indicator variable is calculated as 1 if all indicators are in the direction of market power (i.e. reduced variance, reduced coefficient of variance and higher prices), there are several options (that I address in the next section) to evaluate hypotheses about the distribution of data in a single population (Sheskin 2004) .

These options include a chi-square goodness of fit test, the binomial sign test for a single sample, and the $z$ test for a population proportion. These tests evaluate the research hypothesis that an underlying population is composed of two categories and that the proportion of observations in one of the two categories equals a specific value (Sheskin 2004). Where there are two categories and a large

sample, the k = 2 categories, the chi-square goodness-of fit test is the most appropriate statistic. The overall goodness of fit of the data versus the expected market power indicator variable frequencies was evaluated using a chi-square test as calculated using Equation 7-1. (Sheskin 2004) where for each cell, the expected frequency (E) is subtracted from the observed frequency (O), squared, and divided by the expected frequency. These results are then summed to arrive at the chi-square. The goodness of fit tests the overall statistical deviation from an expected distribution of numbers compared to an observed distribution.

Controlling the family-wise error rate is essential when evaluating a number of significant variances; otherwise the probability of error is too great. The use of a Bonferroni adjustment may result in a more conservative evaluation (Knoke 1976). For example, in the first digit comparisons, there were 9 tests (and for second digit comparisons there were 10), and a Bonferroni adjustment was made to maintain the family-wise error rate at 0.01 (i.e., $0.01/9 \approx 0.001$), the critical value of z at 0.0005 for a two-tailed test was 3.27 (Sheskin 2004).

## 8.4. Results

As in Abrantes-Metz (2006) mean and standard deviations for price were plotted. Overall price dispersion for lobster was largely clustered at a higher mean price and lower standard deviation (see Figure 8.1 Overall Price Dispersion for Lobster 1997-2006).

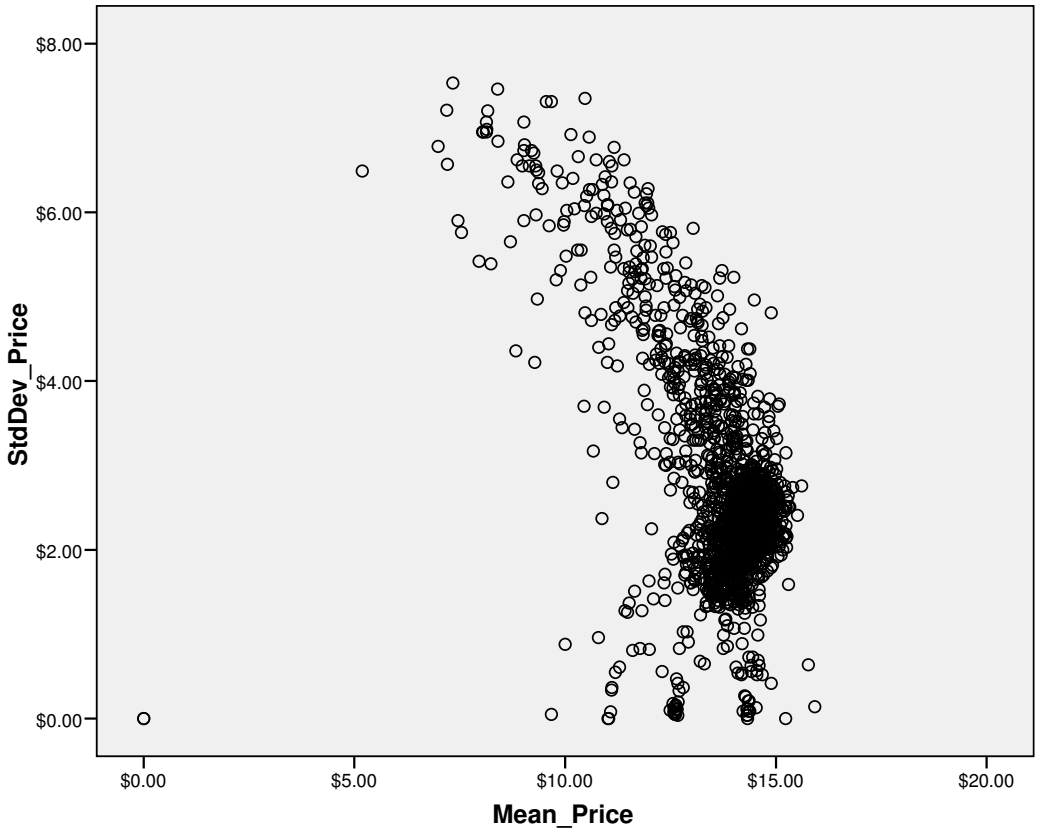



**Figure 8.1 Overall Price Dispersion for Lobster 1997-2006**

Also consistent with Abrantes-Metz et al. (2006), the mean price was higher than average (see Figure 8.2), and the standard deviation and coefficient of variation were lower than average (Figure 8.3 and Figure 8.4).

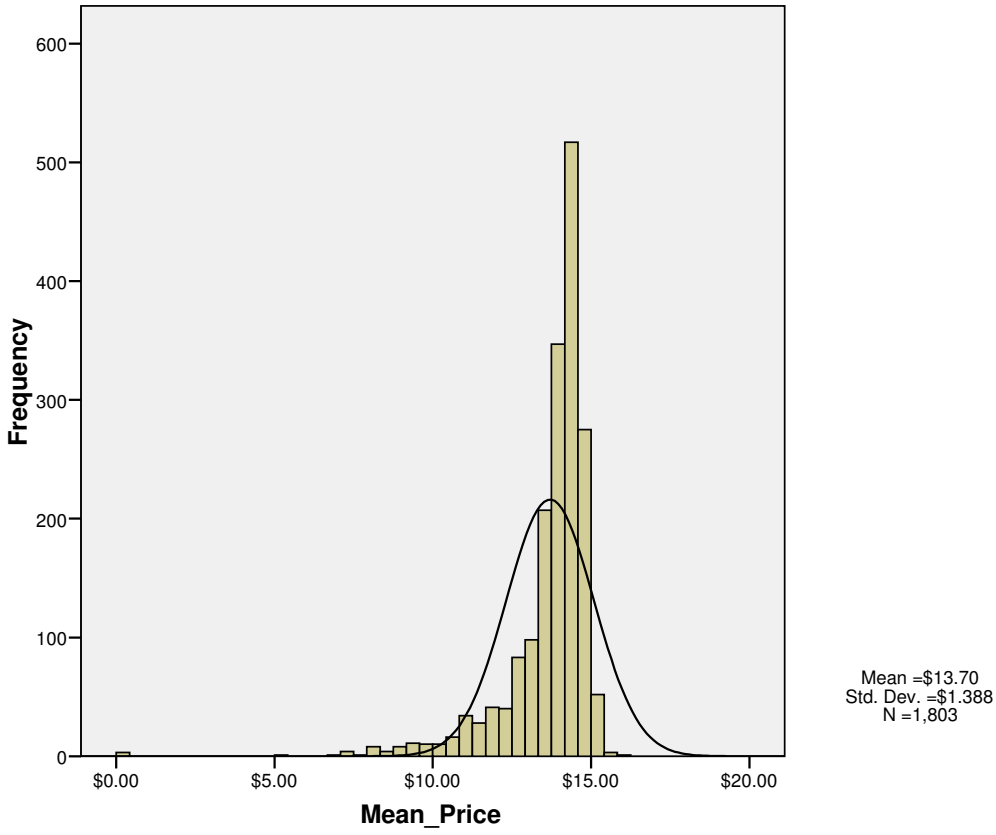



**Figure 8.2 Overall Mean Price for Lobster 1997-2006**

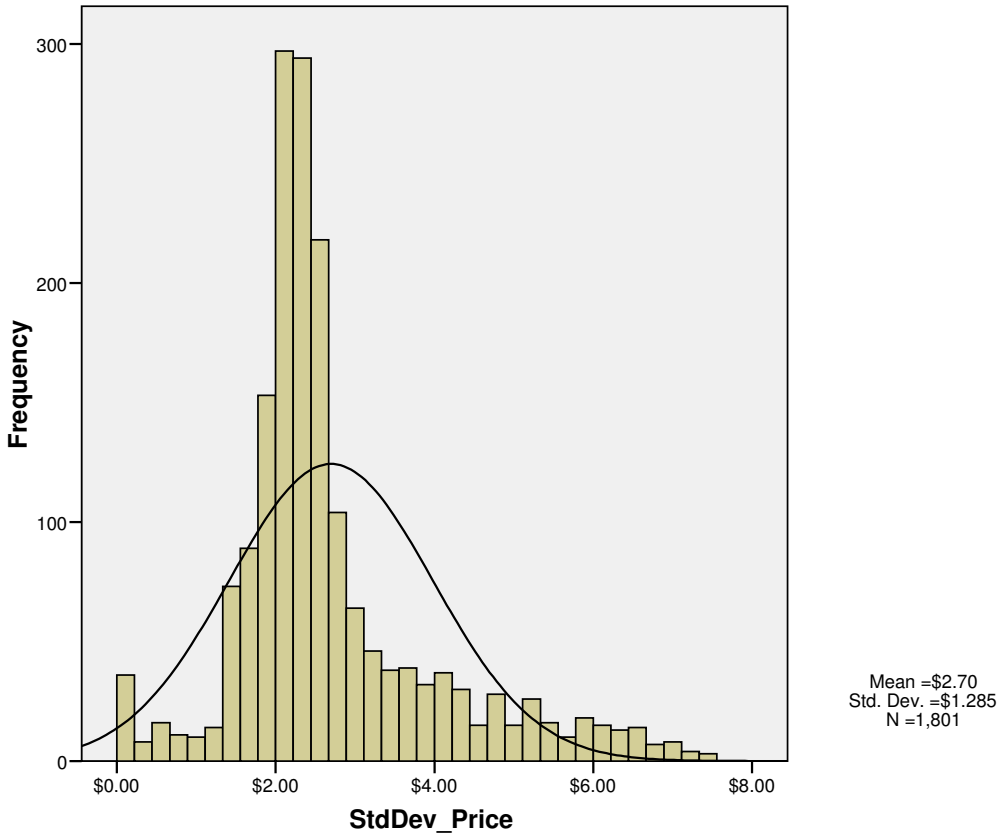



**Figure 8.3 Overall Price Standard Deviation for Lobster 1997-2006**

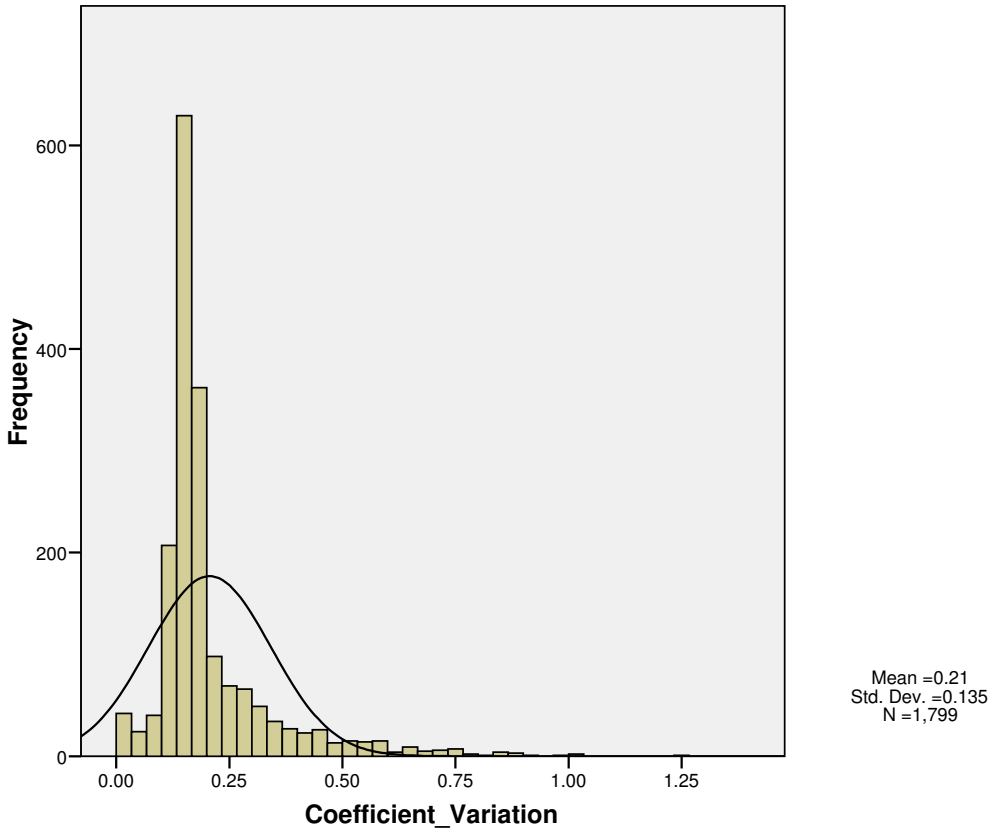



**Figure 8.4 Overall Price Coefficient of Variation for Lobster 1997-2006**

*Overall Market Power Indicator variable*

A chi square goodness of fit test was completed on the overall market power indicator variable for the lobster fishers in the sample. Table 1 reports the $\chi^2$ of 3694.69 for the sample, with df = 1 and a critical value of 10.827. Thus using a chi-square goodness of fit test the lobster fishery varied significantly from the expected distribution. The expected distribution is in the proportion of .875 (no market power) and .125 (market power) if the market power indicator variable was based on probability alone.

| | Lobster Fishermen | |
|---|---|---|
| **Market power Indicator variable** | **0** | **1** |
| **Observed** | **1140** | **1297** |
| **Expected** | **2132** | **305** |
| $\chi^2$ | **3694.69, df=1, p<.001** | |

**Table 8-1 1Overall market power indicator variable for the lobster fishery**

*Postal code*

A total of 475 unique postal codes having at least one lobster licensee are in LFA 33 and 34. Individual chi-square tests were completed for postal codes for each of LFA33 and 34 where the expected frequency of market power was greater than 5 (Sheskin 2004). This resulted in 12 comparisons, and a Bonferroni adjustment was made to maintain the family-wise error rate at 0.05. i.e., 0.05/12 = 0.004167, critical value of chi-square at .005 for each test with df = 1 was 7.88. Since 0.004167 falls just beneath the .005 level, a critical value of 10.83 was used, representing a test-wise error rate of $p<0.001$(Sheskin 2004) . Table 8.2 shows eleven of the twelve comparisons were statistically significant.

| Area | Community | Chi (E>=5) |
|---|---|---|
| 33 | Community 14 | |
| 33 | Community 49 | x |
| 33 | Community 54 | x |
| 34 | Community 62 | x |
| 34 | Community 65 | x |
| 34 | Community 71 | x |
| 34 | Community 75 | x |
| 34 | Community 79 | x |
| 34 | Community 81 | x |
| 34 | Community 82 | x |
| 34 | Community 99 | x |

**Table 8-2 Significant Comparisons**

*Time Series*

Over time, four communities in LFA33 and six communities in LFA34 showed consistent indications of market power. This resulted in 91 comparisons, and a Bonferonni adjustment was made (i.e., .10/91 = 0.001099, a critical value of 10.84 was used, resulting in a family-wise error rate of .10). Table 8-3 shows 88 of the 91 comparisons were significant. Indications of market power were consistent over time, regardless of the fluctuations in price.

| LFA | Community | 1997 | | 1998 | | 1999 | | 2000 | | 2001 | | 2002 | | 2003 | | 2004 | | 2005 | | 2006 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 33 | A | 16.20 | x | 120.91 | x | 34.89 | x | 28.60 | x | 5.87 | | 28.73 | x | 7.76 | | 32.47 | x | 26.37 | x | 21.75 | x |
| 33 | Z | 329.49 | x | 55.05 | x | 288.09 | x | 195.09 | x | 179.56 | x | 198.61 | x | 267.45 | x | 288.10 | x | 294.98 | x | 294.98 | x |
| 33 | B | 463.18 | x | 224.64 | x | 438.36 | x | 443.16 | x | 287.66 | x | 460.21 | x | 455.04 | x | 534.91 | x | 469.14 | x | 413.06 | x |
| 33 | C | | | 461.76 | x | 137.98 | x | | | | | | | | | | | | | | |
| 34 | D | 148.58 | x | 114.50 | x | 249.29 | x | 60.54 | x | 154.29 | x | 152.02 | x | 42.56 | x | 71.70 | x | 87.04 | x | 38.94 | x |
| 34 | F | 406.02 | x | 180.38 | x | 406.02 | x | 219.32 | x | 236.52 | x | 349.34 | x | 59.45 | x | 139.31 | x | 220.18 | x | 410.19 | x |
| 34 | H | 236.70 | x | 89.05 | x | 215.75 | x | 80.18 | x | 199.29 | x | 230.03 | x | 78.14 | x | 66.34 | x | 51.13 | x | 87.89 | x |
| 34 | I | | | 122.79 | x | 163.58 | x | 114.75 | x | 55.05 | x | 155.57 | x | 10.42 | | 48.75 | x | 32.04 | x | 20.24 | x |
| 34 | J | 238.23 | x | 143.19 | x | 270.03 | x | 245.84 | x | 185.10 | x | 296.65 | x | 66.59 | x | 112.00 | x | 129.33 | x | 86.49 | x |
| 34 | K | 223.51 | x | 76.46 | x | 169.07 | x | 121.39 | x | 91.43 | x | 111.08 | x | 38.03 | x | 44.23 | x | 65.31 | x | 122.31 | x |

**Table 8-3 Consistent indications of market power in ten communities from LFA 33 and LFA34 over time**

*Buyers*

A chi square goodness of fit test was completed on the overall market power indicator variable for the lobster brokers in the sample. Table 4 reports a $\chi^2$ of 31.00366 for the sample, with df = 1 and a critical value of 10.827. Thus using a chi-square goodness of fit test the brokers varied significantly from the expected distribution. The expected distribution is in the proportion of .875 (no market power) and .125 (market power) if the market power indicator variable was based on probability alone.

| | **Lobster Brokers** | |
|---|---|---|
| **Market power Indicator variable** | **0** | **1** |
| **Observed** | **500** | **124** |
| **Expected** | **546** | **78** |
| $\chi^2$ | **31.00366, df=1, p<.001** | |

**Table 8-4 Market power indicator variable for lobster brokers**

Of the 624 brokers, 124 had an indicator variable indicating market power. Of the 124 with a market power indicator variable, 70 had sales from communities that also showed the potential for market power (see Table 5). On average, sales from communities with the potential for market power accounted for 5.7% and 2.6% of sales from the identified communities and from LFA 33/34 respectively and this is summarized in Table 8-5.

| Year | Sales between Collusive Flagged Fisherman and Buyers | Sales from Collusive Flagged Fisherman in identified Communities | Total Sales from Identified Communities | Total Sales from LFA 33 and LFA 34 |
|---|---|---|---|---|
| 1997 Total | $ 4,390,690.15 | $ 23,440,968.68 | $ 65,880,521.56 | $151,750,582.96 |
| 1998 Total | $ 4,044,717.75 | $ 26,316,072.97 | $ 78,837,054.78 | $174,742,859.31 |
| 1999 Total | $ 4,345,722.03 | $ 32,908,558.13 | $100,753,334.46 | $233,104,720.99 |
| 2000 Total | $ 4,244,755.42 | $ 32,101,564.52 | $ 97,625,051.93 | $222,721,208.35 |
| 2001 Total | $ 7,789,310.93 | $ 40,925,200.85 | $120,874,592.21 | $277,991,245.78 |
| 2002 Total | $ 7,547,661.77 | $ 43,189,714.40 | $124,297,443.97 | $283,838,606.84 |
| 2003 Total | $ 9,005,714.43 | $ 47,568,549.66 | $149,882,811.29 | $300,823,339.06 |
| 2004 Total | $ 7,259,687.05 | $ 38,182,311.69 | $125,205,541.19 | $256,850,154.57 |
| 2005 Total | $ 8,788,834.12 | $ 45,825,649.06 | $151,771,287.68 | $305,909,203.45 |
| 2006 Total | $ 8,503,191.02 | $ 38,069,081.83 | $129,561,026.82 | $255,530,693.49 |
| Grand Total | $65,920,284.67 | $368,527,671.79 | $1,144,707,716.96 | $2,463,262,614.80 |

**Table 8-5 Potential dollar value of collusive sales versus total sales from LFA33 and 34**

## 8.5. Summary

Businesses that engage in fraud and collusion behaviour clearly breach the ethical behaviour required by government reporting rules such as tax law and, in this case, honest fishing return data. This case study provides the first empirical test of market power screening in a commercial fishery with large implications for government revenue and policy, especially if my results, replicate to other fisheries in Canada and around the world.

For the postal codes evaluated, the approximate dollar values in landings represented for the entire 1997 – 2006 time period were $2.46 billion for LFA 33 and 34. Quantitative support for community-based differences in compliance with fisheries regulations has been demonstrated, and extends the qualitative finding in Arai (1994) and McMullan et al. (2002) that some communities are more prone to compliance issues than others. In a traditional sense, this does not demonstrate collusion (Frass and Greer 1977). Rather, this research suggests that there exist smaller, geographically constrained pockets where market power is evident. While there may be further indications of market power in postal codes that might be uncovered from the use of the binomial sign test as noted above, the payoff with tasking fisheries and tax resources to further examine fisheries activity in postal codes evaluated in the current study is potentially large. In other words, the policy direction for the government would be to focus enforcement efforts on areas with the largest potential payoff.

The direct cause of the market power cannot be determined by the methodology in this study. Obvious candidates are the licensees or the licensees in collaboration with the brokers, or the brokers overlooking the activities of the licensees, as once the lobster are in the processing plants, the more exports and profits for both brokers and licensees (McMullan and Perrier 2002). Obviously, this would be fruitful future research, but I do not underestimate the difficulties of identifying these effects – e.g. through methods of participant observation (Festinger et al. 1956). Last, since information on the quality or grade of the lobster is not collected, it is possible that the higher than average prices reflect higher quality lobster. However, this argument is not consistent with previous research Arai, (1994), McMullan et al. (2002) and the notion that higher quality lobster are more randomly distributed amongst licence holders.

From this study there is value in including a market power indicator variable as a variable of interest in the model. Further, geographic location data such as postal code data for licensees and buyers should also be considered for inclusion in the model.

# 9. Study 3: Predicting Compliance in the Atlantic Canadian Lobster Fishery

## 9.1. Introduction

Recall that overall, LFA 33 and LFA 34 showed signs of non-conformity with Benford's law (Graham, Hasseldine and Paton 2007). While Benford's Law cannot uncover specific cases of non-conformity, it does show that further study and development of techniques to better determine the level of underreporting/manipulation is required. Although there is a possibility of a Type I error, the use of a conservative chi-square and z-test, in addition to a conservative confidence level of 99% with a family-wise error rate reduces the probability of a Type I error to 0.01 (Sheskin 2004).

Nigrini's (1996) methodology and the above application of Benford's Law are a good descriptor of a data set's compliance with Benford's Law and serves as a screening tool to identify broad categories for further investigation. However, an analysis using Benford's Law alone does not provide a model, characteristics of, or definitively indicate fraud.

Also recall that Cowell (1990) has asserted that the underground economy can create market power as a consequence. It was previously demonstrated that over time, four communities in LFA33 and six communities in LFA34 showed consistent indications of market power. Of the 624 brokers, 124 had an indicator variable indicating market power. Of the 124 with a market power indicator variable, 70 had sales from communities that also showed the potential for market power (see Table 5). On average, sales from communities with the potential for market power accounted for 5.7% and 2.6% of sales from the identified communities and from LFA 33/34 respectively.

The preliminary work with Benford's Law and collusion screening leads to the following questions:

Can these indicators be used in combination with variables from the data to predict the incidence of enforcement sanctions in LFA 33 and LFA 34?

In this chapter I will look at a panel data model that will attempt to address these questions. Next I outline the hypotheses that will guide the model's development.

## 9.2. Variable Selection

### 9.2.1. Dependent Variable

The first consideration in developing the model was selecting a dependent variable. The options were to select a variable available from the data set or create a latent variable. When looking at potential indicators of latent variables, the first decision is the methodology to evaluate the groupings these latent constructs. The two primary methods are factor analysis and principal components analysis. The differences between these methods is discussed in Velicer and Jackson(1990a). Velicer and Jackson suggest that factor and principal components are equally generalizable, arrive at similar solutions, and that differences only appear when too many components are extracted. Widaman (1993) added that factor analysis should be the primary choice for researchers look for latent constructs or factors. Notwithstanding the option to look at a latent variable (i.e., participation in the underground economy in the lobster fishery), I believe that the availability of enforcement data can function as a stand-in for the latent variable. "Sanction" was thus used as the dependent variable in the model and is the best available observed indicator of illegal or unreported activity in the lobster fishery.

### 9.2.2. Independent Variables

Next I reviewed the relevant literature as well as my results from Chapter 7 and Chapter 8 to develop the independent variables for the empirical model under development in this Chapter.

## Benford's Law

In Chapter 7, I demonstrated that non-conformity with Benford's Law was observed in both the lobster fishery in LFA33 and LFA34 plus the snowcrab fishery (Graham, Hasseldine and Paton 2007). I had also stated that Benford's Law alone should not be used as an effective tool for isolating specific fishermen for audit or investigation. Specifically, non-conformance with Benford's Law does not mean that there is certainty of fraud or human manipulation (Durtschi, Hillison and Pacini 2004; Geyer and Williamson 2004). As such, I expected that Benford's Law would contribute as a predictor of enforcement actions (i.e., licence sanctions) in the lobster fisheries.

## Market Power

In Chapter 8 I had shown quantitative support for community-based differences in compliance with fisheries regulations and extended the qualitative finding in Arai (1994) and McMullan et al.

(2002) that some communities are more prone to compliance issues than others. In a traditional sense, this does not demonstrate collusion (Frass and Greer 1977). I had also concluded in Chapter 8 that there is value in including a market power indicator variable as a variable of interest in the model.

## Weight, Price, Value

For transactional models, the weight in kilograms for each landing, the value of each landing and the price per kilogram for each landing were included for several reasons. First, market power as a function of price may have an interaction with the price per kilogram. Second, price may have an interaction with both weight and value (as weight x price = value). Last, value is the best available indicator of gross income (before expenses or other deductions).

For licensee models, the total weight in kilograms for each licensee per year, the total value of landed for each licensee per year and the mean price per kilogram for each licencee per year were included for several reasons. First, market power as a function of price may have an interaction with the price per kilogram. Second, price may have an interaction with both weight and value (as weight x price = value). Last, value is the best available indicator of gross income (before expenses or other deductions).

## Area

McMullan and Perrier's (2002) paper on the community-wide nature of business poaching suggests that this manipulation should be detectable within the fisheries data. This variable was included to identify differences, if any, between the two Lobster Fishing Areas, 33 and 34, that were included in the study.

## Licensee and Buyer

There is a longstanding history of non-compliance in the lobster fishery including the illegal trading or transfer of licenses, subsequent tax implications, and the illegal use of licenses as collateral (Bodiguel 2002). Further, illegal lobster fishing activity varies in scale from small-scale and limited to one or two family members to larger scale involving a larger number of related individuals, and business poaching is more of a community effort involving family, crew, buyers and distributers (McMullan and Perrier 2002). Given Bodiguel and McMullan and Perrier, it is prudent to include a licensee and a buyer variable.

The transactional models were based on the landings and data available for each landing. The licensee models were based on the annual summary of landings and data available for each landing.

Dummy variables were created for the Buyer identification categorical variable (Hosmer and Lemeshow 2000; Long and Freese 2006) to enable the transactional model to allow identification of buyer-licensee pairs that may be more likely to result in sanctions.

## 9.3. Empirical Model

This section shows the regression model being estimated. A general-to-specific modeling approach ( e.g., Hendry 1980; Campos, Ericsson and Hendry 2005) was adopted. The full regression model which contains all the factors affecting non-compliance:

$$y_{it} = \beta_0 + \beta_1 Benford_{it} + \beta_2 MarketPower_{it} + \beta_3 Weight_{it} + \beta_4 Value_{it} + \beta_5 \Pr ice_{it} + \beta_6 LobsterFishingArea_i + \beta_7 Licensee_{it} + \beta_8 Buyer_{ti} + \varepsilon_{it}$$

Since a binary outcome (sanction versus no sanction) was being used as the dependent variable, a probit panel data approach was used with the following random effects formula:

*Probit model,*

$$F(w) = \int_{-\infty}^{w} \frac{1}{\sqrt{2\pi}} e^{-\frac{z^2}{2}} du = \Phi(w).$$

$$\Pr(y_{i1}, \ldots, y_{in_i} | \mathbf{x}_{i1}, \ldots, \mathbf{x}_{in_i}) = \int_{-\infty}^{\infty} \frac{e^{-\nu_i^2/2\sigma_\nu^2}}{\sqrt{2\pi}\sigma_\nu} \left\{ \prod_{t=1}^{n_i} F(y_{it}, \mathbf{x}_{it}\beta + \nu_i) \right\} d\nu_i$$

where

$$F(y,z) = \begin{cases} \dfrac{1}{1+\exp(-z)} & \text{if } y \neq 0 \\ \dfrac{1}{1+\exp(z)} & \text{otherwise} \end{cases}$$

**Equation 9-1 Probit Regression Formula for Stata Random Effects**

(Hsaio 2003 p. 189)

A panel data analysis technique in Stata 9 was used to analyze the data. Hsaio (2003 p. 189) highlighted the differences between the linear probability, probit and logit models:

*Linear-probability model,*

$$F(w) = w. \qquad (7.2.7)$$

*Probit model,*

$$F(w) = \int_{-\infty}^{w} \frac{1}{\sqrt{2\pi}} e^{-\frac{z^2}{2}} du = \Phi(w). \qquad (7.2.8)$$

*Logit model,*

$$F(w) = \frac{e^w}{1+e^w}. \qquad (7.2.9)$$

The probit model is more computationally intensive as it calculates the integral for each term as opposed to the more straightforward logit calculation. In preliminary models I found that the logit panel models either failed to run as initial values for lnsig2u could not be calculated or failed to optimize. Probit panel models ran. Since the incidence of the licence sanctions was rare (243/16265 or 1.5% for licencee models) a rare events logistic regression was considered (e.g., relogit (King and Zeng 2003)). However, the relogit models could not handle data with missing completely at random data.

A panel data approach was selected since I wanted to pool information across time and repeated for licensees (Hsaio 2003; Baltagi 2005). Data from other experimental approaches (e.g., controlled laboratory experiments) may lend themselves to other experimental approaches such as OLS regression (Hsaio 2003). The data set is from an entire population, that is, all of LFA 33 and LFA34, and this eliminates the potential for a selectivity bias (Hsaio 2003). It would appear that as the data set has a large N, $N \rightarrow \infty$, and the timeframe is T=10, the data set could be as a "short panel" and not require additional corrections associated with longer timeframes (Cameron and Trivedi 2009).

## 9.4. Data and Methods

The dataset was obtained from the Canadian Department of Fisheries and Oceans. It consists of daily time series data between 1997 through 2006 for two Lobster Fishery Areas (LFAs). Specifically LFA 33 contains 109,664 data points and LFA 34 contains 220, 715 data points. For a complete description of the data, please refer to Chapter 5.

### 9.4.1. Transactional Models

Transactional models were based on the catch data from LFA 33 and LFA 34. Each data record contains details of licensee (licence identification number and postal code), buyer (buyer identification number and postal code), date catch landed, weight and price information. A licensee may have multiple landings in one day. Recall that indicator variables for Benford's Law (Chapter 7) and market power (Chapter 8) were calculated for each licensee by year. For example, if a significant Benford's Law indicator variable resulted for a given year, then all landings for that licensee would be coded as 1 for a significant inconsistency with Benford's Law for that year. Market power was similarly coded. Enforcement data was obtained for the time period. The enforcement data consisted of

information on licence sanctions imposed on licensees. Enforcement data was coded as 0 for no sanctions and 1 for sanctions. The variables for transactional models were summarized in Table 9-1.

| Independent Variable | Definition |
|---|---|
| **Benford's Law** | 0 for consistent with Benford's Law, 1 for significant inconsistency |
| **Market Power** | 0 for absence of market power, 1 for significant presence |
| **Weight** | weight in kilograms per transaction |
| **Price** | price per transaction |
| **Value** | Total value per transaction |
| **Area** | 33 for Area 33, 34 for Area 34 |
| **Licensee** | License number of each licensee |
| **Buyer** | Buyer number for transaction |

**Table 9-1 Variable Definitions for Transactional Models**

### 9.4.2. Licensee Models

Licensee models were based on a collapsed data set and were designed to determine if models based on licensees versus transactions would be useful in identifying specific taxpayers or licensees as opposed to individual transactions. The collapsed data set summarized the data for each licensee for each year. For example, if a licensee had demonstrated significant non-compliance with Benford's law for a given year that data would be coded "1" for Benford's Law. Similarly, each variable for each licensee in a given year was summarized as noted in Table 9-2.

| Independent Variable | Definition |
|---|---|
| **Benford's Law** | 0 for consistent with Benford's Law, 1 for significant inconsistency |
| **Market Power** | 0 for absence of market power, 1 for significant presence |
| **Weight** | Total weight in kilograms by licensee per year |
| **Price** | Mean price by licensee per year |
| **Value** | Total value per licensee per year |
| **Area** | 33 for Area 33, 34 for Area 34 |
| **Licensee** | License number of each licensee |
| **Buyer** | 0 for no transactions with a licensee, 1 for transactions |

**Table 9-2 Variable Definitions for Licensee Models**

Based on the hypotheses and using a general to specific modelling approach, the following sets of models were developed:

| Model Number | Dependent Variable | Independent Variables |
|---|---|---|
| Transactional Models | | |
| $1_T$ | Sanction | Benford's Law, Market Power, Weight, Price, Value, Area, Licensee, Buyer |
| $2_T$ | Sanction | Benford's Law, Market Power, Weight, Price, Value, Area, Buyer |
| $3_T$ | Sanction | Benford's Law, Market Power, Weight, Price, Value, Area, Licensee |
| $4_T$ | Sanction | Benford's Law, Market Power, Weight, Price, Value, Area |
| Licensee Models | | |
| $5_L$ | Sanction | Benford's Law, Market Power, Weight, Price, Value, Area, Licensee, Buyer |
| $6_L$ | Sanction | Benford's Law, Market Power, Weight, Price, Value, Area, Buyer |
| $7_L$ | Sanction | Benford's Law, Market Power, Weight, Price, Value, Area, Licensee |
| $8_L$ | Sanction | Benford's Law, Market Power, Weight, Price, Value, Area |
| $9_L$ | Sanction | Licensee |
| $10_L$ | Sanction | Buyer |

**Table 9-3 Variables for Inclusion in Transactional and Licensee Models**

## 9.5. Transactional Models Results

In this section I outline the results for each model, address methodological challenges, and finally summarize the significance and goodness of fit measures for each model.

### 9.5.1. Model $1_T$

The full model, Model $1_T$, exceeded the limitations of Stata9 as the creation of the dummy variables for each licence holder exceeded the maximum matrix size of 800. Different approaches were tried to overcome this limitation including running the model for each of LFA33 and LFA34 separately, as well as creating a sub-sample (i.e., "by area: sample 40" and "by area: sample:16"), then running the model for each area separately. Notwithstanding these approaches, the model would not run due to the maximum matrix size limitation.

### 9.5.2. Model $1a_T$

Models $1a_T$ was created by substituting the postal code aggregation for licensees (i.e., from Model $1a_T$) in order to circumvent the limitations of Stata9 encountered with the creation of the dummy variables for each licence holder and buyer thereby exceeding the maximum matrix size of 800. Model $1a_T$ had difficulty in optimization – initial values could not be calculated in logit and an probit model failed to move out of a nonconcave region even with alternate iteration methods and with the "difficult" option selected. Since the transaction model was attempting to predict a rare event (e.g., the incidence was 1.5%) an poisson model was also attempted as poisson is more tolerant of rare events (Zou 2003). This model too would not optimize. Last, an ordinary probit model was attempted. The probit model successfully optimized as noted:

LR chi2(510) = 6580.15

Prob > chi2 = 0

Log likelihood = -18144.2 Pseudo R2 = 0.1535

Again, while the probit model had a respectable area under the ROC curve of 0.8172, the false negative rate of 99.76% was again discouraging.

### 9.5.3. Model $2_T$

Model $2_T$ had difficulty in optimization – initial values could not be calculated in logit and an probit model failed to move out of a nonconcave region even with alternate iteration methods and with the "difficult" option selected. Since the transaction model was attempting to predict a rare event (e.g., the incidence was 1.5%) an poisson model was also attempted as poisson is more tolerant of rare events (Zou 2003). This model too would not optimize. Last, an ordinary probit model was attempted. The probit model successfully optimized as noted:

LR chi2(624) = 6553.1

Prob > chi2 = 0

Log likelihood = -19656.4 Pseudo R2 = 0.1429

Again, while the probit model had a respectable area under the ROC curve of 0.8145, the false negative rate of of 99.07% was discouraging.

### 9.5.4. Model $3_T$

Models $3_T$ exceeded the limitations of Stata9 as the creation of the dummy variables for each licence holder exceeded the maximum matrix size of 800. Different approaches were tried to overcome this limitation including running the model for each of LFA33 and LFA34 separately, as well as creating a sub-sample (i.e., "by area: sample 40" and "by area: sample:16"), then running the model for each area separately. Notwithstanding these approaches, Model $3_T$ would not run due to the maximum matrix size limitation.

### 9.5.5. Model $3a_T$

Model $3a_T$ was then created as an alternative to Model $3_T$:

| | | |
|---|---|---|
| $3a_T$ | Sanction | i.licpostalcode, weight_kg, value, price, mktpower, benford, totalweight, totalvalue |

**Table 9-4 Model $3a_T$ Specification**

Model $3a_T$ had difficulty in optimization – initial values for logit could not be calculated in and a probit model was not significant:

Wald chi2(245) = .
Log likelihood = -20694.4 Prob > chi2 = .

Since the transaction model was attempting to predict a rare event (e.g., the incidence was 1.5%) an poisson model was also attempted as poisson is more tolerant of rare events (Zou 2003). This model too would not optimize. Last, an ordinary probit model was attempted. The probit model successfully optimized as noted:

LR chi2(298) = 4481.53
Prob > chi2 = 0
Log likelihood = -20692.2 Pseudo R2 = 0.0977

While the probit model had a respectable area under the ROC curve of 0.7597, the false negative rate of 99.32% was discouraging.

### 9.5.6. Model $4_T$

Model $4_T$ was then run. Model $4_T$ ran and was within the matrix size limitations. The results for Model 4 are found in Table 9-11. The goodness of fit statistics are summarized in Significance and Goodness of Fit in Table 9-9. Based on the classification table, Model $4_T$ could not correctly classify outcomes:

| | sanction | | |
|---|---|---|---|
| Model$4_T$ | 0 | 1 | Total |
| 0 | 294,204 | 26 | 294,230 |
| 1 | 4,402 | 0 | 4,402 |
| Total | 298,606 | 26 | 298,632 |
| Percent Correct | 98.5% | | |
| Type I | 0.0% | | |
| Type II | 1.5% | | |

**Table 9-5 Classification Table for Model $4_T$**

However, a Hosmer-Lemeshow methodology showed that the model was able to classify outcomes as follows:

| Group | N | Obs | (%) | Exp | (%) | Min % | Max % | HL |
|---|---|---|---|---|---|---|---|---|
| 1 | 29863 | 451 | -1.5 | 59.2 | -0.2 | 0 | 0.2 | 2596.31 |
| 2 | 29861 | 318 | -1.1 | 69.9 | -0.2 | 0.2 | 0.2 | 882.53 |
| 3 | 29858 | 340 | -1.1 | 72.3 | -0.2 | 0.2 | 0.2 | 994.19 |
| 4 | 29861 | 399 | -1.3 | 73.7 | -0.2 | 0.2 | 0.2 | 1440.68 |
| 5 | 29860 | 406 | -1.4 | 75.8 | -0.3 | 0.2 | 0.3 | 1442.03 |
| 6 | 29861 | 492 | -1.6 | 84.9 | -0.3 | 0.3 | 0.3 | 1956.62 |
| 7 | 29861 | 544 | -1.8 | 91.7 | -0.3 | 0.3 | 0.3 | 2238.91 |
| 8 | 29860 | 525 | -1.8 | 101.9 | -0.3 | 0.3 | 0.4 | 1762.82 |
| 9 | 29861 | 443 | -1.5 | 112.6 | -0.4 | 0.4 | 0.4 | 972.96 |
| 10 | 29860 | 484 | -1.6 | 134.9 | -0.5 | 0.4 | 4.5 | 907.48 |
| Total | 298606 | 4402 | -1.5 | 876.9 | -0.3 | 0 | 4.5 | 15194.52 |

**Table 9-6 Hosmer-Lemeshow Classification for Model $4_T$**

The area under the ROC curve was 0.500. Model $4_T$ performed no better than flipping a coin, and this area does not meet the acceptable threshold as discussed in section 9.4.8.

## 9.6. Licensee Models Results

### 9.6.1. Model $5_L$ through $7_L$, $9_L$ and $10_L$

As show in Tables 9-9 and 9-11, Model$5_L$ through 7L, 9L and 10L were not significant. Models $5_L$ through $10_L$ were based on a collapsed data set and were designed to determine if models based on licensees versus transactions would be useful in identifying specific taxpayers or licensees as opposed to individual transactions.

### 9.6.2. Model $8_L$

Model $8_L$ was then run. Model $8_L$ ran and was within the matrix size limitations. The results for Model $8_L$ are found in Tables 9-9 and 9-11. Model $8_L$ had a Log likelihood= -1239.6191 and Prob>chi2=0.0020. Based on a classification table, Model $8_L$ could not correctly classify outcomes:

| | sanction | | |
|---|---|---|---|
| Model $8_L$ | 0 | 1 | Total |
| 0 | 16,022 | 243 | 16,265 |
| 1 | 0 | 0 | 0 |
| Total | 16,022 | 243 | 16,265 |
| Percent Correct | 98.5% | | |
| Type I | 0.0% | | |
| Type II | 1.5% | | |

**Table 9-7 Classification Table for Model $8_L$**

However, a Hosmer-Lemeshow methodology showed that the model was able to classify outcomes as follows:

| Group | N | Obs (%) | Exp (%) | Min % | Max % | HL |
|---|---|---|---|---|---|---|
| 1 | 1627 | 18 (1.1) | 9.1 (0.6) | 0.0 | 0.7 | 8.80 |
| 2 | 1626 | 20 (1.2) | 11.5 (0.7) | 0.7 | 0.8 | 6.27 |
| 3 | 1627 | 17 (1.0) | 12.9 (0.8) | 0.8 | 0.8 | 1.34 |
| 4 | 1626 | 18 (1.1) | 13.7 (0.8) | 0.8 | 0.9 | 1.35 |
| 5 | 1627 | 16 (1.0) | 14.6 (0.9) | 0.9 | 0.9 | 0.14 |
| 6 | 1626 | 29 (1.8) | 15.6 (1.0) | 0.9 | 1.0 | 11.61 |
| 7 | 1627 | 17 (1.0) | 17.2 (1.1) | 1.0 | 1.1 | 0.00 |
| 8 | 1626 | 29 (1.8) | 19.3 (1.2) | 1.1 | 1.3 | 4.99 |
| 9 | 1627 | 38 (2.3) | 21.4 (1.3) | 1.3 | 1.4 | 13.12 |
| 10 | 1626 | 41 (2.5) | 25.9 (1.6) | 1.4 | 11.3 | 8.94 |
| Total | 16265 | 243 (1.5) | 161.0 (1.0) | 0.0 | 11.3 | 56.57 |

**Table 9-8 Hosmer-Lemeshow Classification**

The area under the ROC curve was 0.5833. While better than flipping a coin, this area does not meet the acceptable threshold as discussed in section 9.4.8.

### 9.6.3. Significance and Goodness of Fit

After each model the predicted values were run to calculate the "calculate probability of a positive outcome assuming the random effect is zero" (StataCorp 2005a). This will be used to assess goodness of fit and create classification tables. Next, following the goodness of fit guidance outline in Chapter 5 of Hosmer and Lemeshow (2000) summary and detailed goodness of fit measures were obtained for each model.

Two detailed goodness of fit measures were then calculated. First, Hosmer and Lemeshow (2000) recommend that the receiver operating characteristic (ROC) curve gives a good indication of the accuracy of classification of cases and has its origins in signal theory. The ROC plots the true versus false signals for a variety of cut-offs. The ROC thus determines a model's ability to discriminate cases into sanction versus non-sanction groups. As a rule of thumb, Hosmer and Lemeshow suggest that ROC values of 0.5 or less are equivalent (in a binary outcome model) to flipping a coin. Acceptable ROC values for discriminate are between 0.7 and 0.8, excellent between 0.8 and 0.9 and outstanding over 0.9. Next, classification tables were created by generating comparison variables based on predicted probabilities using a cut-off of p >=.5. Hosmer and Lemeshow caution that classification tables should be used carefully since their classification of cases relies on predicted probabilities and

cases near the cut-off on one side or the other are treated differently. I include the classification tables as a comparison to the other goodness of fit measures. Classification would be of particular interest to tax and fisheries perspective in selecting transactions for further audit or inspection. Hosmer and Lemeshow do not recommend reporting pseudo $R^2$ values for logistic regression due to challenges in their interpretation.

| | **Summary Measures** | | **Detailed Measures** | |
|---|---|---|---|---|
| **Model** | **Significance** **P<0.05** | **Hosmer-Lemeshow** (Hosmer and Lemeshow 2000; Ambler 2011) | **ROC** (Hosmer and Lemeshow 2000; Cleves 2011) | **Classification Tables** (% Correctly Classified:Type I Error: Type II Error) |
| **$1a_T$** | n/a (panel data model) | n/a (panel data model) | n/a (panel data model) | n/a (panel data model) |
| **$2_T$** | n/a (panel data model) | n/a (panel data model) | n/a (panel data model) | n/a (panel data model) |
| **$3a_T$** | n/a (panel data model) | n/a (panel data model) | n/a (panel data model) | n/a (panel data model) |
| **$4_T$** | *Prob>Chi2=0.0000 | chi2(10)= 15194.52 Prob > chi2 = 0 | 0.5000 | n/a |
| **$5_L$** | Prob>Chi2=. | chi2(10) = 9.77 Prob > chi2 = .4612 | 0.5103 | n/a |
| **$6_L$** | Prob>Chi2=1 | chi2(10) = 79.52 Prob > chi2 = 0 | 0.7654 | n/a |
| **$7_L$** | Prob>Chi2=1 | chi2(10) = 116.31 Prob > chi2 = 0 | 0.7293 | n/a |
| **$8_L$** | Prob>Chi2=0.002 | chi2(10) = 56.57 Prob > chi2 = 0 | 0.5833 | n/a |
| **$9_L$** | Prob>Chi2=1 | chi2(10) = 24.77 Prob > chi2 = 0.0058 | 0.7341 | n/a |
| **$10_L$** | Prob>Chi2=1 | chi2(10) = 105.1 Prob > chi2 = 0 | 0.7068 | n/a |

**Table 9-9 Summary of Model Goodness of Fit for Panel Data Models**

Sensitivity is the proportion of sanction outcomes predicted correctly and specificity is the proportion of non-sanction outcomes predicted correctly (Hosmer and Lemeshow 2000). The classifications tables were based on the following format:

| | Observed | |
|---|---|---|
| Predicted | No Sanction | Sanction |
| No Sanction | Correct Prediction | Type II error |
| Sanction | Type I error | Correct Prediction |

**Table 9-10 Classification Table**

(Kennedy 1998)

| Variable | Model $1_T$ | Model $2_T$ | Model $3_T$ | Model $4_T$ | Model $5_L$ | Model $6_L$ | Model $7_L$ | Model $8_L$ | Model $9_L$ | Model $10_L$ |
|---|---|---|---|---|---|---|---|---|---|---|
| Area | | n/a | n/a | 0.086186 | -0.97804 | -0.2956 | -0.44528 | 0.004347 | n/a | n/a |
| | | | | 3.57*** | -4.75*** | -2.8 | -3.98*** | .06 | | |
| Benford | | | | -0.13853 | | | | -0.01557 | | |
| | | | | -6.08*** | | | | -0.22 | | |
| Mktpower | | | | -0.00011 | | | | -0.00036 | | |
| | | | | -2.99** | | | | -2** | | |
| Weight_kg | | | | 9.65E-06 | | -0.00041 | -0.00064 | 2.95E-05 | | |
| | | | | 3.34*** | | -2.01 | -2.84** | 2.2** | | |
| Price | | | | -0.00653 | 0.042927 | | | 0.031837 | | |
| | | | | -2.07** | 2.27** | | | 1.86* | | |
| value | | | | 0.07648** | | 3.28E-05 | 0.000049 | -0.22525 | | |
| | | | | 2.35 | | 2.21 | 3** | -3.09** | | |
| Log likelihood | -20694.4 | n/a | n/a | -12194.8*** | -1020.88 | -1111.8586 | -1127.59 | -1237.2675** | -1154.27 | -1145.08 |
| Marginal Probability | 0.012361 | | | 0.04345 | 0.007016 | .011385 | 0.011804 | 0.014104 | 0.013721 | 0.012445 |
| Joint probability | 0.000276 | | | 0.01367 | 0.000078 | 0.0004 | 0.000464 | 0.000593 | 0.000375 | 0.000496 |
| Odds Ratio | 1.84022 | | | 14.2859 | 1.60522 | 3.24439 | 3.52368 | 3.16125 | 2.04801 | 3.38762 |
| Pearson's r | 0.010053 | | | 0.283488 | 0.004181 | 0.024061 | 0.027822 | 0.028372 | 0.013794 | 0.027738 |
| Yule's Q | 0.29583 | | | 0.86916 | 0.232312 | .52879 | 0.557882 | 0.519375 | 0.343834 | 0.544172 |

**Table 9-11 Significance of Models and Selected Variables for Panel Data Models**

* Significant at 0.10 level, ** significant at 0.05 level, *** significant at 0.001 level

## 9.7. Discussion

It is quite disappointing that all models except Models $4_T$ and $8_L$ as presented have no predictive ability of sanctions within LFA33 and LFA34 in the Atlantic Canadian lobster fishery. Only time will tell if Model $4_T$ or $8_L$ will serve as a useful tool for the Canada Revenue Agency and the Department of Fisheries and Oceans both for the identification of potential cases for audit and investigation. It will also be up to the courts to determine if this is an acceptable tool on which to base audits and investigation. Despite those obvious limitations, I will discuss the statistical considerations, policy implications and future directions.

### 9.7.1. Statistical Considerations

## Causality

As with any study, there is the question of causality. There is a good discussion of causality in Halaby (2004). My first concern is not with causality – it is the identification of relationships between data currently available to the Government of Canada and its usefulness in predicting illegal behaviour (as measured by sanctions) in the Atlantic Canadian lobster fishery. To that end, I believe that this study has demonstrated what I set out to do.

Halaby (2004) indicates that unobserved variables can interfere with causality in one of two ways. First, there can be unit effects or time-invariant unobserved variables. Second, there can be disturbances that have a temporary, time dependent influence on the dependent variable. I will discuss examples of these momentarily.

Antonakis, Bendahan, Jacquart and Lalive(2010) also reviewed causality and making causal claims. In that review Antonakis et al. argued that the primary threat to causal claims was endogeneity or omission of potential causes from a model. This view is also consistent with Halaby. Antonakis et al then defined causality as:

i) x must precede y temporally

ii) x must be reliably correlated with y (beyond chance)

iii) the relation between x and y must not explained by other causes (p. 1087)

In the current study, I could argue that the independent variable precedes sanction and that some of the independent variables are significantly associated with the dependent variables. Nevertheless, I cannot confirm that there are no other viable causes. For example, disturbances that have not been included in the model include policy changes, court decisions, or increases/decreases in federal, provincial or municipal tax rates. Modelling such disturbances would be an interesting extension from the policy perspective to determine the actual or potential impacts of a policy change. Other disturbances that have not been included are changes in licence holder (e.g., retirements, licence transfer) or other forms of attrition (e.g., moves from one postal code to another). An example of a unit or time-invariant effect that was not included in the model is gender.

Notwithstanding causality, I am satisfied that this model helps identify the conditions under which sanctions may be more likely to occur. As Hsaio (2003 p. 8) stated "It is neither feasible nor desirable to include all the factors affecting the outcome of all individuals in model specification, since the purpose of modeling is not to mimic the reality but is to capture the essential forces affecting the outcome."

## Benefits and Limitations of Panel Data

### *Fixed Effects versus Random Effects*

Prior to running a random effects model, a fixed effects model is normally run (Baltagi 2005). The point of running a fixed effects and a random effects model is to statistically substantiate the decision to prefer one or the other via the Hausman test. This test was applied to Model 4 using logit and fixed and random effects models and resulted in a prob>Chi2 of 0.7130. All further tests were calculated using random effects.

## Measurement Errors

Baltagi (2005) outlines some considerations for the validity of panel data models, including measurement errors, attrition, and specification issues. With respect to measurement errors, the data provided on landings is believed to be accurate. Nevertheless there is the possibility that errors in the data are introduced in the recording of the catch, or the transcription of those numbers into the system. As seen in the Snowcrab fishery in Chapter 7, the use of observers is not a guarantee of the accuracy or validity of the numbers. Measurement errors are also minimized since the sanctions measure has been based on a due process. If there were indeed measurement errors in the cases that lead to sanctions,

there was the opportunity to correct this via the judicial process. The current study did not correct or measure attrition from the sample. Attrition is difficult to measure as licence holders can transfer their licences to others – there is the appearance of continuity, but in essence the behaviour of the licence holders may vary. Licence holders may also move within or between LFAs. The impact of movement may be negligible in postal codes with a high dollar value of landings and a larger number of licensees. The impact may be larger in the inverse scenario. Again, this movement was not corrected. Future studies may wish to add an attrition measure for both changes in licence holders and movement. Last, there may be errors in the specification of the model. Nevertheless, the available data and hypotheses were leveraged to the extent possible. The search for latent variables and other data must also continue.

Another source of measurement error is the inclusion of the Benford's Law and market power indicator variables. As these are calculated variables, this introduces a potential source of measurement error. As discussed in the Study 1 and 2, a conservative approach was used in setting the significance level to minimize error.

Turning to threats to validity I consider the questions raised by Antonakis, Benahan, Jacquart et al (2010). First, for omitted variables, it is quite likely that there are variables that may help to more precisely identify the circumstances under which sanctions will or will not be likely. Notwithstanding that, there is the question of their availability. All relevant available data from the data set was used to try to model the conditions in the Atlantic Canadian lobster fishery. Second, in terms of fixed effects, the data set was examined for relevant fixed effects models to statistically justify the use of random effects models (e.g., Hausman test). The Hausman test was not significant as previously noted.. This was taken as sufficient justification to run random effects models. Third, for omitted selection, the group of interest (lobster fishery) was compared to the Snowcrab and grey zone fisheries in Study 1 and Study 2. The models in Study 3 could be expanded to include comparisons between different fisheries (e.g., snowcrab and the grey zone). This could be undertaken in future research. Fourth, the phenomenon of simultaneity where the causal relationship is actually the inverse from what is hypothesized (dependent variable potentially causes an independent variable). It is possible that Structure Equation Modelling may be able to use sanctions as an independent variable, amongst others, that potentially predicts the latent variable of the underground economy. Last there is the potential of misspecification in the models in Study 3. However, by following the Hosmer-Lemeshow (Hosmer

and Lemeshow 2000) methodology and accepted practices for setting up the random effects logistic panel data regression, the opportunity for misspecification is minimized to the extent possible.

The 14 threats to validity.

| Validity threat | Explanation |
|---|---|
| 1. Omitted variables | (a) Omitting a regressor, that is, failing to include important control variables when testing the predictive validity of dispositional or behavioral variables (e.g., testing predictive validity of "emotional intelligence" without including IQ or personality; not controlling for competing leadership styles) |
| | (b) Omitting fixed effects |
| | (c) Using random-effects without statistical justification (i.e., Hausman test) |
| | (d) In all other cases, independent variables not exogenous (if it is not clear what the controls should be) |
| 2. Omitted selection | (a) Comparing a treatment group to other non-equivalent groups (i.e., where the treatment group is not the same as the other groups) |
| | (b) Comparing entities that are grouped nominally where selection to group is endogenous (e.g., comparing men and women leaders on leadership effectiveness where the selection process to leadership is not equivalent) |
| | (c) Sample (participants or survey responses) suffers from self-selection or is non-representative |
| 3. Simultaneity | (a) Reverse causality (i.e., an independent variable is potential caused by the dependent variable) |
| 4. Measurement error | (a) Including imperfectly measured variables as independent variables and not modelling measurement error |
| 5. Common-method variance | (a) Independent and dependent variables are gathered from the same rating source |
| 6. Inconsistent inference | (a) Using normal standard errors without examining for heteroscedasticity |
| | (b) Not using cluster-robust standard errors in panel data (i.e., multilevel hierarchical or longitudinal) |
| 7. Model misspecification | (a) Not correlating disturbances of potentially endogenous regressors in mediation models (and not testing for endogeneity using a Hausman test or augmented regression), |
| | (b) Using a full information estimator (e.g., maximum likelihood, three-stage least squares) without comparing estimates to a limited information estimator (e.g., two stage-least squares). |

**Figure 8-1 The 14 Threats to Validity**

(Antonakis, Bendahan, Jacquart et al. 2010 p. 1091)

### 9.7.2. Model $1_T$

Despite the limitations of the version of Stata9 used and given the lack of results of Model $1_T$, the Department of Fisheries and Oceans and the Canada Revenue Agency would be advised to run Model $1_T$ using the full version of Stata plus the predicted probabilities. While the model did not run, it underscored the importance of exploring alternative methods to potentially the same result.

### 9.7.3. Model $2_T$

A panel data Model $2_T$ did not optimize and should be run in the full version of Stata to determine if it could run.

### 9.7.4. Model $3_T$

Despite the limitations of the version of Stata9 used and given the lack of results of Model $3_T$, the Department of Fisheries and Oceans and the Canada Revenue Agency would be advised to run Model $3_T$ using the full version of Stata plus the predicted probabilities and a tool that is sensitive to modelling rare events. While the model did not run, it underscored the importance of exploring alternative methods to potentially the same result.

### 9.7.5. Models $5_L$ through $7_L$, $9_L$ and $10_L$

As show in Table 9-9 Summary of Model Goodness of Fit, Models $5_L$ through $7_L$, $9_L$ and $10_L$ were either not significant or did not have satisfactory predictive ability. Details on the significant variables and goodness of fit measures for these models can be found in Tables 9-9 and 9-11. Models $5_L$ through $10_L$ were based on a collapsed data set and were designed to determine if models based on licensees versus transactions would be useful in identifying specific taxpayers or licensees as opposed to individual transactions.

With a relatively small number of buyers that have transactions linked to licencees with sanctions, this provides a realistic starting point for auditors and fisheries officers for more indepth analysis. For example, fisheries officers have two types of powers – investigative and inspection. With inspection, the model could help to narrow down inspections to transactions that were more likely to be linked to illegal or underreported landings. If during the inspections evidence of illegal activity was discovered, an investigation could then be commenced.

As mentioned in the Benford's Law study, the fisheries policy implications have an interesting dichotomy. I have shown that there are indications of non-conformity with Benford's Law. As with tax policy, this does not mean that there is certainty of fraud or human manipulation (Durtschi, Hillison and Pacini 2004; Geyer and Williamson 2004). Thus an enforcement action based solely on non-conformance with Benford's Law would be risky and open the Government to challenges about the rationale for enforcement. As part of an enforcement strategy, a fisheries officer would need to have additional information, tools, and techniques to select fishermen for investigation. For fisheries policy, the dichotomy comes from deciding whether a government or non-government response may be more appropriate. For example, a government response would imply that regulations or policies should be changed in an effort to modify the illegal, unreported or unregulated behaviour of the lobster and

snowcrab fishermen. Given the longstanding history of non-compliance in the lobster fishery including the illegal trading or transfer of licenses, subsequent tax implications, and the illegal use of licenses as collateral (Bodiguel 2002), a government-based policy approach may not be practical or effective. Nevertheless, Model 2a builds on the Benford's Law data by including the relationship between licensees and buyers, as well as characteristics of the catch (weight, price, total value) that provides a more fulsome picture of the contributions towards sanctions versus non-sanction results.

There are also other enforcement options that are less severe than sanctions – violations. The predictive ability of the model should be explored to see if there is any transferability of the model to the prediction of violations.

To further understand the lack of predictive ability using sanctions as a dependent variable, a factor analysis was completed for both transactional and licensee data.

Factor analysis/correlation Number of obs = 298606

Method: principal-component factors Retained factors = 3

Rotation: orthogonal varimax (Horst off) Number of params = 18

LR test: independent vs. saturated: chi2(21) = 1.1e+06 Prob>chi2 = 0.0000

| Factor | Variance | Difference | Proportion | Cumulative |
|---|---|---|---|---|
| Factor1 | 2.01395 | 0.46657 | 0.2877 | 0.2877 |
| Factor2 | 1.54737 | 0.53205 | 0.2211 | 0.5088 |
| Factor3 | 1.01533 | . | 0.1450 | 0.6538 |

**Table 9-12 Factors for Transactional Models**

| **Variable** | **Factor1** | **Factor2** | **Factor3** | **Uniqueness** |
|---|---|---|---|---|
| NewSanc | 0.0092 | -0.0459 | 0.7166 | 0.4843 |
| benford | -0.0185 | 0.0425 | 0.7080 | 0.4965 |
| mktpower | 0.0723 | 0.7818 | -0.0061 | 0.3836 |
| weight_kg | 0.9936 | 0.0167 | -0.0035 | 0.0125 |
| value | 0.9880 | 0.0483 | -0.0022 | 0.0215 |
| price | -0.1394 | 0.6479 | 0.0189 | 0.5604 |
| area | 0.1595 | 0.7141 | -0.0118 | 0.4645 |

**Table 9-13 Variables and Factors for Transactional Models**

From the factors retained for the transactional models, the hypothesized independent variables of market power, price and area were more related to Factor 2 while sanctions and the Benford's Law indicator variable were linked to Factor 3. Weight and value were linked to Factor 1. This might explain why the transactional models were not able to optimize as the majority of the independent variables had little relationship with the dependent variable.

For the licensee models, there were 3 retained factors:

Factor analysis/correlation Number of obs = 16265

Method: principal-component factors Retained factors = 3

Rotation: orthogonal varimax (Horst off) Number of params = 18

| Factor | Variance | Difference | Proportion | Cumulative |
|---|---|---|---|---|
| Factor1 | 2.18991 | 0.46868 | 0.3128 | 0.3128 |
| Factor2 | 1.72123 | 0.71919 | 0.2459 | 0.5587 |
| Factor3 | 1.00205 | | 0.1431 | 0.7019 |

**Table 9-14 Factors for Licencee Models**

LR test: independent vs. saturated: chi2(21) = 7.8e+04 Prob>chi2 = 0.0000

| Variable | Factor1 | Factor2 | Factor3 | Uniqueness |
|---|---|---|---|---|
| NewSanc | -0.0038 | 0.0200 | 0.9761* | 0.0469 |
| area | 0.4876* | 0.5340* | -0.0652 | 0.4728 |
| benford | -0.0695 | 0.1526 | -0.2091 | 0.9282 |
| mktpower | 0.1463 | 0.8327* | 0.0103 | 0.2851 |
| weight_kg | 0.9837 * | 0.0727 | -0.0012 | 0.0270 |
| value | 0.9772 * | 0.1068 | 0.0031 | 0.0337 |
| price | 0.0570 | 0.8380* | 0.0356 | 0.2932 |

**Table 9-15 Variables and Facotrs for Licensee Models**

From the factors retained for the transactional models, the hypothesized independent variables of area Benford's Law, market power, and price were more related to Factor 2 while sanctions were positively linked to Factor 3 while the Benford's Law indicator variable was negatively linked to Factor 3. Weight and value were linked to Factor 1 as were area and market power to a lesser extent. . This might explain why the licensee models were generally not significant as the majority of the independent variables had little relationship with the dependent variable. This also introduces the

possibility that sanctions are resulting from factors other than the underground economy. Factor2 for licensee models includes my primary variables of interest (Benford, market power, area and price) and suggests that there is a latent variable of potential interest to the Canada Revenue Agency and the Department of Fisheries and Oceans. Audits of licensees in the top percentiles of this factor (e.g., $95^{th}$ or $99^{th}$ percentiles) could confirm if this was indeed the case. Detailed characteristics of these licensees may yield other variables of interest that could more reliably predict group membership within Factor2.

## 9.8. Summary

The outcome of the model building process were two models (Model $4_T$ and $8_L$) that was significant, but from a classification perspective was not able to classify licence holders into those that were had sanctions versus those that did not. However, a Hosmer Lemeshow test was significant.

While a licensee model would have been ideal for selecting licensees for further audit, a transactional model such as Model 1a or Model 2 might have been useful for spot-checking transactions. This also shows that there is an ongoing requirement for specification of additional variables in order to increase the value of the model. Alternatively, there is also the requirement to try, for example, latent variable structural equation models.

Factor analysis demonstrated that the dependent variable "sanctions" was associated with Benford's Law for transactional models and not associated with other variables for licensee models (LFA and Benford's Law were negatively associated meaning that in the licensee model a higher score on LFA such as LFA34 versus LFA33 and Benford's Law the lower the score on sanctions). This suggested that there is a latent variable of potential interest to the Canada Revenue Agency and the Department of Fisheries and Oceans. Audits of licensees in the top percentiles of Factor 2 for licensees (e.g., $95^{th}$ or $99^{th}$ percentiles) could confirm if this was indeed the case. Detailed characteristics of these licensees may yield other variables of interest that could more reliably predict group membership within Factor2. This analysis suggests a new direction for research on how to best classify and discriminate between underground and non-underground economy events in the lobster fishery. This finding also suggests that the application of sanctions is not overtly linked to the variables such as Benford's Law and market power that were hypothesized to be linked to the underground economy.

# 10. Conclusion

## 10.1. Introduction

As discussed in the Contribution Chapter, the need for research in the lobster fishery was demonstrated by news reports in December 2006 that reported that "Fishermen sometimes try to hide their total catch when they exceed their quotas…occasionally working in collusion with processing companies" (Beeby 2006). To better understand how statistical fraud detection may be used to identify which fishermen are trying to hide their true total catch, extends statistical fraud detection techniques to the lobster fishery. This research will aid the Canadian Government in developing methodologies to detect tax and fisheries management issues in this industry. Academia will also benefit from the extension of these techniques to an industry that has previously not been researched from this perspective. This research will further determine the characteristics of the underground economy in the Atlantic Canadian Lobster fishery and those that participate in this economy, and will help develop a statistical model that will provide assurance regarding the reliability of catch data.

I had also underscored that it is essential that organizations such as the Canada Revenue Agency and the Department of Fisheries and Oceans have a sound understanding of the issues and challenges they face to enable the development of appropriate strategies and methodologies to deal with the underground economy in the lobster fishery. The challenges will have both governmental policy solutions as well as non-governmental options.

Academia, tax administrations (e.g., Canada Revenue Agency or CRA), and non-governmental organizations (e.g., International Monetary Fund, OECD) alike remain interested in modelling and combating the underground economy. The literature has examined factors underlying tax compliance, including ethics (Kaplan and Henderson, 2002), culture (Cummings, Martinez-Vazquez, & MacKee, March 2001), risk aversion (Giles & Johnson, 1999), economic factors (Ritsema, Thomas & Ferrier, June 2003) and tax policy (Hill & Kabir, 1996).

Until this research what appeared to be lacking for the lobster fishery was a model that took available data, linked it to factors underlying compliance and used changes in these factors to help predict where the underground economy may exist. If tax or fisheries administrations were used the

resulting model, it would enable them to takes steps proactively through various means (e.g., policy changes, compliance activities, communication) to ensure that the fishery and the tax base is protected.

I will summarize the main findings of each of the three studies undertaken and highlight the main conclusions from those studies. Next I will discuss the implications policy directions, and general conclusions. Last, I will discuss the limitations of this research and recommend future directions.

## 10.2. Summary and Theoretical Conclusions

### 10.2.1. Benford's Law

Recall from Study 1 that I expected that the data would conform to Benford's Law, and that the observed fisheries (snow crab and grey zone) have greater conformity than non-observed fisheries. The weight and price information was expected to conform to Benford's Law as it conformed to the previously noted constraints (Busta & Weinberg 1998; Durtschi et al. 2004) and is consistent with previous applications (e.g., Nigrini 1996). I expected to see indications of non-conformity with Benford's Law in both LFA33 and 34.

Overall, a conservative approach was used for determining significance. Specifically, all tests were completed using a 99% confidence level for the family-wise error rate. The strongest conformity with the Benford distribution was in the observed fisheries and the weakest in the non-observed fisheries, LFA 33 and LFA 34. Importantly, the time period available for the grey zone was 2002-06 compared with 1997-2006 for snow crab, LFA 33 and LFA 34, and there are large differences in the size of the populations (i.e., the grey zone may not have the population size required for a Benford's Law analysis). There is no clear line of demarcation in the literature as to what constitutes a population.

On a first two digits basis, the results show a large degree of conformity to Benford's Law in the grey zone, and non-conformity in the snow crab fishery, LFA 33 and LFA 34.

Overall, the grey zone, as a highly regulated and observed fishery, showed no indication of non-conformity with Benford's Law. It was expected that the snow crab fishery results would be close to the grey zone results, but the snow crab fishery, an observed fishery, showed indications of non-conformity. LFA 33 and LFA 34 also showed signs of non-conformity. While Benford's Law cannot uncover specific cases of non-conformity, it does show that further study and development of techniques to better determine the level of underreporting/manipulation is required. The non-

conformity in the snow crab fishery was unexpected. Although there is a possibility of a Type I error, the use of a conservative chi-square and z-test, in addition to a conservative confidence level of 99% with a family-wise error rate reduces the probability of a Type I error to 0.01 (Sheskin 2004). More likely is that the participants of the snowcrab fishery have devised a way to circumvent the observers. The form of regulation or the presence of observers does not guarantee the reliability of the reported numbers.

However, an analysis using Benford's Law alone does not provide a model, characteristics of, or definitively indicate fraud. Although care has been taken to ensure that a conservative estimate of the conformity with Benford's Law has been performed, there is still arbitrariness to the significance levels chosen in this study. In addition, the lack of significant results in a given fishery does not necessarily mean that there is no fraud or manipulation. For example, if entire catches are not reported, Benford's Law would not be able to identify that there were missing data. Nevertheless, conservative significance levels plus consideration of family-wise error rates result in a fair indication of whether or not there is conformity with Benford's Law.

The study of Benford's Law in the lobster fishery has shown that:

1. The statistical methods used in previous research were not robust enough;
2. Non-conformity with Benford's Law was observed in both the lobster fishery in LFA33 and LFA34 plus the snowcrab fishery.
3. Benford's Law alone should not be used as an effective tool for isolating specific fishermen for audit or investigation. Specifically, non-conformance with Benford's Law does not mean that there is certainty of fraud or human manipulation (Durtschi, Hillison and Pacini 2004; Geyer and Williamson 2004). the constraints for Benford's Law included (e.g., (Busta and Weinberg 1998; Durtschi, Hillison and Pacini 2004)) a constraint that the population is tested as opposed to a sample.
4. Non-government options such as eco-labeling regimes may be an alternative to direct government policy interventions.

Benford's Law conformity could be used as one of suite of indicators variables. From this conclusion, I believed that further variables were required for inclusion in a model that may help to predict non-compliance in the lobster fishery. For example, I believed that a measure of the presence or absence of collusion in the lobster fishery may have merit as a variable for further study. First, news reports in

December 2006 reported that "Fishermen sometimes try to hide their total catch when they exceed their quotas…occasionally working in collusion with processing companies" (Beeby 2006). Next, Cowell (1990) argues that one effect of the presence of the underground economy is the creation of market power. This thought formed the basis of Study 2 where I examined whether or not there are indications of market power or collusion in the lobster fishery.

### 10.2.2. Market Power

The second study adapted an Abrantes-Metz et al. (2006) alternative screening method for collusion. The method was originally used by Abrantes-Metz et al to try and identify if groups of retail gasoline stations in and around Louisville Kentucky were colluding on prices. While no collusion was found, they reported that price variations were driven more by the proximity to major streets and brand. The technique computed the mean, standard deviation, and the coefficient of variation. Various methods were used to identify outliers (e.g., scatter plots, and histograms overlaid with cut-off points) that would suggest collusion. Collusion would be identified by a combination of higher than mean price, lower than mean standard deviation, and a lower than mean of the coefficient of variation.

A chi square goodness of fit test was completed on the overall market power indicator variable for the lobster fishers in the sample. Using a chi-square goodness of fit test the lobster fishery varied significantly from the expected distribution. The expected distribution was in the proportion of .875 (no market power) and .125 (market power) if the market power indicator variable was based on probability alone.

A total of 475 unique postal codes having at least one lobster licensee are in LFA 33 and 34. Individual chi-square tests were completed for postal codes for each of LFA33 and 34 where the expected frequency of market power was greater than 5 (Sheskin 2004). This resulted in 12 comparisons, and a Bonferroni adjustment was made to maintain the family-wise error rate at 0.05. Eleven of the twelve subsequent comparisons were statistically significant.

Over time, four communities in LFA33 and six communities in LFA34 showed consistent indications of market power. This resulted in 91 comparisons, and a Bonferonni adjustment was made (i.e., .10/91 = 0.001099, a critical value of 10.84 was used, resulting in a family-wise error rate of .10). Table 3 shows 88 of the 91 comparisons were significant. Indications of market power were consistent over time, regardless of the fluctuations in price.

Of the 624 brokers, 124 had an indicator variable indicating market power. Of the 124 with a market power indicator variable, 70 had sales from communities that also showed the potential for market power (see Table 5). On average, sales from communities with the potential for market power accounted for 5.7% and 2.6% of sales from the identified communities and from LFA 33/34 respectively.

Businesses that engage in fraud and collusion behaviour clearly breach the ethical behaviour required by government reporting rules such as tax law and, in this case, honest fishing return data. This case study provides the first empirical test of market power screening in a commercial fishery with large implications for government revenue and policy, especially if my results, replicate to other fisheries in Canada and around the world.

For the postal codes evaluated, the approximate dollar values in landings represented for the entire 1997 – 2006 time period were $2.46 billion for LFA 33 and 34. Quantitative support for community-based differences in compliance with fisheries regulations has been demonstrated, and extends the qualitative finding in Arai (1994) and McMullan et al. (2002) that some communities are more prone to compliance issues than others. In a traditional sense, this does not demonstrate collusion (Frass and Greer 1977). Rather, this research suggests that there exist smaller, geographically constrained pockets where market power is evident. While there may be further indications of market power in postal codes that might be uncovered from the use of the binomial sign test as noted above, the payoff with tasking fisheries and tax resources to further examine fisheries activity in postal codes evaluated in the current study is potentially large. In other words, the policy direction for the government would be to focus enforcement efforts on areas with the largest potential payoff.

The direct cause of the market power cannot be determined by the methodology in this study. Obvious candidates are the licensees or the licensees in collaboration with the brokers, or the brokers overlooking the activities of the licensees, as once the lobster are in the processing plants, the more exports and profits for both brokers and licensees (McMullan and Perrier 2002).

A market power indicator variable for each lobster fisherman was created for inclusion in Study 3.

### 10.2.3. Model 4T and Model 8L

Study 3 focused on building a panel data model that would potential help to identify the characteristics that contribute to illegal and underreported fishing in LFA33 and LFA34. Model 4 succeeded in moderate ability to identify licencees that ought to be followed up for indications of illegal and underreported fishing.

## 10.3. Implications, Policy Directions and General

### 10.3.1. Policy Implications

This study alone provides an indication of the level of human manipulation, whether intentional or unintentional, on a specific data set. This knowledge could be applied in corporate social responsibility, ecolabelling, tax and fisheries contexts. I will explore each of these policy implications in turn, and then lead into the next chapter.

### 10.3.2. Tax and Fisheries Policy

In this section I will outline some of the policy implications for the Government of Canada from the tax and fisheries policy perspectives.

## Tax Policy

The tax policy implications start with a summary of what I have learned from the first study on statistical fraud detection in the lobster fishery. First, the grey zone, as a highly regulated and observed fishery, showed no indication of non-conformity with Benford's Law. Next, it was expected that the snow crab fishery results would be close to the grey zone results, but the snow crab fishery, an observed fishery, showed indications of non-conformity. Last, LFA 33 and LFA 34 also showed signs of non-conformity. While Benford's Law cannot uncover specific cases of non-conformity, it does show that further study and development of techniques to better determine the level of underreporting/ manipulation is required. From this, the Canada Revenue Agency could use a risk-based approach to further audit both snowcrab and lobster fishermen. For example, chi-squared scores for individual licence holders could be compared with the expected distribution for the year under review. However, recall that the constraints for Benford's Law included (e.g., (Busta and Weinberg 1998; Durtschi,

Hillison and Pacini 2004)) a constraint that the population is tested as opposed to a sample. Further note that non-conformance with Benford's Law does not mean that there is certainty of fraud or human manipulation (Durtschi, Hillison and Pacini 2004; Geyer and Williamson 2004). Thus an audit selection tool based solely on non-conformance with Benford's Law would be in itself risky and open the Government to challenges about the rationale for audit selection. As part of an audit selection strategy, an auditor would need to have additional information, tools, and techniques to select fishermen for audit. Additional tax policy considerations to reduce the incentives to maximize income might encourage corporate social responsibility responses of family firms more typical to that found by Chen, Chen et al. (2010).

An audit selection tool based on Model 4 provides a more holistic view of the taxpayer. Subject to the limitations described below, this tool should be used in conjunction with other resources (e.g., compliance history) until the judicial system validates the use of the model in this manner.

Tax systems (Asher 2001) need to be designed to "minimize the opportunities for corruption". Most tax systems incorporate similar strategies such as audits, information and education, and withholding at source and information. Some strategies such as auditing are imperfect (Jellal 2010). It stands to reason that strategies that help to target scarce audit resources will help to improve tax systems and audits.

Notwithstanding the potential dollar amounts involved in the underground economy in the lobsters fishery, it remains a very narrow issue. Broad changes in the tax policy realm (e.g., tax simplification (James and Wallschutzky 1997) while philosophically interesting would do little to bring about real and substantial change in the lobster fishery. The lobster fishery is also a highly regulated industry (see Chapter 3). Layering additional policies or changing existing policies would not likely be viewed favourably by the industry and bureaucracy alike without extensive consultation and modelling of the potential impacts. Further complicating the policy environment is the political aspects of the industry (e.g., the fishing industry is the only self-employed group to be eligible for employment insurance).

As Spiro (2005 p. 180 ) states "whenever there are taxes, there will be evasion. Tax policy cannot be concerned solely or even primarily with minimizing evasion…the underground economy needs to be taken into account in predicting the impact of tax changes". Thus as tax policy (and unemployment policy) changes, the Canada Revenue Agency and the Department of Fisheries and

Oceans need to model these changes and the potential impact on this and other fisheries and undertake a program of economic surveillance. While the United States has found the TCMP to be expensive and unpopular, the TCMP has encouraged research on the American tax regime. Consideration ought to be given to releasing a "sanitized" data set that would not have identifiable data to encourage research and attempt to better model the issues facing the Canadian tax regime.

Other tools that would provide the information for decision making such as the model developed in Study 3 would be either withholding at source or information returns. The landing information collected by the Department of Fisheries and Oceans contains a wealth of information that could be used to assist the Canada Revenue Agency in their enforcement efforts. Care must be exercised on the sharing of information for several reasons. First, the legislative framework must be changed to allow for such a use and exchange of information. Second, the privacy expectations guaranteed under Canadian law must allow for such use. So long as the licensees are advised that the information will be used for enforcement of both the Fisheries and Income Tax Acts, such a use is possible. Third, by imposing an additional control on the licensees, there is a real risk that some may move completely into the underground economy as opposed to their current level of partial compliance. Last, observer reports and information returns are not infallible (e.g., (R. v. Labrador Fisheries Union Shrimp Co. Ltd. 2007)). In R. v. Labrador the observers were sent home early to allow transactions to go unreported. Also in Study 1 there was evidence of non-conformance with Benford's Law in the observed snow crab fishery which suggests that observed fisheries are not infallible. The cost of hiring the observers is borne by the industry which can be a disincentive for the industry to endorse such an option.

While the lobster fishery has demonstrated through qualitative studies (e.g., (Arai 1994; Bodiguel 2002; McMullan and Perrier 2002)) and through my current quantitative research that there is non-compliance with tax and fisheries policy, I do not believe that a simple change in policy will be sufficient (James and Edwards 2008). Further, the issue of non-compliance in the lobster fishery is beyond an economic, sociological, or psychological issue. As demonstrated through the literature review, there are many intertwined elements that weave the fabric called the underground economy. The approach required to address the findings of my research will necessarily be multifaceted. Addressing the challenges associated with self-employment income by ensuring that the Canada

Revenue Agency has the information that they require to model the transactions, licensees and buyers of interest is but the first step.

The framework elaborated by James and Edwards (2008 p. 47 ) to guide the development of tax policy in a complex environment has ten elements:

1. Identify the aims of taxation
2. Establish different methods of achieving the aims
3. Analyse in terms of economic criteria
4. Specify the administrative constraints
5. Identify different risks
6. Analyse behaviour
7. Consider the relationship between different policies
8. Develop strategies
9. Plan and implement strategies including intended outcomes
10. Monitor and evaluate the performance of the strategy against the plan.

While some of the steps are beyond the scope of this dissertation (e.g., identifying the aims of taxation, and developing, planning/implementing and monitoring strategies), the remaining steps can be used to guide the generation of some policy options for consideration by the Government of Canada.

For example, in identifying different methods of achieving the aims of taxation (e.g., raising revenue), the Government of Canada can increase the targeted audits and inspections (both in a fisheries and tax context) thereby increasing the probability of detection. Further, the Government of Canada could implement an information sharing arrangement between the Department of Fisheries and Oceans or implement an information return for use by the Canada Revenue Agency. Next, targeting communications to the extent possible (e.g., such as that used by (Hasseldine, Hite, James et al. 2007) to those involved in higher risk fisheries such as lobster and snowcrab is another option. Last, non-governmental approaches such as ecolabelling and traceability initiatives (see sections 11.4.5 and 11.4.6) that are driven by increasing consumer demand and consumer environmental awareness may provide non-policy options for addressing the underground economy in the lobster fishery. Altering the tax rate specifically for the lobster fishery, as indicated by James and Edwards, may be unfair and inefficient in addition to possibly being perceived as an unfair subsidy by various trading partners.

James and Edwards (2008 p. 47) suggest analysing the options in terms of economic criteria using "efficiency, incentives, equity, incidence and macroeconomic considerations" and in particular by using the evaluations set out in Chapters 3, 4, 5 and 6 of James and Nobes (James and Nobes 1996). From the efficiency perspective, there is an administrative cost of efforts by the Canada Revenue Agency to prevent evasion. By targeting their enforcement efforts in the lobster fishery by using the model set out in Study 3, administration efforts may become more efficient. Next information returns (e.g., (Andreoni, Erard and Feinstein 1998; Canada Revenue Agency 2011a) can improve the observability of transactions in the informal sector (Jellal 2010). As I had discussed earlier, some studies (Andreoni, Erard and Feinstein 1998) explored the effects of penalties and the probabilities. In general higher penalties discouraged tax evasion. Tax authorities could minimize the risk of noncompliance by undertaking matching programs (i.e., matching information returns with individual tax declarations). A key outcome of this research is that the information used to develop this model is not readily available to the Canada Revenue Agency for analysis. The Canada Revenue Agency is therefore missing out on key information with which to better target their audit resources. The information is available to the Department of Fisheries and Oceans but similarly has not been used to better target their inquiries. Consideration needs to be given to either share information between the Department of Fisheries and Oceans and the Canada Revenue Agency or to implement an information return that would detail transactional information that could be used to further develop the model developed here. There is precedent for using transactional information returns in the Canadian construction industry (Canada Revenue Agency 2011a). The information returns for the construction industry were introduced in an attempt to reduce evasion in that industry. However, there are no published data on the effectiveness of those information returns on reducing evasion in the Canadian construction industry.

Sharing of information between the two Government of Canada organizations is not a simple feat. Under Canadian privacy law (Privacy Act 1985), personal information can only be collected for the purposes of administering the laws and regulations of the department collecting the information and for a specific purpose. Since the licensees and buyers are specifically identified in the transactional information collected by the Department of Fisheries and Oceans, the data is considered to be "personal" information. This means that the Department of Fisheries and Oceans cannot share the information with the Canada Revenue Agency. Thus such an information sharing arrangement would

need to be formalized under law. Recall, too, that compliance costs such as completing information returns can increase levels of evasion (Cowell 1992). Thus any effort to implement an information return should attempt to leverage or share the current information reported to the Department of Fisheries and Oceans and attempt to minimize the introductory and compliance costs associated with such changes (James and Nobes 1996).

The self-assessment model of taxation that is in effect in Canada , other Commonwealth countries and the United States has particular challenges (James and Alley 2002). While most taxpayers will pay their tax obligations, the issue becomes "how to ensure compliance" for those taxpayers who do not. James and Alley outlined the two principal models of evasion – economic and behavioural. The two approaches have their place in the pursuit of compliance. The economic approach is suited to intentional evasion. The behavioural approach is better suited to a broader interpretation of compliance. The success of the self-assessment model is contingent upon cooperation between taxpayers and the tax authorities. Audit selection rules are also important in that if there is a strategic selection of files to be audited, those audits are generally better at detecting issues than random audits (Alm, Cronshaw and McKee 2007). No matter the accuracy of the strategic selection of audits, there will be errors (James and Alley 2002) analogous to Type I and Type II errors. As seen with the classification tables in Study 3, if the model was used to strategically select transactions for further audit, some would be correctly classified, and some would not. However, with time, additional variables and fine tuning of the model, the accuracy would be improved. Some caution would need to be exercised vis-à-vis the type of powers exercised by the Canada Revenue Agency and the Department of Fisheries and Oceans as a consequence of using these models to strategically select transactions. I will discuss this further under the Legal Aspects subsection of Policy Implications.

The Canadian courts have affirmed that the Government can use non-random audit selection criteria. For example (Cole v. The Queen 1999) the courts have stated that:

"In the enforcement or policing of legislation it has always been accepted that investigations relating to such enforcement may be conducted on a sample basis, on the basis of informations laid or according to any other objective test relating to the enforcement of the legislation and does not have to be done on a universal basis. It does not seem possible or logical to proceed in any other way. The fact that an investigation is conducted on the above bases is essential to ensure full compliance with the law and not an arbitrary or discriminatory exercise of administrative power. This is not unequal treatment

of individuals in that all persons are subject to the possibility of investigation and that these investigations are conducted on the basis of objective criteria and for objective reasons, impartially and without favour." Still other court decisions reinforce the Canada Revenue Agency's broad powers (R. v. Mckinlay transport ltd. 1999):

> Accordingly, the Minister of National Revenue must be given broad powers in supervising this regulatory scheme to audit taxpayers' returns and inspect all records which may be relevant to the preparation of these returns. The Minister must be capable of exercising these powers whether or not he has reasonable grounds for believing that a particular taxpayer has breached the Act. Often it will be impossible to determine from the face of the return whether any impropriety has occurred in its preparation. A spot check or a system of random monitoring may be the only way in which the integrity of the tax system can be maintained. If this is the case, and I believe that it is, then it is evident that the *Hunter* criteria are ill-suited to determine whether a seizure under s. 231(3) of the *Income Tax Act* is reasonable. The regulatory nature of the legislation and the scheme enacted require otherwise. The need for random monitoring is incompatible with the requirement in *Hunter* that the person seeking authorization for a search or seizure have reasonable and probable grounds, established under oath, to believe that an offence has been committed. If this *Hunter* criterion is inapplicable, then so too must the remaining *Hunter* criteria since they all depend for their vitality upon the need to establish reasonable and probable grounds. For example, there is no need for an impartial arbiter capable of acting judicially since his central role under *Hunter* is to ensure that the person seeking the authorization has reasonable and probable grounds to believe that a particular offence has been committed, that there are reasonable and probable grounds to believe that the authorization will turn up something relating to that particular offence, and that the authorization only goes so far as to allow the seizure of documents relevant to that particular offence.
>
> This is not to say that any and all forms of search and seizure under the *Income Tax Act* are valid. The state interest in monitoring compliance with the legislation must be weighed against an individual's privacy interest. The greater the intrusion into the privacy interests of an individual, the more likely it will be that safeguards akin to those in *Hunter* will be required. Thus, when the tax officials seek entry onto the private property of an individual to conduct a search or seizure, the intrusion is much greater than a mere demand for production of documents. The reason for this is that, while a taxpayer may have little expectation of privacy in relation to his business records relevant to the determination of his tax liability, he has a significant privacy interest in the inviolability of his home.
>
> In my opinion, s. 231(3) provides the least intrusive means by which effective monitoring of compliance with the *Income Tax Act* can be effected. It involves no invasion of a taxpayer's home or business premises. It simply calls for the production of records which may be relevant to the filing of an income tax return. A taxpayer's privacy interest with regard to these documents *vis-à-vis* the Minister is relatively low. The Minister has no way of knowing whether certain records are relevant until he has had an opportunity to examine them. At the same time, the taxpayer's privacy interest is protected as much as possible since s. 241 of the Act protects the taxpayer from disclosure of his records or the information contained therein to other persons or agencies.

Other cases have added validity to the approach of using related audit information discovered during the course of an audit. For example, The Tax Audit circular (Canada Revenue Agency 1984) asserted that "(c) Secondary files - A file may be selected for audit because of its association with another file previously selected. For example, if several taxpayers share a single place of business and

are under the same control, and one of their files has been selected for audit, it is usually more convenient both for the Department and the taxpayers to have all the records examined during the same audit engagement. In addition, the affairs of such taxpayers are often so interwoven as to require the auditor to examine them together." This ability was affirmed by the courts (Canada (National Revenue) v. The Greater Montréal Real Estate Board 2006). This lends further credibility to the model. Recall, for example, that the model was able to identify geographic and buyer cohorts that contributed positively to sanctions. As such, it is feasible and defensible to use this information to audit the transactions affiliated with the geographic and buyer cohorts that contributed positively and significantly to sanctions. Given the probability of a Type I or Type II error, this information would be necessarily sufficient to commence further inquiries, but not sufficient to meet the standard for criminal inquiries.

I conclude that using this model as a tool in the suite of selection tools at the disposal of both auditors and fisheries officers is a reasonable, non-arbitrary method of selecting transactions for further review. As noted by James and Alley (2002) there is perhaps an argument to be made by assisting compliant taxpayers meet their obligations. There is definitely a role for information and education campaigns. There is also the potential for partnering with non-government organizations and fostering consumer demand for legally and ethically sourced products. I will examine this point in more detail in the section on corporate social responsibility and ecolabelling.

## Fisheries Policy

The fisheries policy implications have an interesting dichotomy. I have shown that there are indications of non-conformity with Benford's Law. As with tax policy, this does not mean that there is certainty of fraud or human manipulation (Durtschi, Hillison and Pacini 2004; Geyer and Williamson 2004). Thus an enforcement actions based solely on non-conformance with Benford's Law would be risky and open the Government to challenges about the rationale for enforcement. As part of an enforcement strategy, a fisheries officer would need to have additional information, tools, and techniques to select fishermen for investigation.

The Government of Canada has instituted a fisheries management framework which emphasizes sustainable fisheries management (Shelton and Sinclair 2008). Shelton and Sinclair suggest that the framework will better enable fisheries to meet ecolabelling standards. The Food and Agriculture Organization (FAO) of the United Nations has set guidelines on ecolabelling that

emphasize the role of governments in setting up these programs. However, Shelton and Sinclair note "the initial emphasis has come mainly from consumers, industry, and environmental nongovernmental organizations" (p. 2307). The Marine Stewardship Council (MSC) guidelines are consistent with the FAO guidelines. The guidelines require:

> "that a fishery must be conducted in a manner that does not lead to overfishing or depletion, and for those populations that are depleted, fisheries must be conducted in a manner that demonstrably contributes to their recovery. The intent is to ensure that productive capacities of resources are maintained at , or restored to, high levels designed to retain their long-term productivity and provide margins for error and uncertainty" (p. 2307).

After their analysis, Shelton and Sinclair summarized their guiding principles for sustainable fisheries management that improve upon both Government of Canada policy and international agreements. First, fisheries management should use all available scientific information to arrive at conservation and sustainable usage goals. This principle also underscores the need to foster academic research on the fisheries by more open sharing of data. Second, conservation efforts should be concerned about biodiversity of species and entire ecosystems. This includes both commercially viable species and bycatch (species caught unintentionally during commercial fishing efforts). Third, fishing effort should be adapted according to fisheries management plans that change in response to applicable fish census and maintain fishing effort in a predetermined range. Fourth, harvest rules should be modelled to determine how they perform under a range of fishing behaviours and uncertainty. This would suggest that if there is uncertainty over fishing effort such as the degree of illegal and unreported fishing, then the allowable catch efforts should be decreased to compensate for the uncertainty. Last, conservation and sustainable use should require input and consultation from stakeholders. From the Department of Fisheries and Oceans perspective, this input and consultation process is a cornerstone of their ongoing relationship with stakeholders.

For fisheries policy, the question becomes whether a government or non-government response may be more appropriate. For example, a government response would imply that regulations or policies should be changed in an effort to modify the illegal, unreported or unregulated behaviour of the lobster and snowcrab fishermen. Given the longstanding history of non-compliance in the lobster fishery including the illegal trading or transfer of licenses, subsequent tax implications, and the illegal

use of licenses as collateral (Bodiguel 2002), a government-based policy approach may not be practical or effective. The second approach the Government could take is to encourage a non-government approach. For example, from the eco-labelling perspective, my quantitative finding that there are indicators of non-conformance with Benford's Law could negatively impact certification efforts. Nevertheless, this should not deter the lobster fishery from pursuing certification as the fishery can still choose an advantageous unit of certification (Marine Stewardship Council 2009). The unit of certification is defined as "the entire fishery, a smaller group of vessels within the fishery, or specific gears or fishing methods. Once defined, only fish from that particular unit will later be able to carry the MSC ecolabel in the marketplace" (Marine Stewardship Council 2009 p. 5). Thus if the lobster fishery chose an appropriate unit of certification that excluded fishermen that were participating in illegal, unreported or unregulated lobster fishing. This non-governmental approach could have market access (e.g., provide a barrier to entry to markets wishing to purchase eco-labelled lobster to non-participating fishermen), and subsequent market share and profitability implications. This could be a very effective approach to change illegal and underreporting behaviours in the lobster fishery. Given limited government resources, the market-based approach to combatting illegal, underreported and unreported fishing via consumer demand is also a cost effective approach. Government enforcement efforts can then be targeted towards the cases of greatest size and severity.

What the underreporting in the lobster fishery means is that there is insufficient information on decision making by Department of Fisheries and Oceans officials. This further underscores the "need for the industry to adjust and control fishing effort to maintain a balance with the available resource" (Parsons 2010 p. 396 ). In fact, some research suggests that the Canadian fisheries need to switch to a conservation mode, including the introduction of individual quotas. Nevertheless, the economic benefits such as the survival of fishing communities outstrip the imperative for policy changes in quotas or unemployment insurance even though global economic conditions have dramatically reduced the price for lobster starting in 2009 (Parsons 2010).

### 10.3.3. Compliance and Enforcement

In reviewing options for compliance, it is essential to have a quick review of the economic theory of public enforcement of law (Polinsky and Shavell 1998). Polinsky and Shavell use their article to answer the following questions (p.2): "How much of society's resources should be devoted to

apprehending injurers? If an injurer is caught, should the rule of liability be strict or fault-based? Should the form of the sanction be a fine, an imprisonment term, or a combination of the two? At what level should sanctions be set?" Individuals will generally commit an act if their expected utility exceeds their utility of not committing the act. The utility of commission necessarily takes into account the payoff of committing the act plus the probability of getting caught.

In contrast, the behavioural aspects of sanctions suggest that for those with strong tax ethics, sanctions have little deterrent value (Wenzel 2004b) while strong social norms can increase their effects. However, recall that the lobster fishery is typically community-based and family-based. Wenzel notes that no deterrence effect was found when social norms tolerated tax evasion behaviours. Thus, changing the sanction regime without attempting to change social norms in these communities would likely be futile.

One of the tools available in the compliance and enforcement spectrum are audits. Targeted audits are more effective than random audits at detecting errors, both intentional and unintentional (James and Alley 2002). James and Alley also asserted that no matter the accuracy of audits, there will be errors (both Type I and Type II). As noted in Study 3, there is a reasonable probability of a Type I and Type II in the model's ability to predict non-compliance that would lead to sanctions. While there is a better than random chance that the audit will uncover illegal or underreported activity, the users of the audit selection tool should be cognizant of its limitations and the subsequent requirements for additional information beyond the statistical. Further investigation of the contributions to Factor2 for licencees also needs to occur.

In looking at compliance approaches for the future, some themes emerge that encourage compliance within the current regime (Brand 1996). The themes include simplicity, education, enforcement, increased use of withholding/matching programs. Brand points out that simplicity decreases the opportunities for intentional non-compliance and decreases unintentional non-compliance. One can always infer that more efforts on education could be made, especially in industries like the lobster fishery where compliance is an issue. The Canada Revenue Agency has made efforts in the construction industry, another industry with compliance issues, by educating consumers at trade shows, through advertising campaigns and collaboration with industry. Similar efforts could be attempted with the lobster fishery. As stated before, enforcement efforts could become

much more targeted if using the model from Study 3. Brand's last themes of increasing the use of withholding and matching programs bear further investigation by the Canada Revenue Agency. Gratuities in the hospitality industry are subject to withholding if they are paid via credit card (Canada Revenue Agency 2011b). Cash gratuities are not subject to withholding but are assumed to be a certain percentage of earnings. It is conceivable that either withholding (e.g., buyers would remit income tax on behalf of licensees based on the landings) or returns (e.g., similar to those required in the construction industry (Canada Revenue Agency 2011c). Given that buyers and sellers may collude as previously discussed, having withholding performed by the buyers may introduce additional compliance complexities. Information returns on the other hand, would possibly identify gaps or discrepancies as the lobster worked its way from ocean to table. Since the majority of lobster is exported, the duration of the lobsters' underground economy is limited due to the export documentation required (e.g., manifests, customs declarations, etc.), the information return would fill the information gap between landing and export.

### 10.3.4. Legal Aspects

The legal and regulatory environment governing the lobster fishery and its taxation is complex and were described in Chapter 3. The model that I have developed will have a specific application to either the taxation or fisheries aspects. I will start this section by outlining the legal authorities granted to both auditors and fisheries officers. Next I will explore the jurisprudence and outline its applicability. Last, I will position the model within both tax and fisheries contexts in order to frame the possible uses and challenges in its use.

Both auditor and fisheries officers have two distinct authorities granted to them by the Income Tax Act (Income Tax Act 1985) and the Fisheries Act (Fisheries Act 1985) respectively. These authorities are inspection (fisheries) or audit (taxation) in the regulatory context and investigations in the quasi-criminal contexts.

The Fisheries Act specifies inspection responsibilities as:

> **49.** (1) Subject to subsection (2), for the purpose of ensuring compliance with this Act and the regulations, a fishery officer or fishery guardian may enter and inspect any place, including any premises, vessel or vehicle, in which the officer or guardian believes on reasonable grounds there is any work or undertaking or any fish or other thing in respect of which this Act or the regulations apply and may
>
> (*a*) open any container that the officer or guardian believes on reasonable grounds contains any fish or other thing in respect of which this Act or the regulations apply;

(*b*) examine any fish or other thing that the officer or guardian finds and take samples of it;

(*c*) conduct any tests or analyses and take any measurements; and

(*d*) require any person to produce for examination or copying any records, books of account or other documents that the officer or guardian believes on reasonable grounds contain information that is relevant to the administration of this Act or the regulations.

Operation of data processing systems and copying equipment

(1.1) In carrying out an inspection of a place under subsection (1), a fishery officer or fishery guardian may,

(a) use or cause to be used any data processing system at the place to examine any data contained in or available to the data processing system;

(b) reproduce any record or cause it to be reproduced from the data in the form of a print-out or other intelligible output and remove the print-out or other output for examination or copying; and

(c) use or cause to be used any copying equipment at the place to make copies of any record, book of account or other document.

Duty to assist

(1.2) The owner or person in charge of a place that is inspected by a fishery officer or fishery guardian under subsection (1) and every person found in the place shall

(a) give the officer or guardian all reasonable assistance to enable the officer or guardian to carry out the inspection and exercise any power conferred by this section; and

(*b*) provide the officer or guardian with any information relevant to the administration of this Act or the regulations that the officer or guardian may reasonably require.

The Income Tax Act outlines inspection responsibilities as:

**231.1** (1) An authorized person may, at all reasonable times, for any purpose related to the administration or enforcement of this Act,

(*a*) inspect, audit or examine the books and records of a taxpayer and any document of the taxpayer or of any other person that relates or may relate to the information that is or should be in the books or records of the taxpayer or to any amount payable by the taxpayer under this Act, and

(*b*) examine property in an inventory of a taxpayer and any property or process of, or matter relating to, the taxpayer or any other person, an examination of which may assist the authorized person in determining the accuracy of the inventory of the taxpayer or in ascertaining the information that is or should be in the books or records of the taxpayer or any amount payable by the taxpayer under this Act,

and for those purposes the authorized person may

(*c*) subject to subsection 231.1(2), enter into any premises or place where any business is carried on, any property is kept, anything is done in connection with any business or any books or records are or should be kept, and

(*d*) require the owner or manager of the property or business and any other person on the premises or place to give the authorized person all reasonable assistance and to

answer all proper questions relating to the administration or enforcement of this Act and, for that purpose, require the owner or manager to attend at the premises or place with the authorized person.

Reasonable grounds is also defined by the courts as a standard of proof that is "something less than a balance of probabilities but nevertheless requires a judge to hold a bona fide belief in a serious possibility based on credible evidence" (Canada (National Revenue) v. Clarke 2011). Thus the hierarchy of proof is:

Reasonable grounds < balance of probabilities < beyond a reasonable doubt

It is also important to note the differences between administrative or civil actions and more serious offences. The thresholds are discussed in Table 10-1:

| Department | Civil Standard of Proof | Criminal Standard of Proof | Threshold between civil and Criminal |
|---|---|---|---|
| Canada Revenue Agency | Balance of Probabilities | Beyond a reasonable doubt | Courts have helped to define the delineation between an audit and investigation (R. v. Jarvis 2002). In general, an audit can have civil remedies and an investigation can have quasi-criminal or criminal remedies. An important detail was clarified by R. v. Jarvis in that once an investigation was started, the information garnered via the audit process could not be shared with investigators. Rather, proper use of warrants and cautions (e.g., taxpayers need to be advised of their constitutional rights) needs to be exercised to generate information for the investigation. In either case, "there is a diminished expectation of privacy in records produced during the ordinary course of regulated activities and there is a relatively low privacy interest in records relevant to a tax return". The Income Tax Act has sweeping powers to "enter a taxpayer's place of business or place of record keeping; require the taxpayer and third parties to answer questions put to them; and require the taxpayer and third parties to furnish information and documents upon request". |
| Department of Fisheries and Oceans | Balance of Probabilities | Beyond a reasonable doubt | Courts have specified that "there is a clear and fundamental difference between ss. 49 and 49.1. The former section is aimed at "ensuring compliance with [the] Act", that is to say, ensuring that offences against the Act are not being committed. By clear and unequivocal contrast, s. 49.1 is aimed at investigation of known breaches of the Act which are being or have been committed."(R. v. Douglas 2000). Thus once a breach is identified during an inspection, the focus becomes an investigation and more stringent criteria apply (e.g., warrants). However, inspection powers can still be exercised if there is pre-existing information |

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|---|---|---|---|
| | | | such as a tip or complaint (R. v. Kinnear 1997). Further, as a regulated industry, there ought to be an expectation that licensees will be inspected (R. v. Leahy 2004) to ensure compliance. Information gathered during inspections can be removed, evaluated and used for investigations and at subsequent trials (Labrador Sea Products v. Her Majesty the Queen 2008). The protections of the Charter of Rights and Freedoms take effect when the the adversarial relationship has crystallized between the licensee and the Crown (i.e., the decision has been taken to proceed with a formal investigation leading to charges). It is not possible to go back to an inspection once the threshold has been passed (R. v. Douglas 2000) but it is possible to choose between civil and quasi-criminal remedies. |

**Table 10-1 Thresholds for Burden of Proof**

In order to position the usefulness and applicability of the model generated in Study 3, I would posit that it could be used as one factor amongst others to meet the standard for civil sanctions (i.e., balance of probabilities). This also implies that the model and its predictions could be used as one factor amongst others as the reasonable grounds required to obtain judicial authorization for a warrant. It is doubtful that the model in its current form would meet the standard for quasi-criminal or criminal proceedings as there is enough doubt regarding the robustness of its classification abilities to dispel its usefulness in this regard.

### 10.3.5. Corporate Social Responsibility

Another interesting implication of the evidence of potential human manipulation of data in the lobster fisher is the link between tax avoidance, tax evasion and corporate social responsibility. First, I need to restate the definition of tax avoidance and tax evasion. Tax avoidance is legitimate or legal efforts to avoid paying taxes while tax evasion is the illegal effort to avoid paying taxes. Second I would like to examine the implications of the current research on tax evasion and corporate social responsibility.

Chen, Chen et al. (2010) examined the aggressiveness of family versus non-family firms on tax issues. The first premise in Chen, Chen et al.'s paper was that most shareholders prefer a certain degree of tax aggressiveness as shareholders are supportive of any measures that provide value to them. Nevertheless, there are also non-tax costs to tax aggressiveness. Interestingly, Chen, Chet et al. found

that tax aggressiveness was more prevalent in non-family firms than family firms. Interestingly, illegal activity such as collusion has been found anecdotally in family firms (McMullan and Perrier 2002).

Recall that some others such as Sikka (2010) asserts that stated corporate social objectives may diverge from practice in the case of tax avoidance. Since the participants in the lobster fishery are largely self-employed individuals that operate as sole-proprietorships, what then is the relationship to corporate social responsibility? Notwithstanding the literature (e.g., (Chen, Chen, Cheng et al. 2010)) there are significant indicators of human manipulation of numerical data in a predominantly family-firm industry. Why are these family-firms behaving more like Sikka's corporations than Chen, Chen et al.'s family-firms? I believe that I need to return to the introduction to the lobster fishery from Chapter 2. Recall that input controls such as the effort required to catch lobster produce a response that maximizes effort in an attempt to maximize income. This also creates a common resource management issue similar to the "Tragedy of the Commons" (Hardin 1968). This response also parallels the corporate imperative to provide value to shareholders and is consistent with news reports that news reports in December 2006 that "Fishermen sometimes try to hide their total catch when they exceed their quotas…occasionally working in collusion with processing companies" (Beeby 2006). Policy considerations that reduce the incentives to maximize income might encourage corporate social responsibility responses of family firms more typical to that found by Chen, Chen et al. (2010). Nevertheless, paying ones fair share of taxes as an indicator of corporate social responsibility does not have the cache of other corporate social responsibility initiatives such as ecolabelling.

### 10.3.6. Ecolabelling

Ecolabelling of fisheries products is becoming more common and is an overt point-of-purchase indicator of the sustainability of the fisheries practices used in a given fishery (Roheim 2003). As an indicator it could also be considered an overt sign of corporate social responsibility and the fisheries' adherence to a commonly understood set of social responsibility criteria. One of the major ecolabelling certification authorities, the Marine Stewardship Council, reported that by the end of 2009-2010, 187 fisheries producing 7 million tonnes or 12 percent of the wild fisheries production were certified or in the certification process (Marine Stewardship Council 2010). The Marine Stewardship council was founded by the World Wildlife Federation and the consumer goods

conglomerate Unilever (Roheim 2003). The Marine Stewardship Council is now funded via charitable organizations (Potts and Haward 2006).

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| **Certification:** declaration that "focus on the legal permissibility of the harvest and that the fish have been caught within an agreed regulatory framework" (Potts and Haward 2006 p. 95) |
| **Ecolabelling:** moves beyond certification and "tends to be granted on the basis of investigation into the ecological integrity of the harvest, including ecosystem considerations within the fishery" (Potts and Haward 2006 p. 95). Further refinements are possible with respect to the type of label. For example, some labels address a specific issue (e.g., tuna is caught via a dolphin-friendly harvesting method) whereas others cover the entire life cycle of the product from ocean to consumer and may include strict chain of custody requirements (Potts and Haward 2006). |

**Table 10-2 Definition of Ecolabelling and Certification**

Certification of the sustainability and ecolabelling of how various seafood is also emerging as an important non-government fisheries management mechanism especially in the areas of illegal, unreported and unregulated fishing (Potts and Haward 2006). The presence of an ecolabel also attempts to persuade consumers at the point of purchase to purchase a product with more sustainable fishing practices than an otherwise identical, directly substitutable product (Potts and Haward 2006).

As more and more markets move towards ecolabelling requirements such as the European Union (Potts and Haward 2006), the Atlantic Canadian lobster fishery will be faced with some challenges. For example, if the lobster fishery wished to participate in an ecolabelling initiative, the chain of custody would be difficult for some fishermen to substantiate if their sales were cash and unreported. As a market-driven initiative, ecolabelling then becomes a non-government mechanism to persuade fishery participants to adopt more sustainable practices including perhaps the cessation of illegal, unreported, and unregulated fishing.

Further, the presence of research outlining illegal activities (Bodiguel 2002) and issues reported in Arai (1994) and McMullan et al. (2002) that some communities are more prone to compliance issues than others would be potentially problematic for a bid to certify the lobster fishery or pursue an eco-label. For example, poaching in the lobster fishery in Atlantic Canada can be classified as communal, outlaw and business poaching (McMullan and Perrier 2002). Communal poaching is tolerated within the community and is usually not for resale (i.e., it is for personal or family use), while outlaw poaching is not tolerated within the community and is typically for profit (McMullan and

Perrier 2002). Outlaw poaching differs from business poaching in the degree of illegality; outlaw poaching is completely illegal, while business poaching is an illegal supplement to an otherwise legitimate commercial operation (McMullan and Perrier 2002).

Another distinguishing feature of the three types of poaching is the number of people involved. Communal poaching is small-scale and limited to one or two family members. Outlaw poaching typically involves a larger number of related individuals, and business poaching is more of a community effort involving family, crew, buyers and distributers (McMullan and Perrier 2002).

The illegally caught lobster is soon reintroduced into the legitimate market when the lobster is exported or distributed within Canada. McMullan and Perrier's (2002) paper on the community-wide nature of business poaching suggests that this manipulation should be detectable within the fisheries data. From the certification perspective, my quantitative finding that there are indicators of manipulation could negatively impact certification efforts. This should not deter the lobster fishery from pursuing certification as the fishery can still choose an advantageous unit of certification (Marine Stewardship Council 2009). The unit of certification is defined as "the entire fishery, a smaller group of vessels within the fishery, or specific gears or fishing methods. Once defined, only fish from that particular unit will later be able to carry the MSC ecolabel in the marketplace" (Marine Stewardship Council 2009 p. 5). Thus if the lobster fishery chose an appropriate unit of certification that excluded fishermen that were participating in illegal, unreported or unregulated lobster fishing. This non-governmental approach could have market access (e.g., provide a barrier to entry to markets for non-participating fishermen as market demand for eco-labelled lobster increases), and subsequent market share and profitability implications.

### 10.3.7. Traceability

An ancillary measure to ecolabelling is also emerging. Ecotrust Canada recently launched a traceability initiative (Thisfish and Ecotrust Canada 2011a) in which consumers can trace their purchases back to the fisherman that caught their meal, the fishing methods used, date harvested, and any intermediate processing that occurred. One of the major Canadian grocery chains, Sobey's (Sobey's Inc. 2011) is actively promoting this concept for their fish products. In store displays include quick response codes that can be scanned with smartphones to provide instant information on the program and its benefits. Some restaurants (Thisfish and Ecotrust Canada 2011b) are also touting this as a

benefit to their patrons. Ecolabelling is not a prerequisite of the fish information program, although the two appear to be complimentary. As consumer awareness and interest in this program grows, this will become another non-government measure for combatting illegal, underreported and unreported catches. As consumer demand for information on where their food comes from and the ethical harvest of natural resources, this non-governmental approach could have market access (e.g., provide a barrier to entry to markets for non-participating fishermen), and subsequent market share and profitability implications.

## 10.4. Limitations and Recommendations for Further Research

### 10.4.1. Stata9

One of the primary limitations of Stata9/IC was the maximum matrix size of 800. When running a logistic regression with the xtlogit command and dummy variables for each licensee and buyer, the required matrix was larger than the maximum available. Despite this limitation, a workaround was developed that used the aggregation of licensees and buyers by postal code. A geographic component had been hypothesized, thus this was not an unreasonable aggregation. Running the models for licensee and buyer with an unrestricted version of Stata is recommended.

The speed to run the aggregated version of the full model (licensee postal codes and buyer postal codes) was slow. It took well over a week on a machine with 8MB RAM, Windows 7, and an AMD Athlon™ II x4 (4 core) 640 processor running at 3.00Ghz to process the truncated full model (Model 3a). Another limitation of Stata9/IC was the ability to use only one of the four processors available. Running the models with a multiple core edition of Stata is also recommended.

Steps were also taken to ensure that the processing of the model was as fast as possible despite the processing limitation of Stata9/IC. First, the xtlogit command was used as opposed to the xtprobit or glamm commands. Second, adaptive quadrature was used (Rabe-Hesketh, Skrondal and Pickles 2002). Third, different optimization techniques (Newtonian versus quasi-Newtonian) were used as appropriate. Newtonian was found to be the quickest to optimize. Quasi-Newtonian were used when there were issues with optimization. Last, the “difficult” option was used when nonconcave regions were encountered by Stata.

### 10.4.2. Choice of Statistics

The choice of Stata's xtlogit command was guided primarily based on the criteria that included 1) panel data; 2) the existence of binary outcomes (sanctions vs. no sanctions). Rules of thumb indicate that fixed effects be examined prior to examining random effects. Prior to running a random effects model, a fixed effects model is normally run (Baltagi 2005). The point of running a fixed effects and a random effects model is to statistically substantiate the decision to prefer one or the other via the Hausman test. This test was applied to Model 4 using xtlogit and fixed and random effects models and resulted in a prob>Chi2 of 0.7130. All further tests were calculated using random effects. Due to the structure of the remaining models, the Hausman test could not be run (e.g., indicator variables for Buyer).

Other options for the data used could have included xtprobit or the GLLAMM module for Stata (Skrondal and Rabe-Hesketh 2004). Arguably, the results of xtlogit, xtprobit or GLLAMM would end up at approximately the same point. The choice of post-estimation commands for xtlogit seems somewhat limited. There are other options such as what was presented in Study 3 such as the analysis of predicted probabilities (Long and Freese 2006).

Structural Equation Modelling (SEM) is another option that may have been a better choice than xtlogit. In fact, the use of SEM would be an ideal next step in this research as there is a better specification of variables for such a model as a result of these studies. SEM can also uncover further relationships between the variables used. Nevertheless it is a matter of debate whether a panel data or SEM approach is preferable as "Logistic regression showed better overall classification rate due to better prediction of non-events … On the other hand, events were better predicted by SEM" (Kupek 2006). This direction of research would, perhaps, more appropriately model the underground economy as a latent variable with sanctions, Benford's Law and market power, amongst others as indicator variables. The strengths and limitations of SEM need to be further explored vis-à-vis its suitability for this type of data (Tomarken and Waller 2004).

Hsaio (2003) also discusses some additional statistical considerations. First, there is the missing variable issue. As seen in the differences between the transactional and licensee models, there is quite likely an unmeasured or unspecified variable that would perhaps lead to a better specification of the licensee model. As such, the quest for additional variables that could lead to a better specification needs to be ongoing.

### 10.4.3. Generalizability

The data set was obtained from the Department of Fisheries and Oceans Canada (Department of Fisheries and Oceans 2007). The data set for the model consisted of LFA 33 (non-observed) (1997-2006), 109 664 landings and LFA 34 (non-observed) (1997-2006), 220 715.

Both LFA33 and 34 data were used since combined they account for 74% of the lobster landed in the Maritimes Region of DFO and 77% of the Maritimes Region value (and half of the overall Canadian value) (Department of Fisheries and Oceans 2005).

While not random, the data represents a large proportion of the population. LFA33 and 34 also represent the areas of highest anecdotal evidence of underground activity (Beeby 2006). Since the entire population of LFA33 and LFA34 were used, the model holds for those regions. While the data represents a large proportion of the overall Maritimes Region and Canadian value, further testing will be required to confirm the generalizability to the Canadian lobster fishery. There is no doubt that the model holds only for the following conditions:

1) For LFA33 and LFA34
2) For the variables selected; and
3) For those licensees reporting catches.

The model does not hold for those licensees that are not reporting a catch. Nevertheless the geographic information can be leveraged as a starting point for unreported activity.

### 10.4.4. Available data

The analysis was conducted using all available, relevant data from the Department of Fisheries and Oceans. Tax data was not available from the Canada Revenue Agency. This meant that many correlates such as gross and net income, deductions were not specified in the model. This is not a specification error per se, but rather an acknowledgement that the model is not meant to be a static effort.

In fact, "intellectual firepower is mandatory, but no guarantee of success now that the game's financial giants have cracked the code" (Verducci 2011 p. 39). This means that the model must be dynamic and continually adjusted in an attempt to stay ahead of the curve, preferably in a non-publicized manner. Ideally a “risk score” should be developed for each licensee that takes into account their compliance history, their association with geographic and buyer risk factors, as well as non-

quantifiable factors (e.g., officer judgment). In addition, other data can be evaluated for inclusion into the model.

Other variables that were not available but may have an influence on the overall model may be experience and minor non-compliance (e.g., license sanctions are the most severe penalty available, whereas fines may also have an explanatory role in the overall compliance picture). Self-employment, occupation and withholding status are fixed since all participants in the lobster fishery are self-employed. Other variables (e.g., Jackson and Milliron 1986) age, education, and gender are not collected in the data available. Compliant peers are addressed through the use of geographic information such as postal codes. Modeling the impact of policy changes such as tax rates, enforcement strategies and the like is possible by adding in dummy variables to indicate the pre- and post-policy change periods. Incorporating policy changes into the model is a direction for future research. This would enable the Government of Canada to study the influence of historical policy changes and model the impact of future policy directions.

License sanctions were used as the dependent variable and as an indicator of illegal and underreported fishing in the lobster fishery. It is possible that license sanctions could be construed as an indicator variable of a latent construct such as "participation in the underground economy". This would require the development and testing of a structural equation model and is a direction for future research.

### 10.4.5. Legal

As the model grows and develops, its use in selecting files for audit, its legal validity will no doubt be challenged. Nevertheless, this will be one of many instruments required for the auditors' and fisheries officers' suite of tools on which they rely for selecting cases for further examination. In Section 11.4.3, the value as evidence was discussed. The model in Study 3 needs be used as one factor amongst others to meet the standard for civil sanctions (i.e., balance of probabilities). This also implies that the model and its predictions could be used as one factor amongst others as the reasonable grounds required to obtain judicial authorization for a warrant. It is doubtful that the model in its current form would meet the standard for quasi-criminal or criminal proceedings. The model needs to be continually adjusted in light of additional information and its usefulness and precision may grow to the point where it can be used as evidence beyond a reasonable doubt. Since the legal system is looking for indicators

of causation beyond a reasonable doubt, statistical methods show an increased risk at best (Eisenberg 2000). As such, the use of this model needs to be carefully monitored and limited to the uses described in section 11.4.3 until such time as it is tested and accepted by the courts. Nevertheless due to various forensics-based television programmes, juries are demanding statistical and forensic evidence (Stinson, Patry and Smith 2007). Caution is urged "when considering the admissibility of statistics in connection with such evidence (Thompson 1989).

### 10.4.6. Recommendations for Future Research

In section 11.5.2 the possibility of applying a SEM approach to this introduced. While it was noted that the overall precision of SEM was not vastly different than that of the panel data approach used, it does, however, introduce the underground economy as a latent variable. The current research used the application of sanctions as an indicator variable of illegal, unreported and underreported activity. The classification of transactions (and licensees) according to the model developed still has a number of Type I and Type II errors. Regardless, the application of a SEM approach seems to be the next logical approach.

Another recommendation for future research would be to model the various policy options discussed in section 11.4 to assess their likely impact. Further, any real policy changes could also be included in the model by including a binary pre-post implementation variable. Thus any effects that could likely be attributed to the policy change could be better identified.

The third area for further research is the analysis of the profile of licensees with sanctions versus those that have not been sanctioned. For example, future research in this area should apply Lu et al.'s (2006) reinforcement learning methodology to the current data sets to demonstrate that their technique was effective and by reporting some requisite detection, sensitivity and timeliness data. Alternatively, Paton & Williams (2002) use a univariate probit model to examine possible pricing irregularities in a betting market. Future research should explore the application of Paton & Williams' (2002) methodology, as it could identify possible seller-buyer collusion. As more information is gathered on the nature and characteristics of fraud in the lobster fishery a semi-supervised fraud detection technique may also become a viable research direction. Other avenues from the fraud detection literature (Hand and Henley 1997; Lu, Boritz and Covvey 2006; Khan, Corney, Clark et al. 2010) include further development of the profile of a non-compliant transaction developed in Study 3.

This could generate a transaction by transaction risk profile for follow-up by the tax or fisheries authorities. The inclusion of audit or inspection results as a result of these leads could further train the model.

## 10.5. Summary

This dissertation was introduced with the quote "…the story of searching for any edge through information"(Verducci 2011 p. 41). This quote was intended to lay the groundwork of the remainder of the dissertation, in that it was indeed the story of searching for an advantage via information. The quote originated from a sports context and the story of the Oakland A's baseball team and their quest to win a championship without having to pay for superstar players on their team. The story was that the Oakland A's developed a system of statistical analysis that identified high performing but undervalued players. The team would then hire such players. While the Oakland A's never won a championship as a result of their strategy, they have outperformed teams with higher player budgets. Their competitive advantage was information, as well as using that information in a timely manner.

In the case of the underground economy of the Atlantic Canadian lobster fishery, the Government of Canada has information and a fresh analysis of the information that may enable them to better target audits or inspections. There is no illusion that the information will, in sports parlance, "win the championship" however, it is hoped that with this analysis and continued improvement that the Government of Canada will outperform those that seek to evade tax and fisheries policy. This analysis will only help to target those that are at least partially compliant, but that has been acknowledged as a limitation from the start.

Enforcement and sanctions are only one route that the Government of Canada may choose in tackling the underground economy in the lobster fishery. A multi-faceted approach ought to be considered that includes support and development of non-policy options such as ecolabelling and traceability need to be considered in this instance.

There is no reasonable expectation that this model will win the championship in the battle against the underground economy in the lobster fishery. Like the Oakland A's, a successful outcome in the underground economy would be for the government to outperform and remain competitive through the use of information.

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